CONTENTS

A VERY INEXPENSIVE SCHEME ON RFEM TO USE IN CFD AND OTHER PROBLEMS

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Note, Reference [1] should be read before reading this paper. In this paper I am going to use the Reduced Finite Element Method (RFEM), see [1] with a constant amount of Element Degree Limiter, Field Variable Limiter (EDL, FVL) coefficient to obtain an inexpensive scheme of non-oscillatory, for this purpose I used third degree Lagrangian elements on full upwind difference scheme (FUDS) and its result was very successful.

Keywords: Reduced Finite Element Method, Non-oscillatory, Full upwind difference scheme, Third-order scheme.

The non-oscillatory shape functions [1] is written as follows:

$$\begin{aligned} N_0^{EDL,FVL} &= (1-\delta_i)N_0^{(p)} + \delta_i N_0^{(ref)} \\ N_j^{EDL,FVL} &= (1-\delta_i)N_j^{(p)} + \delta_i N_j^{(ref)} \\ N_L^{EDL,FVL} &= (1-\delta_i)N_L^{(p)} + \delta_i N_L^{(ref)} \end{aligned} \quad (1)$$

Where δ_i is Element Degree Limiter, Field Variable Limiter (EDL, FVL), $N^{(p)}$ is p-order shape functions (in this paper degree of p is 3) and $N_0^{(ref)}$, $N_j^{(ref)}$ and $N_L^{(ref)}$ are reference functions I used equation (40) of [1] as reference function that is

$$N_0^{(ref)} = N_0^{(1)}, \quad N_j^{(ref)} = 0, \quad N_L^{(ref)} = N_L^{(1)} \quad (2)$$

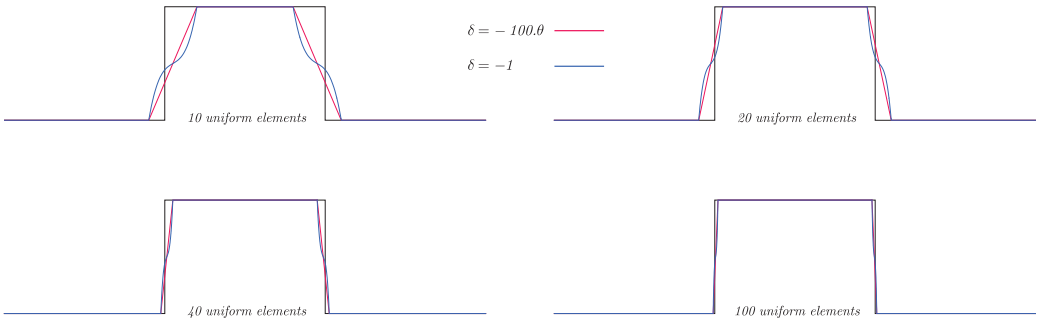

Fig. 1. 1D advective equation $u_t + u_x = 0$

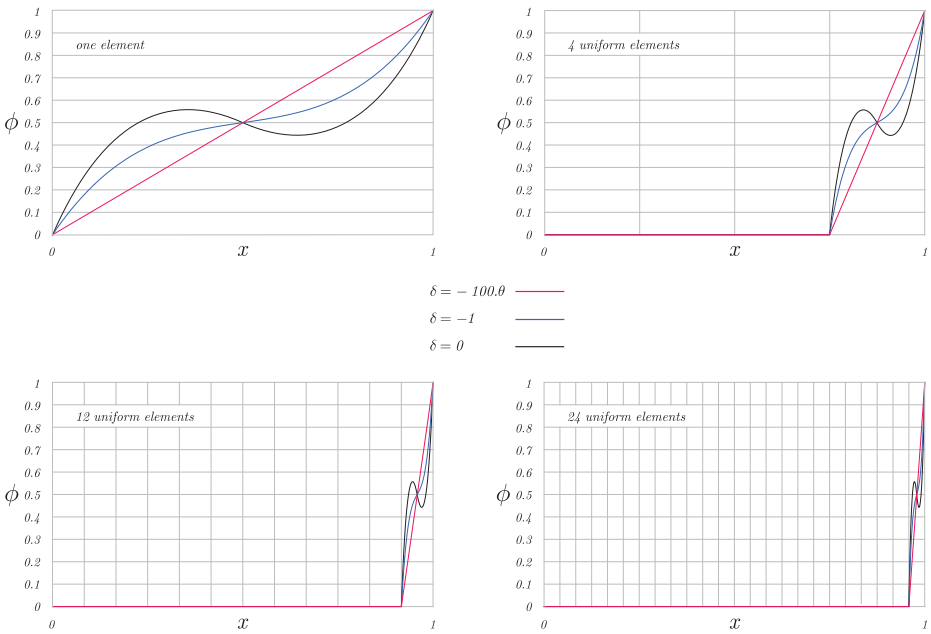

Fig. 2. 1D convection-diffusion equation $a\phi_x - k\phi_{xx} = 0$

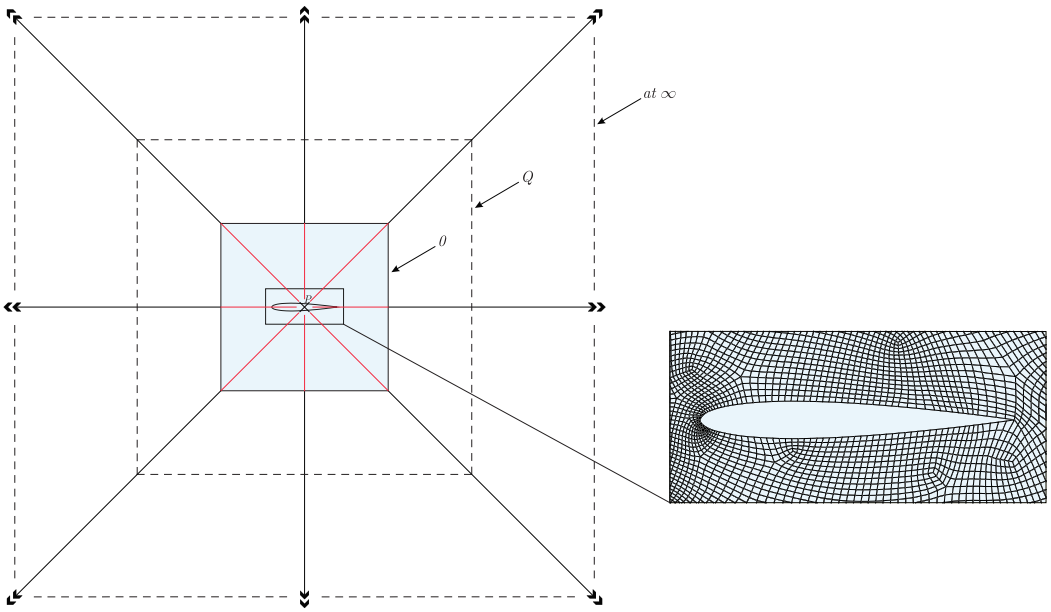

Fig. 3. Grid for flow over a NACA 0012 airfoil

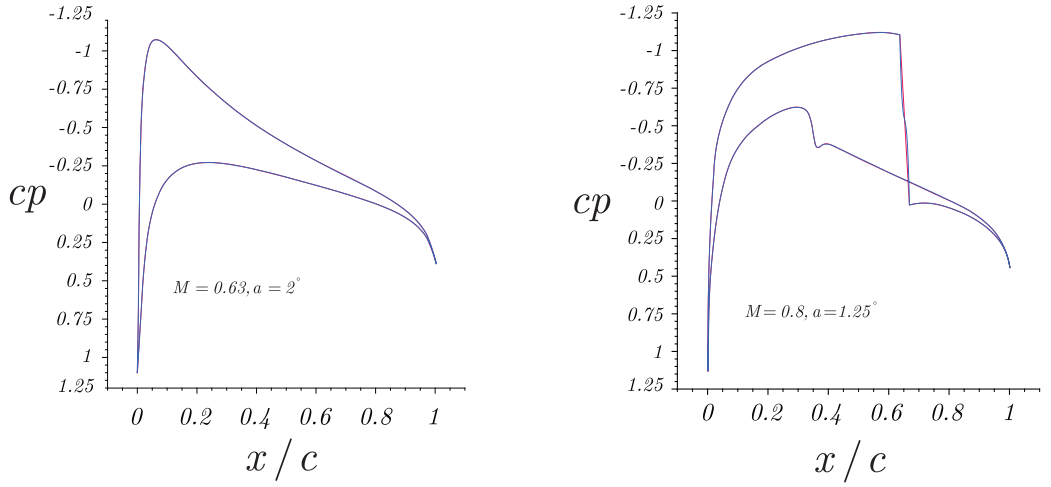

Fig. 4. Pressure distribution on surface of NACA 0012 airfoil, steady-state

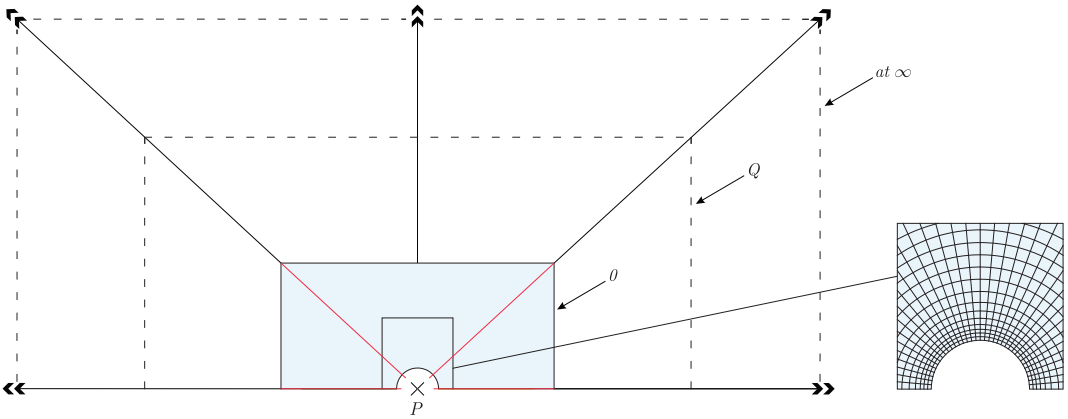

Fig. 5. Grid for flow around a cylinder.

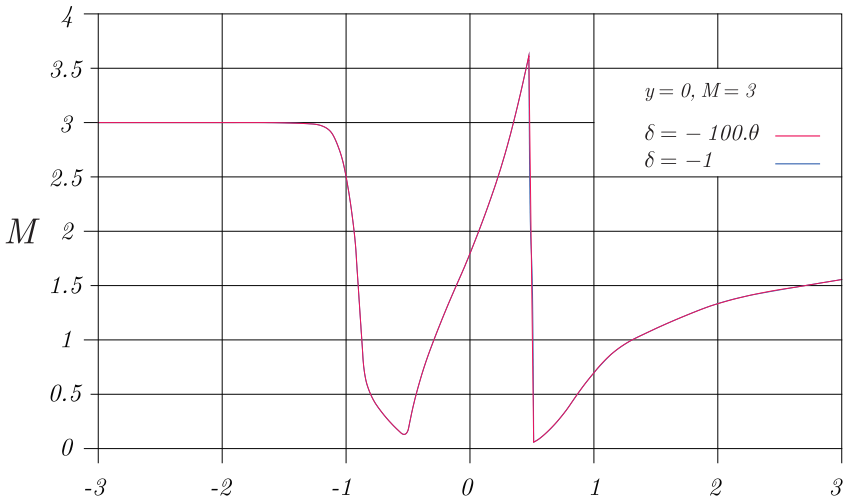

Fig. 6. Flow around a cylinder, steady-state

Where $N_0^{(1)}$ and $N_L^{(1)}$ are liner shape functions, by putting equation (2) in (1) and also $\delta_i = -1$ we have

$$N_0^{EDL,FVL} = 2N_0^{(p)} - N_0^{(1)}$$
$$N_j^{EDL,FVL} = 2N_j^{(p)} \qquad (3)$$
$$N_L^{EDL,FVL} = 2N_L^{(p)} - N_L^{(1)}$$

Equation (3) is non-oscillatory shape functions that will be used in this paper for CFD problems.

Examples

In this section, I am going to use the equation (3) as shape function for approximating a few equation and compare its result with non-constant δ_i. As first example, I approximated 1D advective equation by Point Collocation weight function, see figure (1). In second example, I approximated 1D convection-diffusion equation in $p_e = \infty$ by Galerkin weight function, see figure (2). In third example, I approximated 2D Euler equations for pressure distribution on surface of NACA 0012 airfoil [1] by Galerkin weight function and infinite elements for non-solid boundaries, see figure (4), and flow around a cylinder [1] by Subdomain Collocation weight function see figure (6).

Conclusions

As can be seen from the results, with any number of elements solutions are non-oscillatory, and when we use fine mesh (usually in CFD is used) solutions are very close together. So, using of constant EDL, FVL is useful.

References

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DEVELOPMEND OF METHOD OBTAINING M-XYLYLENEDIAMINE FOR PRODUCTION OR POLYMERIC MATERIALS

[1,2]AbildinT.S., [2]Zhubanov K.A., [1,2]Aubakirov E.A., [1,2]Vasilina G.K., [1,2]Burkhanbekov K.E.

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The results of studying reaction of isphthtalonitrile hydration upon promoted catalysts at the foundation of Ni-Rhenejais alloy Ni:Al = 1:1 in spirit environment under the pressure of oxygen in presence of ammonia.

It is established that in the described conditions studied catalysts can be placed in the following line according to degradation of isophthalonitrile hydration:

$$Ni\text{-}Nb_{sk} > Ni\text{-}Ti_{sk} > Ni\text{-}Mg_{sk} > Ni_{sk}$$

And according to output of m-xylylenediamine (m-XDA) sequence of catalysts preserves. Alloying of Ni-Al-alloy with a small amount of Ti, Nb has a positive effect upon activity and selectivity. Activity of $Ni\text{-}Nb_{ск}$ catalyst in 2–3 times greater that of $Ni\text{-}Ti_{ск}$ and Ni-Mgск, and 4–5 times greater than that of $Ni_{ск}$.

It is shown that the studied solvents can be placed in the following line according to degradation isophthalonitrile hydration speed on $Ni\text{-}Nb_{ск}$ under 4,0 MPa of H_2 and 80 °C:

$$CH_3OH + NH_3 > C_2H_5OH + NH_3 > iso\text{-}C_3H_7OH + NH_3 > iso\text{-}C_4H_9OH + NH_3 >$$

In aliphatic spirits (C_1-C_4), under nitrile-ammonia proportion = 1–3 (g/g), output of XDA equals 96–98 % on $Ni\text{-}Nb_{ск}$ catalyst.

Nowadays attention of reserchers is mostly drawn to problems of using lipid-aromatic diamines in synthesis of heat-resistant polymers, as introduction of aromatic rings into the chain of polymers increases solidity of thermomolecula, temperature of softening and melting sharply [1]. The basic similar product for heat-resistant polymers will be m-, p-xylylendiamines, synthesized via catalyst hydration of isophthalo- and terephthalonitriles, received via oxidation ammonolysis of m-, p-xylols [1, 2]. Therefore, problem of synthesizing m-, p-xylylendiamines draws our interest for studying.

The most rational method of receiving m-xylylendiamine is catalyst hydration of isophtholodinitrile, received via oxidation ammonolysis of oil m-xylol. Up until the modern days kinetics and mechanisms of hydration isophthalodinitrile into m-xylylendiamine are not studied sufficiently.

The objective of this work is to develop an efficient method of receiving m-xylylendiamine, monomer for heat-resistant polymers, via hydrating isophthalonitrile.

Earlier all researches, devoted to a direct hydration of isophthalo-, terephthalonitriles were carried out in static conditions, and consumption of hydrogen was monitored according to a drop of hydrogen pressure in the system. Among such researches we can outline works by academy member A.A. Balandin, L.K. Freindlin, T.A. Sladkova, and others [3, 4] and academy member D.V. Sokolskiy, F.B. Bazhanov [5]. Among the disadvantages of these works we can outline lack of studies on kinetics of nitrile group hydration, hard conditions of the process, and insufficient output of the desired product (P_{H_2} = 10,0–20,0 MPa H_2, T = 120–150 °C, output of m-, p-xylylendiamine 80–90 %).

The work [6] describes catalyst method of receiving m-xylylendiamine from isophthalonitrile on Ni / fossil meal under 80–100 °C, 8,0 MPa H_2 in presence of organic solvent and ammonia (mole proportion of isophthalonitrile:dioxane:ammonia = 1:3:2). Output of m-xylylendiamine equals 80-85 %).

The author's testimony [7] describes catalyst method of receiving m-, p-xylylendiamine from isophthalo-, terephthalonitriles on Pt-Ni / Al_2O_3 or Pd-Ni / AI_2O_3 under 120–130 °C, 22,0 MPa H_2 in presence of organic solvent (xylol, toluol, propanol) and ammonia (mole proportion of isophthalonitrile/ ammonia = 1:50–100). Output of m-, p-xylylendiamine 90–95 %. For disadvantages of this method we can outline hard conditions of the process on noble metals in presence of great amount of ammonia.

In industry m-xylylendiamine is received via electrochemical restoration of isophthalonitrile, its catalyst hydration on Ni-Rheneja, Pt, or Pd / AI_2O_3 (60–100 °C, 10,0–13,0 MPa H_2) in organic solvents leads to cyanbensilamine.

Materials and methods of research. With the aim of intensifying the catalytic synthesis of m- xylylenediamine isophthalonitrile for the first time we studied in the presence of various alloyed catalysts based on Ni-Raney, showed high activity and selectivity in hydrogenation reactions of other aromatic compounds.

Catalytic hydrogenation of isophthalonitrile was conducted in the liquid phase in the isobaric-isothermal mode to a high-pressure kinetic (KUVD) allowing monitoring the consumption of hydrogen per unit time [8]. The reactor is a catalytic "duck" stainless steel. The volume of the reaction vessel is 0,15 l., the number of single-sided swing of 600–700 per minute. Solvent – alcohol + NH_3. Hydrogenation is carried out until the termination of hydrogen uptake from the gas phase. The equipment and the experimental procedure described previously [9], the catalyst is prepared according to known methods [5].

For the analysis of hydrogenation products were applied potentiometric titration, IKS, Fourier-spectroscopy and elemental analysis.

Results of research and their discussion. In the study of catalytic hydrogenation isophthalonitrile we deliberately were trying to select such process conditions – the catalyst, solvent, temperature, hydrogen pressure, and the ratio of ammonia to dinitrile, which could provide a high yield and quality of the desired product while reducing the duration of the experiment.

Comparative results for the hydrogenation of isophthalonitrile Ni-Reneyaiz Ni-alloy Ni: Al = 50:50 and modified with additives Mg, Ti, Nb catalysts based on Ni-Raney in ethanol at 4,0MPa H_2 pressure and 80 °C show that a characteristic feature of the kinetics of the hydrogenation of isophthalonitrile as in the case of the hydrogenation terephthalonitrile it is constant and fairly large (for large initial velocities) reducing the reaction rate throughout the experiment [1, 10].

On the Ni-Raney ($Ni_{ск}$), a fairly sharp decrease in the rate of hydrogenation, and by the time hemihydrogenation (after absorption of 2,0 moles (50%) of the desired hydrogen) it becomes zero, that is, reaction dies, apparently as a result of the formation of byproducts.

On the catalysts Ni-Mg_{sk}, Ni-Ti_{sk} and Ni-Nb_{sk} hydrogenation rate of izoftalonitrile hemihydrogenation becomes an order of magnitude lower than the original; the test was terminated by absorption of the calculated amount of hydrogen. By active catalyst Ni-Nb_{sk} turned is 5 times as active Ni_{sk} and Ni-Mg_{sk}, Ni-Ti_{sk}- almost 2–3 times.

It has been established that catalysts Ni-Mg_{sk}, Ni-Ti_{sk}, and Ni-Nb_{sk} izftalonitrila hydrogenation proceeds at a decreasing rate with time, the calculated amount of hydrogen is absorbed. The hydrogenation starts with a very high rate of absorption to two moles of hydrogen per mole of dinitrile, after which the rate of hydrogen absorption decreases somewhat, the next two moles of hydrogen are joined slowly.

Hydrogenation of izoftalonitrile to m-xylylenediamine in a liquid phase under a hydrogen pressure of isobaric-isothermal conditions investigated to reduce the activity of catalysts arranged in series:

$$Ni\text{-}Nb_{sk} > Ni\text{-}Ti_{sk} > Ni\text{-}Mg_{sk} > Ni_{sk}$$

We have previously shown that the hydrogenation terephthalonitrile significant influence on the process by the nature of the solvent, and the best results are achieved when using alcohols in the presence of ammonia [1, 10] . Solubility of phthalonitriles, e.g., methanol at 25 °C in order to increase the presence of ammonia in comparison with pure methanol, and the temperature rises to 50 °C for a further two times.

We are in our studies under the hydrogenation of izoftalonitrile to m-xylylenediamine for the catalyst Ni-Nb_{sk} in liquid phase under a hydrogen pressure of isobaric-isothermal conditions (4,0 MPa H2, at 80 C) was used as solvent, methanol, ethanol, isopropanol previously saturated with ammonia under cooling (nitrile: ammonia = 1: 1 and 1: 3 ratio in g).

It was shown that the investigated solvents to reduce the rate of hydrogenation of izoftalonitrile arranged in the following series:

$$CH_3OH + NH_3 > C_2H_5OH + NH_3 > iso\text{-}C_3H_7OH + NH_3 > iso\text{-}C_4H_9OH + NH_3 >$$

The output from m-xylylenediamine (m-CDA), the sequence arrangement of solvents is maintained. The shape of the kinetic curves does not change.

Suitable ratio of the reactants on the catalyst surface in alcohol in our experiments is observed at a ratio of nitrile: ammonia = 1:3 (g /g). In the alcohol in a ratio of nitrile: ammonia = 1: 3 (g / g), the yield of m-CDA on Ni_{sk} 68–70% on Ni-Mg_{sk}, Ni-Ni-Ti_{sk} and Nb_{sk} catalysts 90–91, 91–92 and 96–98% respectively.

From this sequence, it follows that as the molecular weight increases the rate of hydrogenation of izoftalonitrile alcohol in a solvent decreases.

Increasing the speed of hydrogenation and high yield of m-xylylenediamine (96–98%) in the alcohol-ammonia solutions favors aldiminovogo mechanism [1, 3, 5, 9–14].

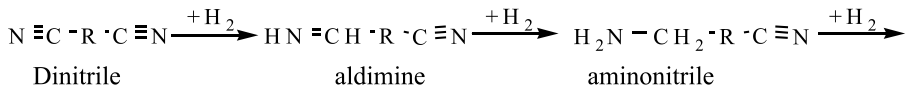
To confirm the completeness of the reaction hydrogenation of izoftalonitrile to m-xylylenediamine, we studied the infrared spectra of the final product to catalytic reduction izoftalonitrile-promoted the skeletal catalyst Ni-Nb_{sk}.

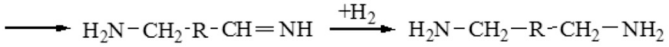
The final product (after the absorption of 4.0 moles of hydrogen required) in the IR spectrum the absorption bands disappear completely, corresponding S≡N group (valency fluctuations 2240–2230 cm^{-1}), and in 3400–3290 cm^{-1} manifested intense absorption bands of stretching vibrations of the NH_2 group [9, 10, 15].

The desired product m-xylylenediamine – a colorless liquid; temp. Solidification 14 °C. temp. boiling. 245–248 °C, 105 °C / 2 mm Hg.; d^{20}_4 1,055; n_D^{20} 1,5720. It is readily soluble in ether, dioxane, and lower aliphatic alcohols.

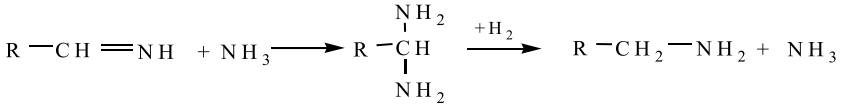
FT-IR and Raman spectra of the starting materials and reaction products were recorded on FTIR spectrometer IFS-66 with Raman prefix FRA-106.

The formation of the aminonitrile in the catalytic hydrogenation of aromatic dinitriles indicates sequential recovery of the nitrile groups [1, 5, 10, 12]. First intermediate compound formed on the surface of the catalyst in the hydrogenation of nitriles and dinitriles is aldimine [1, 3, 5, 9–14]:





The classic way of getting primary mono- and diamines is hydrogenation process of nitriles and dinitrils in the presence of ammonia [1, 3–7, 9–12]. Ammonia prevents reactive aldimines react with a primary amine, which are formed by reacting a Schiff base and further reaction with hydrogen passes to a secondary amine. It is also possible interaction with a secondary amine aldimine [5, 9–13]. A reactive aldimine interacting with ammonia forms an unstable compound, which is easily transferred to the primary amine, by interacting with the hydrogen and splitting off the ammonia [1, 5, 9, 10, 12]:

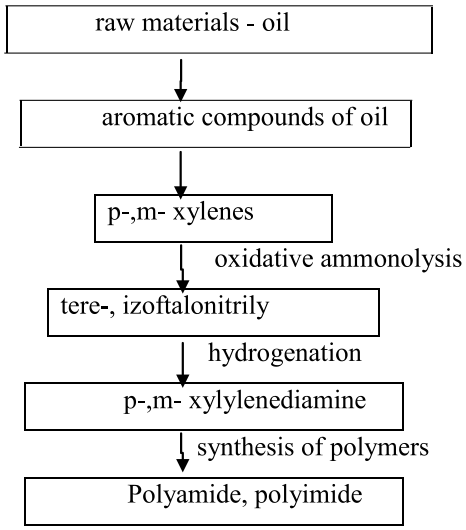


To direct the reaction towards the formation of primary mono- and diamines is necessary to increase the hydrogen concentration on the catalyst surface, for example, using elevated hydrogen pressure and strengthen the adsorption of hydrogen bond with the surface by promoting the skeletal nickel, or the selection of the solvent, in particular, its introduction into the ammonia or additives basic character [1, 3–7, 9–12, 16, 17].

Many authors attributed the increased activity of skeletal Ni-Ti_{sk}, and Ni-catalysts Nb_{sk} to a change ratio $NiAl_3$ aluminide alloy and Ni_2Al_3 in upward phase $NiAl_3$, which leads to a change in the lattice parameters Ni. The observed deformation of the lattice of nickel is an additional indication in explaining the higher activity of the catalyst. The activity and selectivity of studied catalysts under the catalytic synthesis of primary amines can be associated with a high degree of enrichment of the catalyst strongly bound by adsorbed hydrogen and the oxides of d-metal oxide catalysts in skeletal layer leads to an increase in the proportion of micropores, increase in the specific surface of the catalyst influence the adsorption properties, selectivity and stability.

Introduction to the Ni-Al-alloy and oxidize easily leachable infusion (up to 10 wt.%), leads to an increase in efficiency factor [1, 10, 16, 17].

General Linear flowsheet producing polymers can be represented as follows:



The authors of [1] terephthalonitrile synthesized by hydrogenation of p-xylylenediamine, and on its basis – heat-resistant polymers.

Conclusion. Experiments with a high-pressure kinetic showed that under the conditions of the experiment on Ni-promoted Mg_{sk}, Ni-Ti_{sk}, Ni-Nb_{sk} catalizators the liquid phase hydrogenation proceeds at a decreasing rate over time. The hydrogenation starts with a very high rate of absorption to two moles of hydrogen per mole of dinitrile, after which the rate of hydrogen absorption decreases somewhat, the next two moles of hydrogen are joined slowly.

The activity of the catalyst Ni-Nb_{sk} in 2–3 times higher than Ni-Ti_{sk} and Ni-Mg_{sk} and 4-5 times higher activity of Ni-Raney (Ni_{sk}.).

It is shown that the experimental conditions studied (4,0 MPaN2 and 80 °C) with increasing molecular weight of the alcohol rate of hydrogenation in a solvent izoftalonitrile is decreasing. The form of the kinetic curves is being unchanged. The aliphatic alcohols (C_1-C_4) at a ratio of nitrile: ammonia = 1: 3 (g / g), the yield of m-xylylenediamine is on Ni-catalyst Nb_{sk} 96–98 %.

An attempt was made to explain the course of the process of catalytic hydrogenation of izoftalonitrile to m-xylylenediamine by aldimine mechanism.

General linear flowsheet producing polymers can be represented as follows: Raw material – Oil → Aromatic compounds of oil → p, m-xylene → tereftalo-, izoftalonitrily → p, m-xylylenediamine → polymers.

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SPACE MONITORING OF MAN-MADE HAZARDS IN CENTRAL KAZAKHSTAN

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In article features of data processing of space monitoring of territories with the purpose of prevention of technogenic emergencies are condsidered. Here is the interferogram, settling in the region of Karaganda region.

Space monitoring is the continuous multiple getting information about qualitative and quantitative characteristics of natural and man-made objects and processes with the exact geographical position at the expense of processing the data received from the satellites, Earth remote sensing (ERS). Space monitoring allows to obtain uniform and comparable quality information at a time for vast territories, which is almost unattainable for any of ground surveys. Based on this definition, we can distinguish a number of basic requirements to space monitoring: the ability to monitor large areas and long features; high spatial resolution (up to 50 cm) and precision, including without ground anchor points; high frequency of surveys, the efficiency of obtaining the original and processed RS data; the possibility of building digital elevation models (DEM) and of localities on the stereo images from the SPACECRAFT (SC) remote sensing; the ability to take the picture in a large number of spectral channels; possibility of use of materials of space monitoring directly in all standard GIS.

Operational space monitoring of natural and technogenic emergencies and disasters in recent years has become the most important and necessary component of information provision services respond to emergencies. Every day we receive space data is widely used for providing information for audit and predictive models security areas and hazardous production facilities. Using the modern GIS-technologies, allowing to unite the diverse information with space data. This allows you to automate the calculations of the risk of disaster (fires, droughts, floods etc). Possibilities of space monitoring zones of emergency from space are determined by the availability of imagery, spatial resolution of observed objects, availability of images.

Data processing of remote sensing – the process of the operations of aerospace images, including their correction, transformation and improvement, interpretation, visualization.

The main stages of space images processing: the preliminary processing, the thematic.

Preliminary processing of multispectral data is the correction and improvement of satellite images.

The pre-processing includes the geometric correction of satellite images, the radiometric calibration of images, the radiometric correction of influence of the atmosphere, the restoration of the missing pixels, the contrasting, the filtering. Geometric correction includes the elimination of the image geometric distortion (orthorectification), the geographical location.

Photos, originally received from satellites that have been recorded in the so-called “raw values” brightness DN (Digital Number). The data in this format cannot adequately be compared with the data of other surveys. The task radiometric calibration is adjusting these values in physical units.

Image contrast is the difference between the maximum and minimum values of brightness.

Weak contrast – the most widespread defect images.

Filtering is a transformation that allows you to enhance the reproduction of certain objects, suppress unwanted veiling, to resolve other random interference (noise). The essence of objects is useful to define at the image in natural colors, but to share and delineate objects easier on the image in false colors. Choosing the right scale allows the

operator to visually identify objects that are a little different in brightness on a gray scale image. In such images more Yaro and contrastly allocated objects compared to the original image. Principal component analysis is a method of multispectral analysis of correlated data. Classification of computer image interpretation or process automated units of all pixels of the picture into groups (classes), which correspond to different objects. To monitor vertical distortion underworked areas Kostenko mine (Karaganda region) was used satellite radar interferometry.

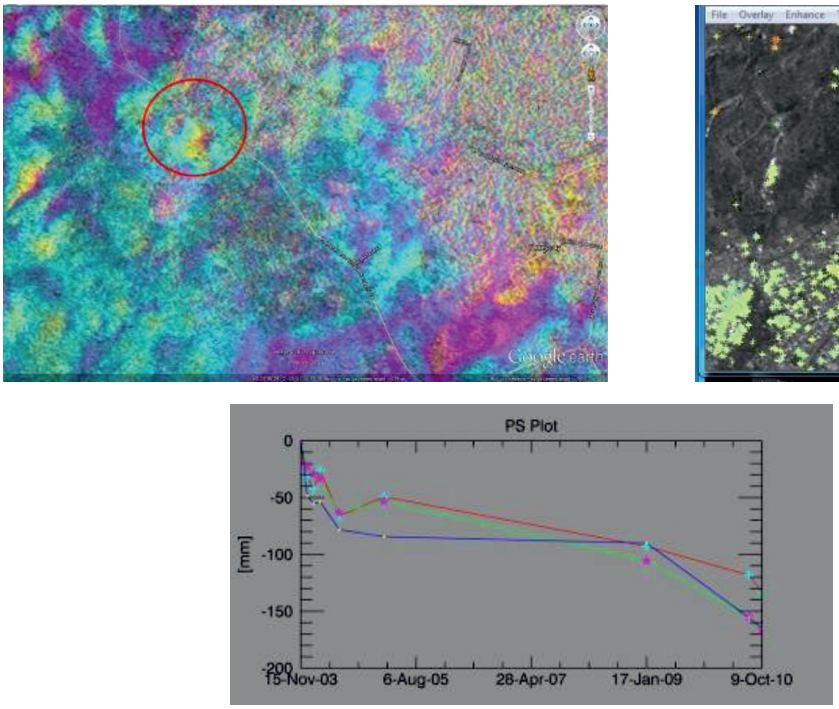

Fig. 1. Sedimentation in the area of mine it. Kostenko

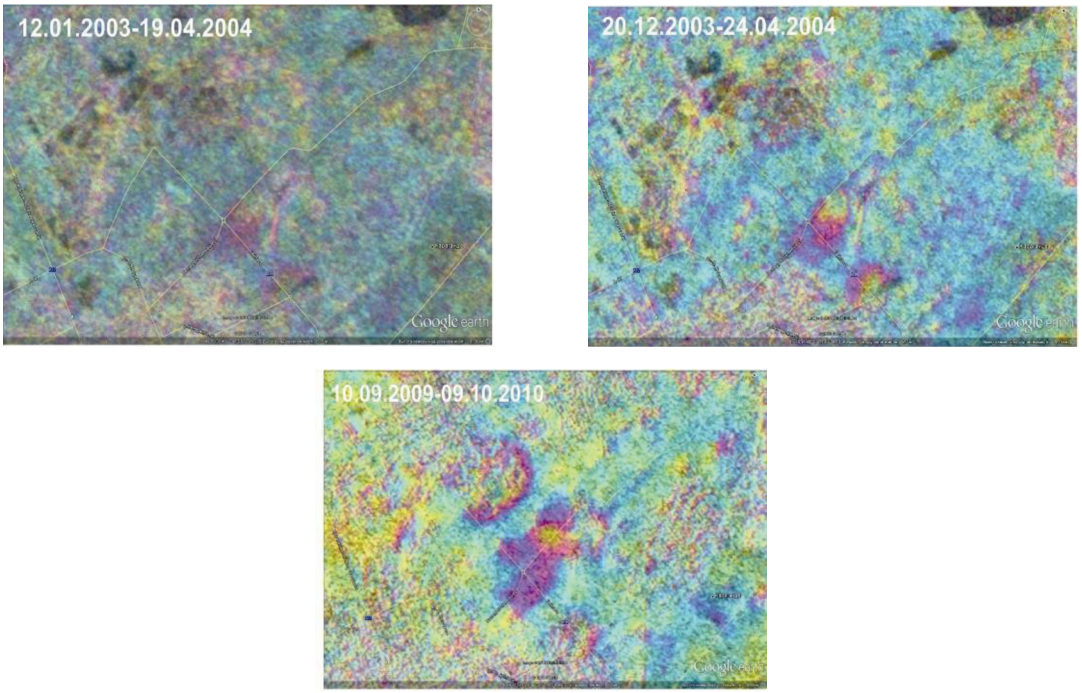

Fig. 2. Building a differentiated interferogram

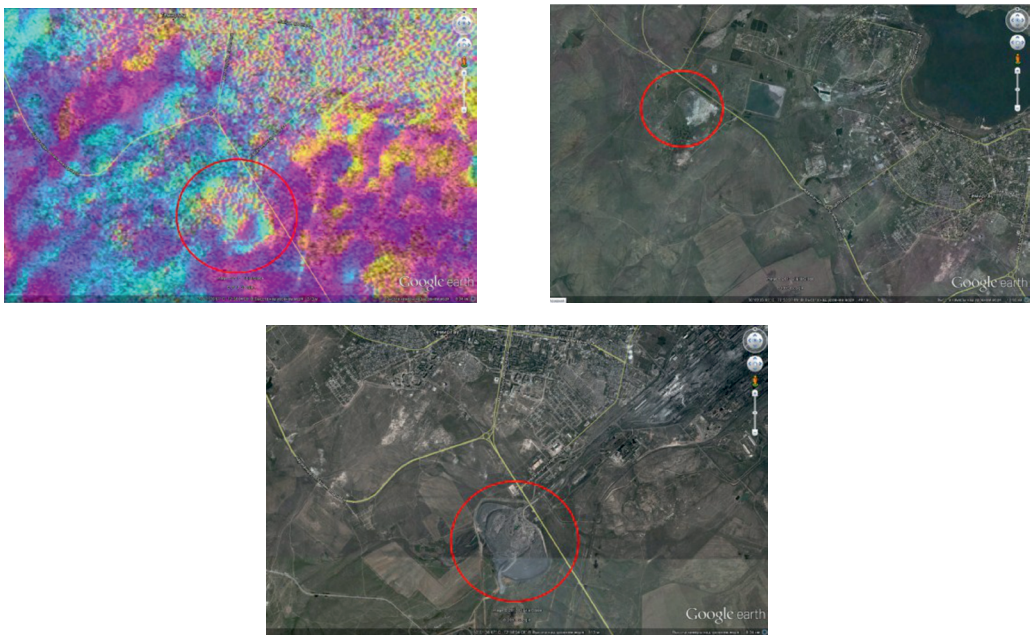

Fig. 3. Settling between water store and the village of Aktau

The main output file when calculating the displacement of the Earth's surface is differential interferometer graph representing the result of subtracting the synthesized phases of the topography of integrated interferogram. Geocoding and calibration are relative been obtained earlier digital elevation model of the city of Karaganda. The calculations showed that in 2003 in the mine area Kostenko have started to form 2 of the mould of subsidence. Up to 2010. mould concretion only increase. Sedimentation are on average 2,5 cm during the reporting period, i.e. approximately 30–50 days.

On mine Kostenko currently conducted the work on formation K1 on the lava 45 K1-C capacity removable reservoir made up 2,m/ Subsidence of a terrestrial surface is calculated by the method of PSI, also showed subsidence in Kostenko mine area (fig. 1). According to the schedule, sedimentation are active character from 2003 to 2004-up to 80 mm 2005 to 2009 there is a small settlement in the region of 40 mm With 2009 is actively mining layer, which leads to an active process of displacement of the Earth's surface and subsidence of the mould displacement.

The interferogram of the Karaganda region shown in fig. 3. (Processing of satellite images ENVISAT 2010/07/31 and 2010/10/09, subsidence of up to 5 cm).

Found subsidence on the undermined territories of the city of Karaganda indicate geodynamic processes, which may further lead to the destruction of asphalt pavement, paludification or flooding of land, and ultimately to failure. In this area it is necessary to monitor the state of the earth's surface to predict the parameters of deformation and detection of potentially dangerous zones.

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A NEW COMPUTATIONAL PACKAGE FOR USING IN CFD AND OTHER PROBLEMS

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First, I should mention that this is a basic package and is not limited to CFD, it can also be used for other problems.

Finite Element Method (FEM) is a powerful numerical method which has been used successfully

for the solution of the existing problems in various scientific and engineering fields such as its application in CFD. Many algorithms have been expressed based on FEM, but none has been used in popular CFD software. In this section, full monopoly is according to Finite Volume Method (FVM) due to better efficiency and adaptability with the physics of problems in comparison with FEM. It doesn't seem that FEM could compete with FVM unless it was fundamentally changed. In this paper, I am going to show those changes and its result will be a powerful method which has much better performance in all subjects in comparison with FVM and other computational method, I called it Reduced Finite Element Method (RFEM).

The general form of a linear differential equation with boundary conditions can be shown as follows [Zienkiewicz and Morgan (1983); Zienkiewicz and Taylor (2001)]:

$$R_\Omega = \mathfrak{L}\,\phi + P$$
$$R_\Gamma = \mathfrak{M}\,\phi + r \qquad (1)$$

The operators $\mathfrak{L}$ and $\mathfrak{M}$ in equations (1) can be zero-order, odd-order, even-order or a combination of two or all three

$$R_\Omega = \mathfrak{L}\,\phi + P = \overset{odd}{\mathfrak{L}}\,\phi + \overset{even}{\mathfrak{L}}\,\phi + \overset{zero}{\mathfrak{L}}\,\phi + P$$
$$R_\Gamma = \mathfrak{M}\,\phi + r = \overset{odd}{\mathfrak{M}}\,\phi + \overset{even}{\mathfrak{M}}\,\phi + \overset{zero}{\mathfrak{M}}\,\phi + r \qquad (2)$$

The weighted residual relationship for these relationships on any element is

$$\int_{\Omega^e} W_i\, R_\Omega\, d\Omega$$
$$\int_{\Gamma^e} \overline{W_i}\, R_\Gamma\, d\Gamma \qquad (3)$$

And

$$\int_{\Omega^e} W_i\, R_\Omega\, d\Omega + \int_{\Gamma^e} \overline{W_i}\, R_\Gamma\, d\Gamma = 0 \qquad (4)$$

By inserting (2) in (3) we have

$$\int_{\Omega^e} W_i \overset{odd}{\mathfrak{L}}\,\phi\, d\Omega + \int_{\Omega^e} W_i \overset{even}{\mathfrak{L}}\,\phi\, d\Omega + \int_{\Omega^e} W_i \overset{zero}{\mathfrak{L}}\,\phi\, d\Omega + \int_{\Omega^e} W_i\, P\, d\Omega$$
$$= \int_{\Omega^e} W_i\, \mathfrak{L}\,\phi\, d\Omega + \int_{\Omega^e} W_i\, P\, d\Omega \qquad (5)$$
$$\int_{\Gamma^e} \overline{W_i} \overset{odd}{\mathfrak{M}}\,\phi\, d\Gamma + \int_{\Gamma^e} \overline{W_i} \overset{even}{\mathfrak{M}}\,\phi\, d\Gamma + \int_{\Gamma^e} \overline{W_i} \overset{zero}{\mathfrak{M}}\,\phi\, d\Gamma + \int_{\Gamma^e} \overline{W_i}\, r\, d\Gamma$$
$$= \int_{\Gamma^e} \overline{W_i}\, \mathfrak{M}\,\phi\, d\Gamma + \int_{\Gamma^e} \overline{W_i}\, r\, d\Gamma$$

The approximate relation of the field also is equal to

$$\phi \approx \hat{\phi} = \sum_{j=0}^{M} N_j\, \hat{\phi}_j \qquad (6)$$

By inserting (6) in (5) we have

$$\int_{\Omega^e} W_i \overset{odd}{\mathfrak{L}} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Omega + \int_{\Omega^e} W_i \overset{even}{\mathfrak{L}} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Omega + \int_{\Omega^e} W_i \overset{zero}{\mathfrak{L}} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Omega$$
$$+ \int_{\Omega^e} W_i\, P\, d\Omega = \int_{\Omega^e} W_i\, \mathfrak{L} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Omega + \int_{\Omega^e} W_i\, P\, d\Omega \qquad (7)$$
$$\int_{\Gamma^e} \overline{W_i} \overset{odd}{\mathfrak{M}} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Gamma + \int_{\Gamma^e} \overline{W_i} \overset{even}{\mathfrak{M}} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Gamma + \int_{\Gamma^e} \overline{W_i} \overset{zero}{\mathfrak{M}} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Gamma$$
$$+ \int_{\Gamma^e} \overline{W_i}\, r\, d\Gamma = \int_{\Gamma^e} \overline{W_i}\, \mathfrak{M} \sum_{j=0}^{M} N_j\, \hat{\phi}_j\, d\Gamma + \int_{\Gamma^e} \overline{W_i}\, r\, d\Gamma$$

Together all the elements a comprehensive system of equations is obtained which can be written quite generally as

$$K\,\hat{\phi} = f \qquad (8)$$

And

$$K_{ij} = \sum_{e=1}^{E} K_{ij}^{e},\ f_i = \sum_{e=1}^{E} f_i^{e} \tag{9}$$

Finally by using of equation (7) can write

$$K_{ij}^{e} = \int_{\Omega^e} W_i\ \mathfrak{L} N_j d\Omega + \int_{\Gamma^e} \overline{W_i}\ \mathfrak{N} N_j d\Gamma$$

$$f_i^{e} = -\int_{\Omega^e} W_i\ P\, d\Omega - \int_{\Gamma^e} \overline{W_i}\ r\, d\Gamma \tag{10}$$

$$\hat{\phi}^{\mathrm{T}} = (\hat{\phi}_1, \hat{\phi}_2, \hat{\phi}_3 ..., \hat{\phi}_M)$$

And this is the general form of approximation to a differential equation by the finite element method.

New Formulation for Finite Element Method (NFFEM)

Here I will introduce a new formulation for finite element method which its performance is much better than all conventional algorithms of finite element method in CFD. In NFFEM relationship (9) is written as follows:

$$K_{ij}^{*} = \sum_{e=1}^{E} K_{ij}^{e*},\ f_i^{*} = \sum_{e=1}^{E} f_i^{e*} \tag{11}$$

And each of the matrix coefficients are

$$K_{ij}^{e*} = \overset{odd\ e*}{K_{ij}} + \overset{even\ e*}{K_{ij}} + \overset{zero\ e*}{K_{ij}} \tag{12}$$

Where $\overset{odd\ e*}{K_{ij}}$ become

$$\overset{odd\ e*}{K_{ij}} = (1-\frac{b}{2}(\left|\bar{\beta}_{i^{klm}_{(x,y,z)}}\right| - \bar{\beta}_{i^{klm}_{(x,y,z)}})) \int_{\Omega^e} W_i\ \overset{odd}{\mathfrak{L}}\ N_j\, d\Omega \tag{13}$$

For $\overset{even\ e*}{K_{ij}}$ we have

$$\overset{even\ e*}{K_{ij}} = (1-\frac{b}{2}(\left|\bar{\beta}_{i^{klm}_{(x,y,z)}}\right| - \bar{\beta}_{i^{klm}_{(x,y,z)}})) \int_{\Omega^e} W_i\ \overset{even}{L}\ N_j\, d\Omega \tag{14}$$

For $\overset{zero\ e*}{K_{ij}}$ we have

$$\overset{zero\ e*}{K_{ij}} = (1-\frac{b}{2}(\left|\bar{\beta}_{i^{klm}_{(x,y,z)}}\right| - \bar{\beta}_{i^{klm}_{(x,y,z)}})) \int_{\Omega^e} W_i\ N_j\, d\Omega \tag{15}$$

And for f_i^{e*} we have

$$f_i^{e*} = (1-\frac{b}{2}(\left|\bar{\beta}_{i^{klm}_{(x,y,z)}}\right| - \bar{\beta}_{i^{klm}_{(x,y,z)}})) \int_{\Omega^e} W_i\ P\, d\Omega \tag{16}$$

These relations are used for boundary integrals the same way, these are relations completely of NFFEM.

In the equations (13) to (16), by choosing b = 1 full upwind difference scheme (FUDS) and by choosing b = 0 central difference scheme (CDS) is obtained (Flux Vector Splitting Methods (FVSM) can also use with NFFEM, in this form b = 1 is considered and equations are written separately for positive and negative-terms after that the sum of the equations is done). These relationships are also valid for non-linear operators ($\mathfrak{L}(\phi)$), which leads to $K_{ij}^{e*}(\phi)$. In the equations presented above, $\bar{\beta}_{i^{klm}_{(x,y,z)}}$ is given by

$$\bar{\beta}_{i^{klm}_{(x,y,z)}} = \frac{2(\bar{\beta}_{i^{k}_{(x)}} + \bar{\beta}_{i^{l}_{(y)}} + \bar{\beta}_{i^{m}_{(z)}}) - (\left|\bar{\beta}_{i^{k}_{(x)}}\right| + \left|\bar{\beta}_{i^{l}_{(y)}}\right| + \left|\bar{\beta}_{i^{m}_{(z)}}\right|)}{\left|2(\bar{\beta}_{i^{k}_{(x)}} + \bar{\beta}_{i^{l}_{(y)}} + \bar{\beta}_{i^{m}_{(z)}}) - (\left|\bar{\beta}_{i^{k}_{(x)}}\right| + \left|\bar{\beta}_{i^{l}_{(y)}}\right| + \left|\bar{\beta}_{i^{m}_{(z)}}\right|)\right|} \tag{17}$$

For the central difference scheme the following equation can also be used instead of $(1-\frac{b}{2}(\left|\bar{\beta}_{i^{klm}_{(x,y,z)}}\right| - \bar{\beta}_{i^{klm}_{(x,y,z)}}))$ in equations (13) to (16)

$$(1-\frac{1}{2}(\left|\bar{\bar{\beta}}_{i^{klm}_{(x,y,z)}}\right| - \bar{\bar{\beta}}_{i^{klm}_{(x,y,z)}})) \tag{18}$$

Where $\bar{\bar{\beta}}_{i^{klm}_{(x,y,z)}}$ is given by

$$\bar{\bar{\beta}}_{i^{klm}_{(x,y,z)}} = \frac{\left|\bar{\beta}_{i^{k}_{(x)}} + \bar{\beta}_{i^{l}_{(y)}} + \bar{\beta}_{i^{m}_{(z)}}\right| - (\left|\bar{\beta}_{i^{k}_{(x)}}\right| + \left|\bar{\beta}_{i^{l}_{(y)}}\right| + \left|\bar{\beta}_{i^{m}_{(z)}}\right|)}{\left|\left|\bar{\beta}_{i^{k}_{(x)}} + \bar{\beta}_{i^{l}_{(y)}} + \bar{\beta}_{i^{m}_{(z)}}\right| - (\left|\bar{\beta}_{i^{k}_{(x)}}\right| + \left|\bar{\beta}_{i^{l}_{(y)}}\right| + \left|\bar{\beta}_{i^{m}_{(z)}}\right|)\right|} \tag{19}$$

In this form, the number of participating elements in the equation of node *i* are limited to two elements in 1D, 2D and 3D. The $\bar{\beta}_{i^{k}_{(x)}}$, $\bar{\beta}_{i^{l}_{(y)}}$ and $\bar{\beta}_{i^{m}_{(z)}}$ are equal to

$$\bar{\beta}_{i^{k}_{(x)}} = \beta_{i^{k}_{(x)}}\alpha_{i(x)},\ \ \bar{\beta}_{i^{l}_{(y)}} = \beta_{i^{l}_{(y)}}\alpha_{i(y)},\ \bar{\beta}_{i^{m}_{(z)}} = \beta_{i^{m}_{(z)}}\alpha_{i(z)} \tag{20}$$

Where

$$\beta_{i^{k}{}_{(x)}} = \left(\frac{x_i{}^k - x_0{}^k}{\left| x_i{}^k - x_0{}^k \right|} + \frac{x_i{}^k - x_L{}^k}{\left| x_i{}^k - x_L{}^k \right|} \right),$$

$$\beta_{i^{l}{}_{(y)}} = \left(\frac{y_i{}^l - y_0{}^l}{\left| y_i{}^l - y_0{}^l \right|} + \frac{y_i{}^l - y_L{}^l}{\left| y_i{}^l - y_L{}^l \right|} \right) \qquad (21)$$

$$\beta_{i^{m}{}_{(z)}} = \left(\frac{z_i{}^m - z_0{}^m}{\left| z_i{}^m - z_0{}^m \right|} + \frac{z_i{}^m - z_L{}^m}{\left| z_i{}^m - z_L{}^m \right|} \right)$$

And α_i is the sign of the unknown variable or derivations coefficients (any term that changes the sign of the matrix coefficients)

$$\alpha_{i(x)} = \frac{A\phi_x}{\left| A\phi_x \right|}, \quad \alpha_{i(y)} = \frac{B\phi_y}{\left| B\phi_y \right|}, \quad \alpha_{i(z)} = \frac{C\phi_z}{\left| C\phi_z \right|} \qquad (22)$$

Equation (17) can be written with β_i and $-\beta_i$ instead of the $\bar{\beta}_i$ that its result will be $\beta_{i^{klm}{}_{(x,y,z)}}$, depending on the sign of β_i that we have chosen, the $\beta_{i^{klm}{}_{(x,y,z)}}$ gives the forward or backward differencing scheme.

Superscript *k*, *l* and *m* represent the terms are located on lines *k*, *l* and *m* (The node *i* in three dimensions is located on three lines, line *k* at *x* direction, line *l* at *y* direction, and line *m* at *z* direction, see figures (1) and (2)).

For hierarchical shape functions, the shape functions dependent to the sides and element as shown in figures (3) and (4) attributable to the points (these points as $\xi_{0^k}, \eta_{0^l}, \zeta_{0^m}$, $\xi_{i^k}, \eta_{i^l}, \zeta_{i^m}$ and $\xi_{L^k}, \eta_{L^l}, \zeta_{L^m}$ to calculate $\bar{\beta}_i$ also to determine lines *k*, *l* and *m* are used).

When wind direction is constant before and after discontinuity (shock), as an alternative (or as another option for all position), β_i' can be used instead of $\bar{\beta}_i$, where β_i' is

$$\beta'_{i^{k}{}_{(x)}} = \beta_{i^{k}{}_{(x)}} \alpha'_{i(x)}, \quad \beta'_{i^{l}{}_{(y)}} = \beta_{i^{l}{}_{(y)}} \alpha'_{i(y)},$$

$$\beta'_{i^{m}{}_{(z)}} = \beta_{i^{m}{}_{(z)}} \alpha'_{i(z)}. \qquad (23)$$

Where

$$\alpha'_{i(x)} = \frac{\left| \sum_{j \geq 0}^{L} \frac{\partial^2 N_{j^k}}{\partial x^2} \Big|_0^{e^+} \phi_j \right| - \left| \sum_{j \leq L}^{0} \frac{\partial^2 N_{j^k}}{\partial x^2} \Big|_L^{e^-} \phi_j \right|}{\left\| \sum_{j \geq 0}^{L} \frac{\partial^2 N_{j^k}}{\partial x^2} \Big|_0^{e^+} \phi_j \right| - \left| \sum_{j \leq L}^{0} \frac{\partial^2 N_{j^k}}{\partial x^2} \Big|_L^{e^-} \phi_j \right\|}$$

$$\alpha'_{i(y)} = \frac{\left| \sum_{j \geq 0}^{L} \frac{\partial^2 N_{j^l}}{\partial y^2} \Big|_0^{e^+} \phi_j \right| - \left| \sum_{j \leq L}^{0} \frac{\partial^2 N_{j^l}}{\partial y^2} \Big|_L^{e^-} \phi_j \right|}{\left\| \sum_{j \geq 0}^{L} \frac{\partial^2 N_{j^l}}{\partial y^2} \Big|_0^{e^+} \phi_j \right| - \left| \sum_{j \leq L}^{0} \frac{\partial^2 N_{j^l}}{\partial y^2} \Big|_L^{e^-} \phi_j \right\|} \qquad (24)$$

$$\alpha'_{i(z)} = \frac{\left| \sum_{j \geq 0}^{L} \frac{\partial^2 N_{j^m}}{\partial z^2} \Big|_0^{e^+} \phi_j \right| - \left| \sum_{j \leq L}^{0} \frac{\partial^2 N_{j^m}}{\partial z^2} \Big|_L^{e^-} \phi_j \right|}{\left\| \sum_{j \geq 0}^{L} \frac{\partial^2 N_{j^m}}{\partial z^2} \Big|_0^{e^+} \phi_j \right| - \left| \sum_{j \leq L}^{0} \frac{\partial^2 N_{j^m}}{\partial z^2} \Big|_L^{e^-} \phi_j \right\|}$$

Because β_i is zero for internal nodes, there is no need to calculate α_i', however it can be calculated by the following equation

$$\alpha'_{i(x)} = \frac{\left| \frac{\phi_L - \phi_i}{x_L{}^k - x_i{}^k} \right| - \left| \frac{\phi_i - \phi_0}{x_i{}^k - x_0{}^k} \right|}{\left\| \frac{\phi_L - \phi_i}{x_L{}^k - x_i{}^k} \right| - \left| \frac{\phi_i - \phi_0}{x_i{}^k - x_0{}^k} \right\|},$$

$$\alpha'_{i(y)} = \frac{\left| \frac{\phi_L - \phi_i}{y_L{}^l - y_i{}^l} \right| - \left| \frac{\phi_i - \phi_0}{y_i{}^l - y_0{}^l} \right|}{\left\| \frac{\phi_L - \phi_i}{y_L{}^l - y_i{}^l} \right| - \left| \frac{\phi_i - \phi_0}{y_i{}^l - y_0{}^l} \right\|} \qquad (25)$$

$$\alpha'_{i(z)} = \frac{\left| \frac{\phi_L - \phi_i}{z_L{}^m - z_i{}^m} \right| - \left| \frac{\phi_i - \phi_0}{z_i{}^m - z_0{}^m} \right|}{\left\| \frac{\phi_L - \phi_i}{z_L{}^m - z_i{}^m} \right| - \left| \frac{\phi_i - \phi_0}{z_i{}^m - z_0{}^m} \right\|}$$

Note that NFFEM only for quadrilateral and hexahedron elements can be used. Solving the system of equations of the NFFEM can be performed simply by element by element solving method and line by line sweeping method.

Reduced Finite Element Method (RFEM)

A new method for the finite element formulation presented in the previous section, In this section, I'm going to limit the participating nodes in equation for each node to the nodes that are located on lines *k*, *l* and *m* the node. For this purpose, I introduce reduced elements, characteristics of these elements is as follows:

1 – The different elements are used for different directions of operator, see figures (5) and (6).

2 – For each direction of operator, element only in the same direction has DOF (for one direction of shape function is used *p* – degree function and for other directions is used zero degree function, see figures (5), (6), (7) and (8)).

3 – For equation of node *i*, element only on the lines *k*, *l* and *m* the same node has the node, see figures (7) and (8).

In RFEM relationship (11) is written as follows:

$$\overset{*}{K}_{ij^{k|l|m}} = \sum_{e=1}^{E} \overset{e*}{K}_{ij^{k|l|m}}, \quad \overset{*}{f}_{i^{klm}} = \sum_{e=1}^{E} \overset{e*}{f}_{i^{klm}} \qquad (26)$$

And each of the matrix coefficients are

$$K_{ij\,k|l|m}^{e*} = K_{ij\,k|l|m}^{odd\ e*} + K_{ij\,k|l|m}^{even\ e*} + K_{ij\,k|l|m}^{zero\ e*} \tag{27}$$

Where

$$\begin{aligned} K_{ij\,k|l|m}^{odd\ e*} &= K_{ij\,k_{(x)}}^{odd\ e*}\ or\ K_{ij\,l_{(y)}}^{odd\ e*}\ or\ K_{ij\,m_{(z)}}^{odd\ e*} \\ K_{ij\,k|l|m}^{even\ e*} &= K_{ij\,k_{(x)}}^{even\ e*}\ or\ K_{ij\,l_{(y)}}^{even\ e*}\ or\ K_{ij\,m_{(z)}}^{even\ e*} \\ K_{ij\,k|l|m}^{zero\ e*} &= K_{ij\,k_{(x)}}^{zero\ e*}\ or\ K_{ij\,l_{(y)}}^{zero\ e*}\ or\ K_{ij\,m_{(z)}}^{zero\ e*} \end{aligned} \tag{28}$$

For $K_{ij\,k_{(x)}}^{odd\ e*}$, $K_{ij\,l_{(y)}}^{odd\ e*}$ and $K_{ij\,m_{(z)}}^{odd\ e*}$ we have

$$\begin{aligned} K_{ij\,k_{(x)}}^{odd\ e*} &= (1-\frac{b}{2}(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right| - \bar{\beta}_{i\,klm_{(x,y,z)}}))\int_{\Omega^e} W_i\, \mathcal{L}_{(x)}^{odd}\, N_{j\,k}\, d\Omega \\ K_{ij\,l_{(y)}}^{odd\ e*} &= (1-\frac{b}{2}(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right| - \bar{\beta}_{i\,klm_{(x,y,z)}}))\int_{\Omega^e} W_i\, \mathcal{L}_{(y)}^{odd}\, N_{j\,l}\, d\Omega \\ K_{ij\,m_{(z)}}^{odd\ e*} &= (1-\frac{b}{2}(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right| - \bar{\beta}_{i\,klm_{(x,y,z)}}))\int_{\Omega^e} W_i\, \mathcal{L}_{(z)}^{odd}\, N_{j\,m}\, d\Omega \end{aligned} \tag{29}$$

For $K_{ij\,k_{(x)}}^{even\ e*}$, $K_{ij\,l_{(y)}}^{even\ e*}$ and $K_{ij\,m_{(z)}}^{even\ e*}$ we have

$$\begin{aligned} K_{ij\,k_{(x)}}^{even\ e*} &= (1-\frac{b}{2}(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right| - \bar{\beta}_{i\,klm_{(x,y,z)}}))\int_{\Omega^e} W_i\, \mathcal{L}_{(x)}^{even}\, N_{j\,k}\, d\Omega \\ K_{ij\,l_{(y)}}^{even\ e*} &= (1-\frac{b}{2}(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right| - \bar{\beta}_{i\,klm_{(x,y,z)}}))\int_{\Omega^e} W_i\, \mathcal{L}_{(y)}^{even}\, N_{j\,l}\, d\Omega \\ K_{ij\,m_{(z)}}^{even\ e*} &= (1-\frac{b}{2}(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right| - \bar{\beta}_{i\,klm_{(x,y,z)}}))\int_{\Omega^e} W_i\, \mathcal{L}_{(z)}^{even}\, N_{j\,m}\, d\Omega \end{aligned} \tag{30}$$

For $K_{ij\,k_{(x)}}^{zero\ e*}$, $K_{ij\,l_{(y)}}^{zero\ e*}$ and $K_{ij\,m_{(z)}}^{zero\ e*}$ we have

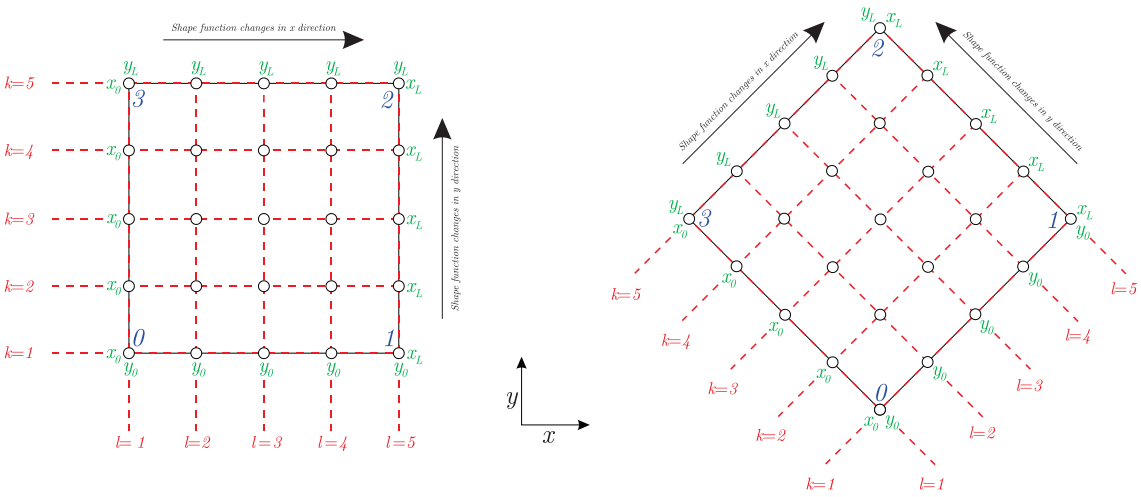


Fig. 1. Lines k and l on two fourth-degree elements in two dimensions

$$
\begin{aligned}
\overset{zero\ e*}{K}_{ij\,k_{(x)}} &= \frac{1}{3}\left(1-\frac{b}{2}\left(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right|-\bar{\beta}_{i\,klm_{(x,y,z)}}\right)\right)\int_{\Omega^e} W_i\, N_{j\,k}\, d\Omega \\
\overset{zero\ e*}{K}_{ij\,l_{(y)}} &= \frac{1}{3}\left(1-\frac{b}{2}\left(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right|-\bar{\beta}_{i\,klm_{(x,y,z)}}\right)\right)\int_{\Omega^e} W_i\, N_{j\,l}\, d\Omega \\
\overset{zero\ e*}{K}_{ij\,m_{(z)}} &= \frac{1}{3}\left(1-\frac{b}{2}\left(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right|-\bar{\beta}_{i\,klm_{(x,y,z)}}\right)\right)\int_{\Omega^e} W_i\, N_{j\,m}\, d\Omega
\end{aligned}
\tag{31}
$$

Note: for the $\overset{zero}{\mathfrak{L}}$ operator, unknown variable is written in all directions and each direction is no belongs to particular unknown variable. And for $\overset{e*}{f}_{i\,klm}$ we have

$$
\overset{e*}{f}_{i\,klm} = \left(1-\frac{b}{2}\left(\left|\bar{\beta}_{i\,klm_{(x,y,z)}}\right|-\bar{\beta}_{i\,klm_{(x,y,z)}}\right)\right)P_i\int_{\Omega^e} W_i\, d\Omega \tag{32}
$$

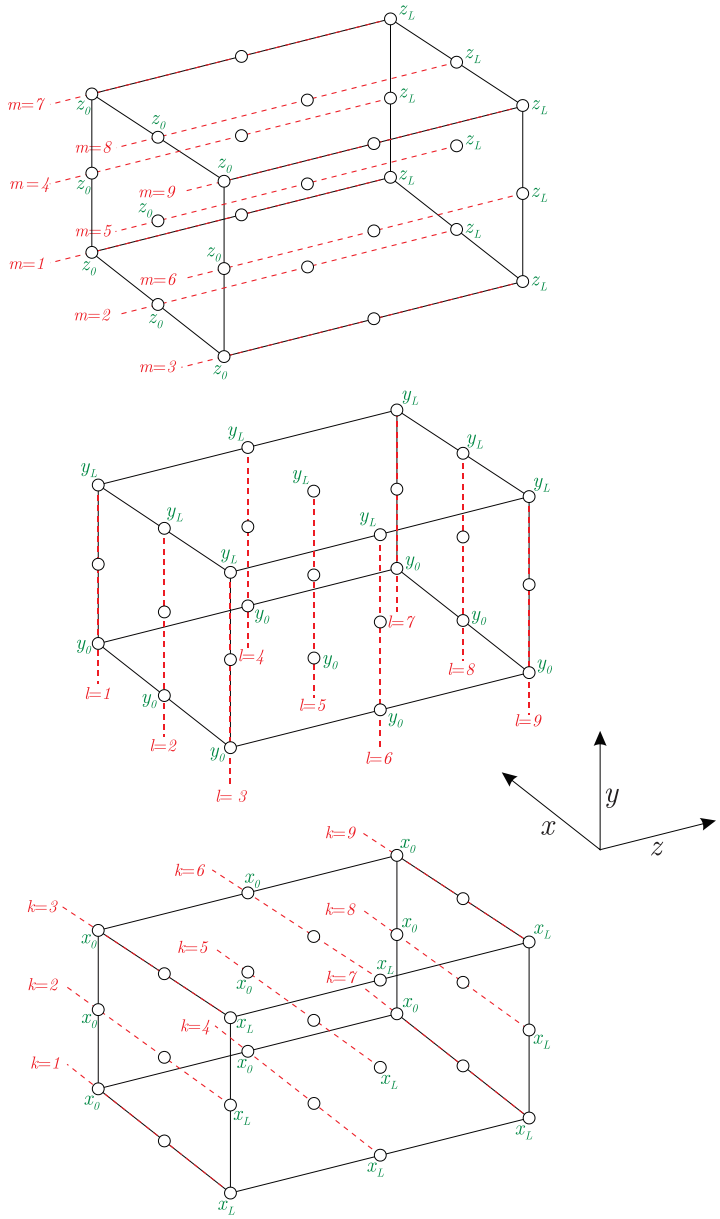


Fig. 2. Lines k, l and m on a quadratic element in three dimensions

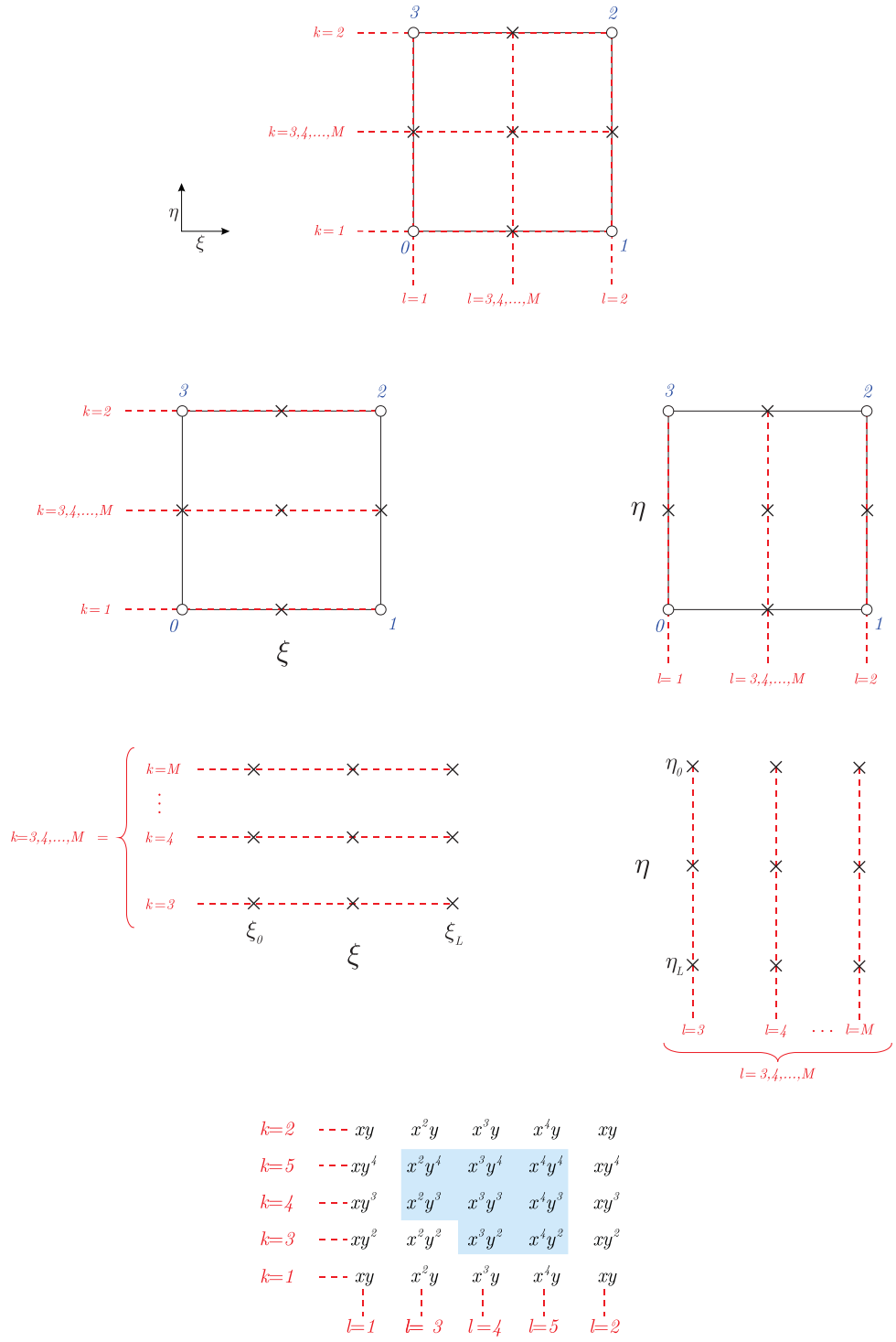


Fig. 3. Lines k and l also the places that β is calculated on for a hierarchical element in two dimensions

For approximating the mixed derivatives we will need to more DOF for example; if in three dimensions, the mixed derivative be in two-direction, like following derivative

$$\frac{\partial^2 \phi}{\partial x \partial y} = \frac{\partial}{\partial x}\frac{\partial}{\partial y} = \overset{mix}{\mathfrak{L}}_{xy}\phi \tag{33}$$

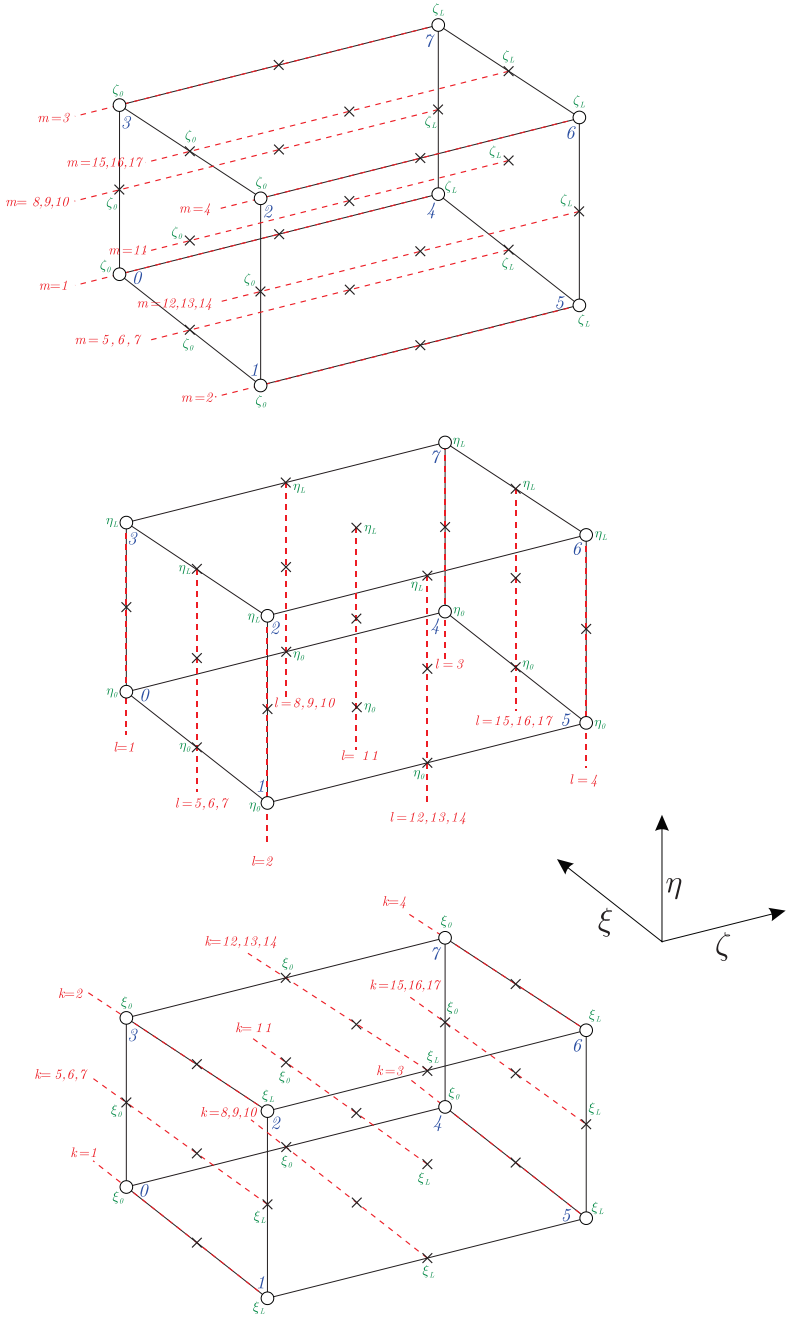


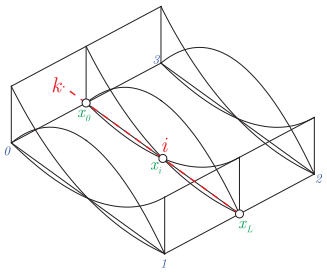
Fig. 4. Lines k, l and m also the places that β is calculated on for a fourth-degree hierarchical element in three dimensions

We use the shape function with two DOF in x and y directions, see figure (9). This elements are used only for mixed operator.

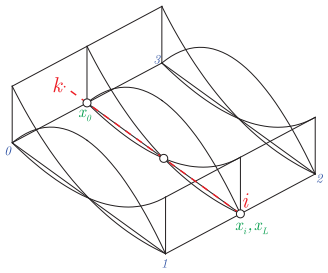
When we use the hierarchical shape functions, for some equations have two unknown variable (ϕ_i and a_i, see figure (6)), the additional equation for additional unknown can be written as follows:

$$3\phi_i - \left[\sum_{j=0}^{L} N_{j^l}\Big|_i \phi_j + \sum_{j=0}^{L} N_{j^l}\Big|_i a_j\right] + \left[\sum_{j=0}^{L} N_{j^m}\Big|_i \phi_j + \sum_{j=0}^{L} N_{j^m}\Big|_i a_j\right] + \left[\sum_{j=0}^{L} N_{j^k}\Big|_i \phi_j + \sum_{j=0}^{L} N_{j^k}\Big|_i a_j\right] = 0 \qquad (34)$$

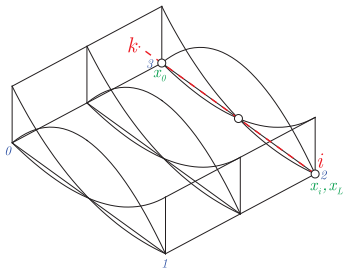
RFEM can be used to isogeometric analysis as well (see the following sections and examples).



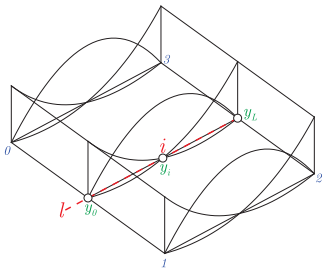
For the operator of x direction of node i



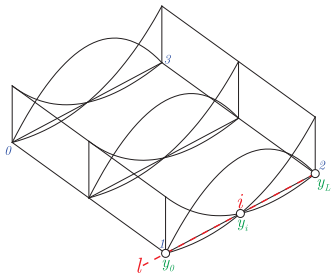
For the operator of x direction of node i



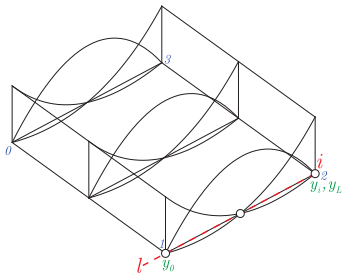
For the operator of x direction of node i



For the operator of y direction of node i

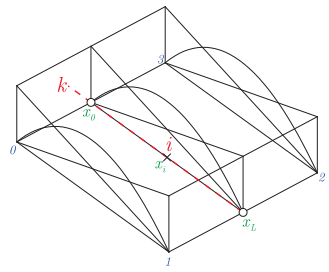


For the operator of y direction of node i

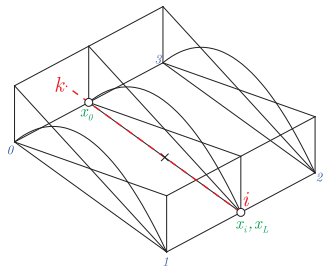


For the operator of y direction of node i

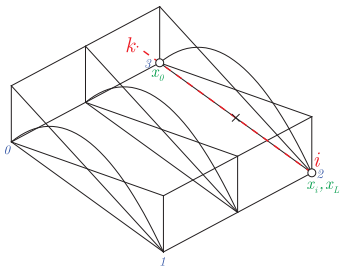
Fig. 5. A reduced standard quadratic element in two-dimensional, lines k and l also the participating nodes in the equation of node i for each of them



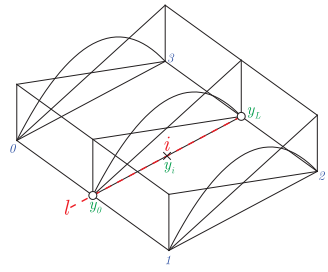
For the operator of x direction of parameter i



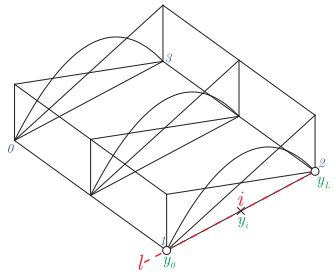
For the operator of x direction of node i



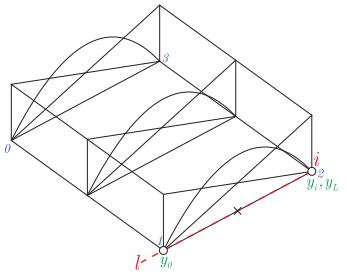
For the operator of x direction of node i



For the operator of y direction of parameter i



For the operator of y direction of parameter i



For the operator of y direction of node i

Fig. 6. A reduced hierarchical quadratic element in two-dimensional, lines k and l also the participating nodes in the equation of node i for each of them

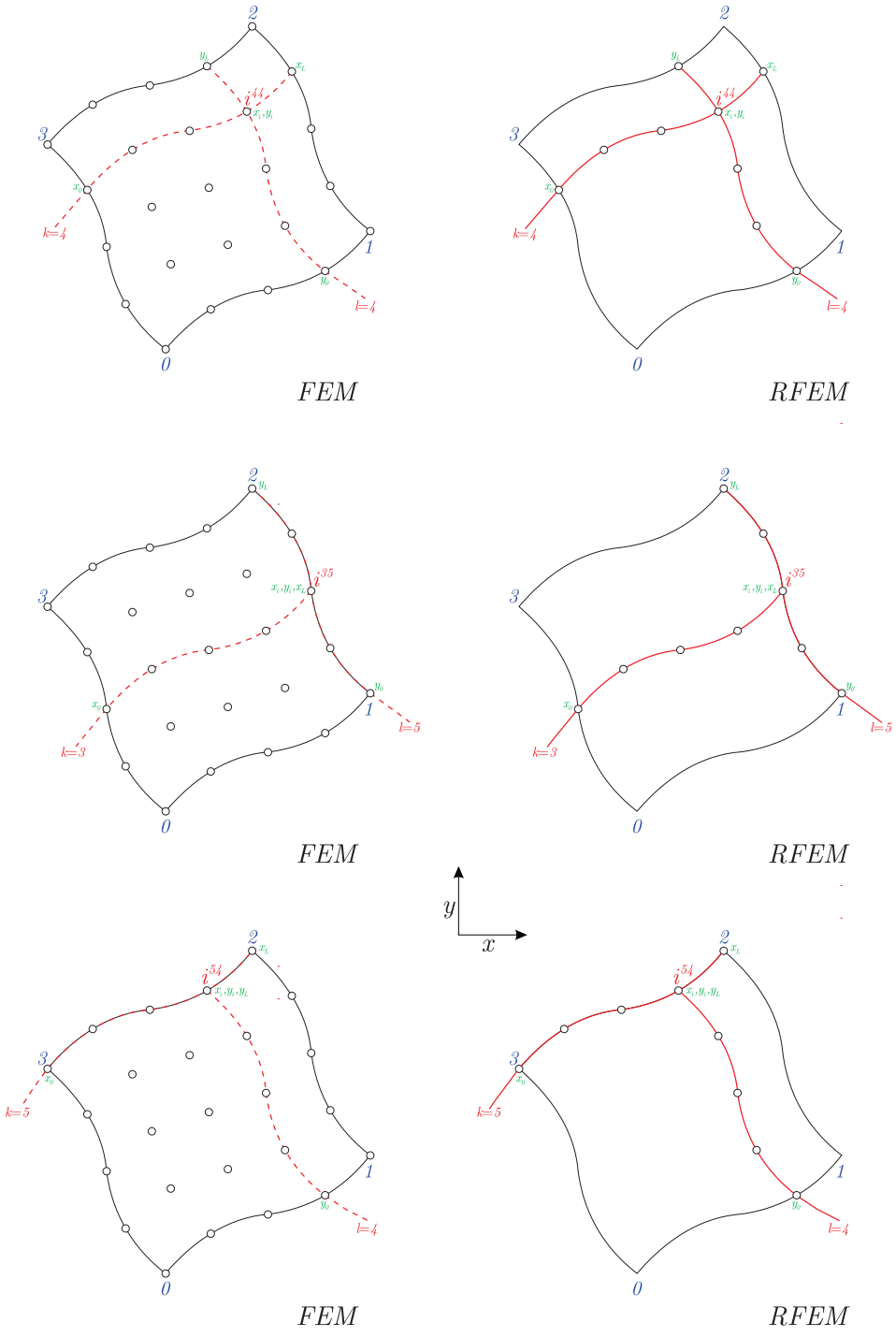


Fig. 7. Nodes involved in the equation of node i for FEM and RFEM on several fourth-degree elements in two dimensions

A new hybrid difference scheme (HDS) for liner shape functions

In this section, I will introduce a technique to eliminate oscillations for using the FEM and RFEM on liner shape functions, in this case *b* is written as follows:

$$b = \theta_{i(x,y,z)} \tag{35}$$

Where $\theta_{i(x,y,z)}$ is "Upwind Parameter" and is chosen in the range $0 \le \theta_{i(x,y,z)} \le 1$. It is clear that there are many choices that can be used for. I used the following equation for it

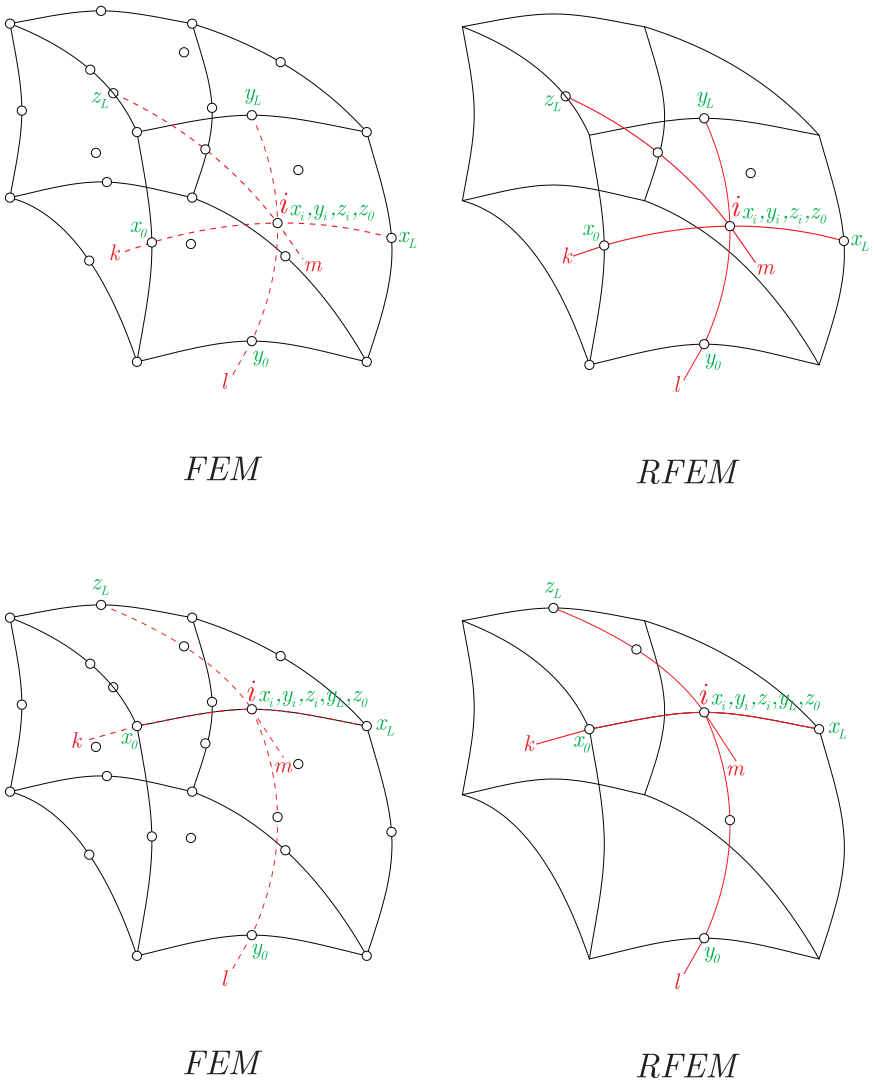


Fig. 8. Nodes involved in the equation of node i for FEM and RFEM on two quadratic elements in three dimensions

$$\theta_{i_{(x,y,z)}} = (1 - r_{i^{klm}{}_{(x,y,z)}})^7 \tag{36}$$

Where

$$r_{i^{klm}{}_{(x,y,z)}} = \min\left[r_{i^{k}{}_{(x)}}, r_{i^{l}{}_{(y)}}, r_{i^{m}{}_{(z)}}\right] \tag{37}$$

And

$$r_{i^{k}{}_{(x)}} = \frac{\min\left[\left|\frac{\phi_{i+1}-\phi_i}{x_{i+1}{}^k - x_i{}^k}\right|, \left|\frac{\phi_i-\phi_{i-1}}{x_i{}^k - x_{i-1}{}^k}\right|\right]}{\max\left[\left|\frac{\phi_{i+1}-\phi_i}{x_{i+1}{}^k - x_i{}^k}\right|, \left|\frac{\phi_i-\phi_{i-1}}{x_i{}^k - x_{i-1}{}^k}\right|\right]},$$

$$r_{i^{l}{}_{(y)}} = \frac{\min\left[\left|\frac{\phi_{i+1}-\phi_i}{y_{i+1}{}^l - y_i{}^l}\right|, \left|\frac{\phi_i-\phi_{i-1}}{y_i{}^l - y_{i-1}{}^l}\right|\right]}{\max\left[\left|\frac{\phi_{i+1}-\phi_i}{y_{i+1}{}^l - y_i{}^l}\right|, \left|\frac{\phi_i-\phi_{i-1}}{y_i{}^l - y_{i-1}{}^l}\right|\right]} \tag{38}$$

$$r_{i^{m}{}_{(z)}} = \frac{\min\left[\left|\frac{\phi_{i+1}-\phi_i}{z_{i+1}{}^m - z_i{}^m}\right|, \left|\frac{\phi_i-\phi_{i-1}}{z_i{}^m - z_{i-1}{}^m}\right|\right]}{\max\left[\left|\frac{\phi_{i+1}-\phi_i}{z_{i+1}{}^m - z_i{}^m}\right|, \left|\frac{\phi_i-\phi_{i-1}}{z_i{}^m - z_{i-1}{}^m}\right|\right]}$$

The performance of this scheme is much better than other second-order schemes that in the FEM are used for CFD, see figure (11).

A new shape functions for general problems

Equation (35) can be used only for the linear shape functions, in this section another technique is provided for eliminating oscillations that can be used for higher-order shape functions in any degree. This technique works directly on the shape functions (this technique is equivalent to creating new shape functions), for this purpose, the shape functions are written as following

$$N_0^{EDL,FVL} = (1-\delta_i)N_0^{(p)} + \delta_i N_0^{(ref)}$$
$$N_j^{EDL,FVL} = (1-\delta_i)N_j^{(p)} + \delta_i N_j^{(ref)} \quad (39)$$
$$N_L^{EDL,FVL} = (1-\delta_i)N_L^{(p)} + \delta_i N_L^{(ref)}$$

Where δ_i is Element Degree Limiter, Field Variable Limiter (EDL, FVL), and $N^{(p)}$ can be any function of $p \geq 2$ (for example, the functions of Lagrangian, Serendipity and Bezier for standard shape functions and the functions of Legendre, Chebyshev, Fourier, etc. for hierarchical shape functions). $N_0^{(ref)}$, $N_j^{(ref)}$ and $N_L^{(ref)}$ in equation (39) are reference functions, original function for them become

$$N_0^{(ref)} = N_0^{(1)}, \quad N_j^{(ref)} = 0, \quad N_L^{(ref)} = N_L^{(1)} \quad (40)$$

Where $N_0^{(1)}$ and $N_L^{(1)}$ are liner shape functions.

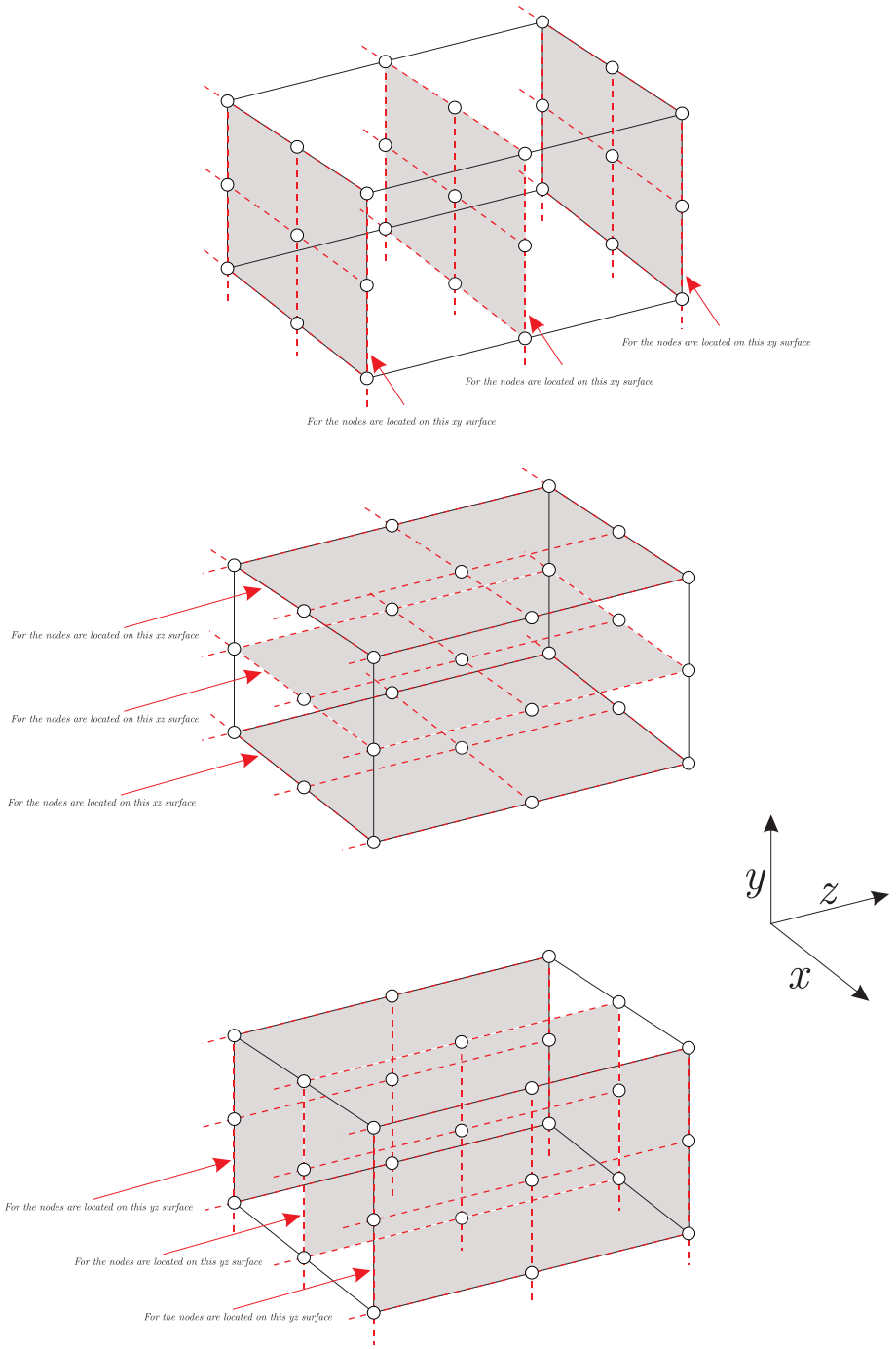


Fig. 9. A reduced quadratic element in three-dimensional with two DOF for approximation the mixed derivatives $\partial^2\phi/\partial x\partial y$, $\partial^2\phi/\partial x\partial z$ and $\partial^2\phi/\partial y\partial z$

The δ_i in equation (39) has two range:

1 – Using the δ_i as EDL by choosing it in the range $0 < \delta_i^{EDL} < \infty$.

2 – Using the δ_i as FVL by choosing it in the range $-\infty < \delta_i^{FVL} < 0$.

Note: if the reference function is greater than the shape function the sign of EDL and FVL will change.

The EDL can be used only in the directions of the shape function (directions of operator) that $\beta_i \neq 0$ is for, and the FVL is used only in the directions of the shape function that $\beta_i = 0$ is for or inverse, or the FVL and EDL can be added on all nodes with identical or non-identical values, and their relationship is written as follows:

$$\delta_i = \left[|\beta_i| \delta_i^{(EDL,FVL)1} + (1 - |\beta_i|) \delta_i^{(EDL,FVL)2} \right] \theta_i \quad (41)$$

The value of the $\delta_i^{(EDL,FVL)1}$ and $\delta_i^{(EDL,FVL)2}$ depending on the application is, see examples. Note that δ_i is applied to shape functions as one-dimensional (separately for each direction of shape functions).

The following functions can also be used as reference function on the Lagrangian, Serendipity and Bezier functions to make the shape functions of non-oscillatory

$$N_0^{(ref)} = eN_L, \quad N_j^{(ref)} = S_j^0 N_0 + S_j^L N_L + N_j,$$

$$N_L^{(ref)} = eN_0 \quad (42)$$

And for boundary elements become

$$N_0^{(ref)} = N_0 + eN_L, \quad N_j^{(ref)} = S_j^L N_L + N_j,$$

$$N_L^{(ref)} = 0 \quad N_0^{(ref)} = 0,$$

$$N_j^{(ref)} = S_j^0 N_0 + N_j, \quad N_L^{(ref)} = N_L + eN_0 \quad (43)$$

Where e is a constant coefficient and N_0, N_j and N_L can be the Lagrangian, Serendipity or Bezier functions and degree them can be chosen 1 or p (for 1 – degree and p – degree the equations and results are different). S_j^0 and S_j^L are a constant coefficients and are given by

$$S_j^0 = (1-e) \frac{\left(\frac{\xi_j - \xi_0}{\xi_L - \xi_0}\right)^\omega}{\sum_{j=1}^{p-1} \left(\frac{\xi_j - \xi_0}{\xi_L - \xi_0}\right)^\omega},$$

$$S_j^L = (1-e) \frac{\left(\frac{\xi_L - \xi_j}{\xi_L - \xi_0}\right)^\omega}{\sum_{j=1}^{p-1} \left(\frac{\xi_L - \xi_j}{\xi_L - \xi_0}\right)^\omega} \quad (44)$$

Where ξ_j is the location of the nodes (control points) and ω is the weight coefficient (optional). For $p \geq 3$ the hierarchical shape functions with $N_j^{(ref)} = 0$ can be used. e is chosen as, $e = 1 - p$ for $\omega = \infty$, $e = -1$ for $\omega = 0$ and $e = 1/1 - p$ for $\omega = -\infty$.

Another reference function is

$$N_0^{(ref)} = \frac{1}{2}(1+\alpha_i)(N_0 + eN_L)$$

$$N_j^{(ref)} = \frac{1}{2}\left[(1+\alpha_i) S_j^L N_L + (1-\alpha_i) S_j^0 N_0\right] + N_j$$

$$N_L^{(ref)} = \frac{1}{2}(1-\alpha_i)(N_L + eN_0) \quad (45)$$

When $\alpha_i = 1$ equation (45) give backward difference approximation and when $\alpha_i = -1$ give forward difference approximation. A reference function with high performance around discontinuities in derivative form is as follows:

$$N_{i(\xi)}^{\prime(ref)} = \frac{1}{2}\frac{1+\alpha_{i(\xi)}^{'}}{\xi_{i^k} - \xi_{i-1^k}} - \frac{1}{2}\frac{1-\alpha_{i(\xi)}^{'}}{\xi_{i+1^k} - \xi_{i^k}}$$

$$N_{i-1(\xi)}^{\prime(ref)} = -\frac{1}{2}\frac{1+\alpha_{i(\xi)}^{'}}{\xi_{i^k} - \xi_{i-1^k}}$$

$$N_{i+1(\xi)}^{\prime(ref)} = \frac{1}{2}\frac{1-\alpha_{i(\xi)}^{'}}{\xi_{i+1^k} - \xi_{i^k}}$$

$$N_{i-1>i>i+1(\xi)}^{\prime(ref)} = 0$$

$$N_{i(\eta)}^{\prime(ref)} = \frac{1}{2}\frac{1+\alpha_{i(\eta)}^{'}}{\eta_{i^l} - \eta_{i-1^l}} - \frac{1}{2}\frac{1-\alpha_{i(\eta)}^{'}}{\eta_{i+1^l} - \eta_{i^l}}$$

$$N_{i-1(\eta)}^{\prime(ref)} = -\frac{1}{2}\frac{1+\alpha_{i(\eta)}^{'}}{\eta_{i^l} - \eta_{i-1^l}}$$

$$N_{i+1(\eta)}^{\prime(ref)} = \frac{1}{2}\frac{1-\alpha_{i(\eta)}^{'}}{\eta_{i+1^l} - \eta_{i^l}}$$

$$N_{i-1>i>i+1(\eta)}^{\prime(ref)} = 0 \quad (46)$$

$$N_{i(\zeta)}^{\prime(ref)} = \frac{1}{2}\frac{1+\alpha_{i(\zeta)}^{'}}{\zeta_{i^m} - \zeta_{i-1^m}} - \frac{1}{2}\frac{1-\alpha_{i(\zeta)}^{'}}{\zeta_{i+1^m} - \zeta_{i^m}}$$

$$N_{i-1(\zeta)}^{\prime(ref)} = -\frac{1}{2}\frac{1+\alpha_{i(\zeta)}^{'}}{\zeta_{i^m} - \zeta_{i-1^m}}$$

$$N_{i+1(\zeta)}^{\prime(ref)} = \frac{1}{2}\frac{1-\alpha_{i(\zeta)}^{'}}{\zeta_{i+1^m} - \zeta_{i^m}}$$

$$N_{i-1>i>i+1(\zeta)}^{\prime(ref)} = 0$$

The difference between equation (46) and equations (40), (42) and (45) on a fourth-degree element around the discontinuity in figure (10).

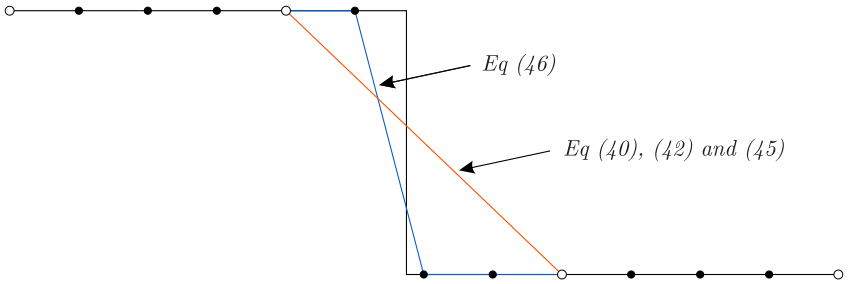


Fig. 10. The difference between equation (46) and equations (40), (42) and (45) on three fourth-degree elements around the discontinuity with FUDS

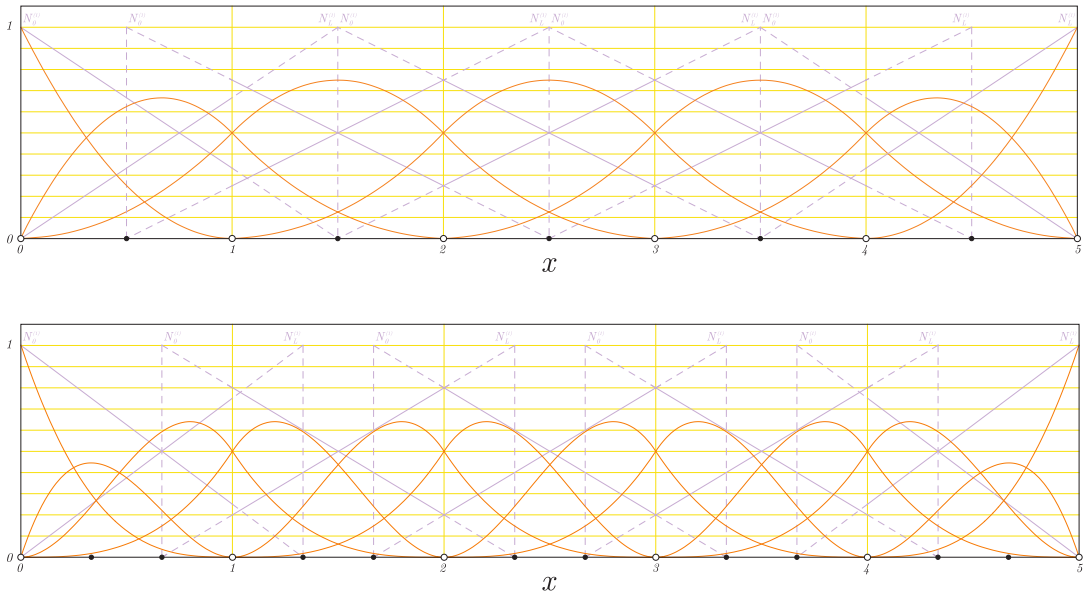


Fig. 11. Liner functions for quadratic and cubic IGA functions

The r for higher-order shape functions is written as r_e (the same for all nodes lines k, l and m)

$$r_{e^{k_{(x)}}} = \min\left[r_{1^{k_{(x)}}}, r_{2^{k_{(x)}}}, r_{3^{k_{(x)}}}, \ldots, r_{L-1^{k_{(x)}}}\right]$$

$$r_{e^{l_{(y)}}} = \min\left[r_{1^{l_{(y)}}}, r_{2^{l_{(y)}}}, r_{3^{l_{(y)}}}, \ldots, r_{L-1^{l_{(y)}}}\right] \quad (47)$$

$$r_{e^{m_{(z)}}} = \min\left[r_{1^{m_{(z)}}}, r_{2^{m_{(z)}}}, r_{3^{m_{(z)}}}, \ldots, r_{L-1^{m_{(z)}}}\right]$$

Where r_i is given by equation (38).

New isogeometric analysis and new functions

In this section, I'm going by reference functions presented in the previous section, I introduce a new isogeometric analysis. The isogeometric analysis [Hughes et al. (2005)] is done by the B-Spline and NURBS functions, although the reference functions presented above are applicable with B-Spline and NURBS functions, here I introduce a new Isogeometric Analysis Functions that are closer to the standard finite element method and more comfortable for the use in CFD and engineering, I made the following algorithm to make these functions on the Bezier functions

$$N_0^{(IGA)} = \frac{1}{2}N_0^{(Bezier)}, \quad N_1^{(IGA)} = \frac{1}{2}N_0^{(Bezier)} + N_1^{(Bezier)}$$

$$N_{2,3,4,\ldots,L-2}^{(IGA)} = N_{2,3,4,\ldots,L-2}^{(Bezier)}$$

$$N_{L-1}^{(IGA)} = \frac{1}{2}N_L^{(Bezier)} + N_{L-1}^{(Bezier)}, \quad N_L^{(IGA)} = \frac{1}{2}N_L^{(Bezier)} \quad (48)$$

Note that $N_{2,3,4,\ldots,L-2}^{(IGA)}$ are local and can add as hierarchical as well, for $p = 2$ these functions are equivalent to the B-Spline functions and for $p = 3$ are similar the PHT-spline functions work of [Deng et al. (2008)] and for more than a third degree are completely new. The equation (48) for first and last boundary elements become

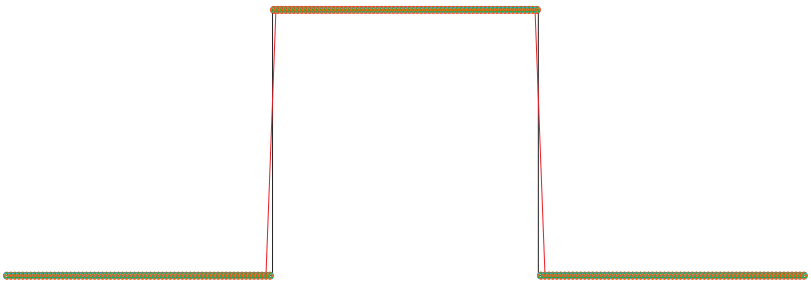
$$N_0^{(IGA)} = N_0^{(Bezier)}, \quad N_1^{(IGA)} = N_1^{(Bezier)}$$

$$N_{2,3,4,\ldots,L-2}^{(IGA)} = N_{2,3,4,\ldots,L-2}^{(Bezier)}$$

$$N_{L-1}^{(IGA)} = \frac{1}{2}N_L^{(Bezier)} + N_{L-1}^{(Bezier)}, \quad N_L^{(IGA)} = \frac{1}{2}N_L^{(Bezier)} \quad (49)$$

$$N_0^{(IGA)} = \frac{1}{2} N_0^{(Bezier)}, \quad N_1^{(IGA)} = \frac{1}{2} N_0^{(Bezier)} + N_1^{(Bezier)} \quad N_{2,3,4,\ldots,L-2}^{(IGA)} = N_{2,3,4,\ldots,L-2}^{(Bezier)}$$

$$N_{L-1}^{(IGA)} = N_{L-1}^{(Bezier)}, \quad N_L^{(IGA)} = N_L^{(Bezier)} \tag{50}$$



p=1

b = 0 (HDS, Eq (35))

Shape function; Standard (Lagrange), 200 uniform elements

Weight function; Subdomain Collocation Method

p=4

b = 1 (FUDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = 1 (Eq (41)) = 0

Shape function; Standard (Lagrange), 20 uniform elements

Weight function; Galerkin Method

Reference function; Eq (46)

p=2

b = 0

δ;0

Shape function; IGA (Eq (48)), 200 uniform elements

Weight function; Point Collocation Method

Reference function; Eq (45), p = 1, e = -1, w = 0

p=2

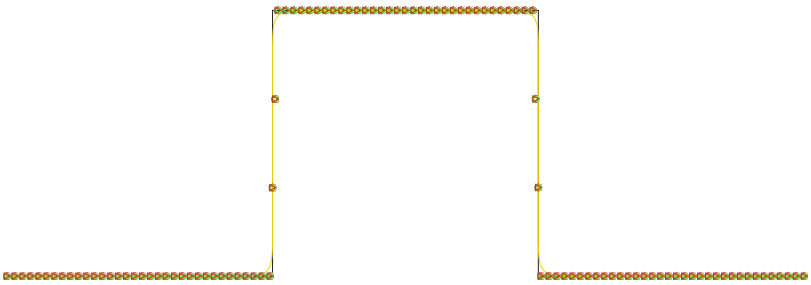
b = 1 (FUDS)

δ; (EDL,FVL)1 = 1/3, (EDL,FVL)2 = 1 (Eq (41))

Shape function; Standard (Lagrange), 200 uniform elements

Weight function; Galerkin Method

Reference function; Eq (45), p = 1, e = -1, w = 0



p=3

b = 1 (FUDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Standard (Bezier), 100 uniform elements

Weight function; Point Collocation Method

Reference function; Eq (40)

p=3

b = 1 (FUDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Hierarchical (Legendre), 100 uniform elements

Weight function; Galerkin Method

Reference function; Eq (40)

p=3

b = 1 (FUDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Standard (Lagrange), 100 uniform elements

Weight function; Subdomain Collocation Method

Reference function; Eq (42), p = 3, e = -1.25, w = 1

p=3

b = 1 (FUDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Hierarchical (Fourier Sine Series), 100 uniform elements

Weight function; Galerkin Method

Reference function; Eq (40)

p=3

b = 0

δ; -10.0

Shape function; IGA (Eq (48)), 100 uniform elements

Weight function; Point Collocation Method

Reference function; Eq (40)

p=3

b = 1 (FUDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Hierarchical (Chebyshev First Kind), 100 uniform elements

Weight function; Galerkin Method

Reference function; Eq (40)

p=3

b =θ (HDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Standard (Lagrange), 100 uniform elements

Weight function; Galerkin Method

Reference function; Eq (42), p = 3, e = -1.25, w = 1

p=3

b = 0 (CDS)

δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0

Shape function; Hierarchical (Chebyshev Second Kind), 100 uniform elements

Weight function; Galerkin Method

Reference function; Eq (40)

Fig. 12. 1D advective equation $u_t + u_x = 0$

For IGA functions, the liner functions to use in equations (40), (42), (45) and (46) are a liner functions between two control points, see figure (10), while the *p*-order functions for using in equations (42) and (45) are the same IGA functions.

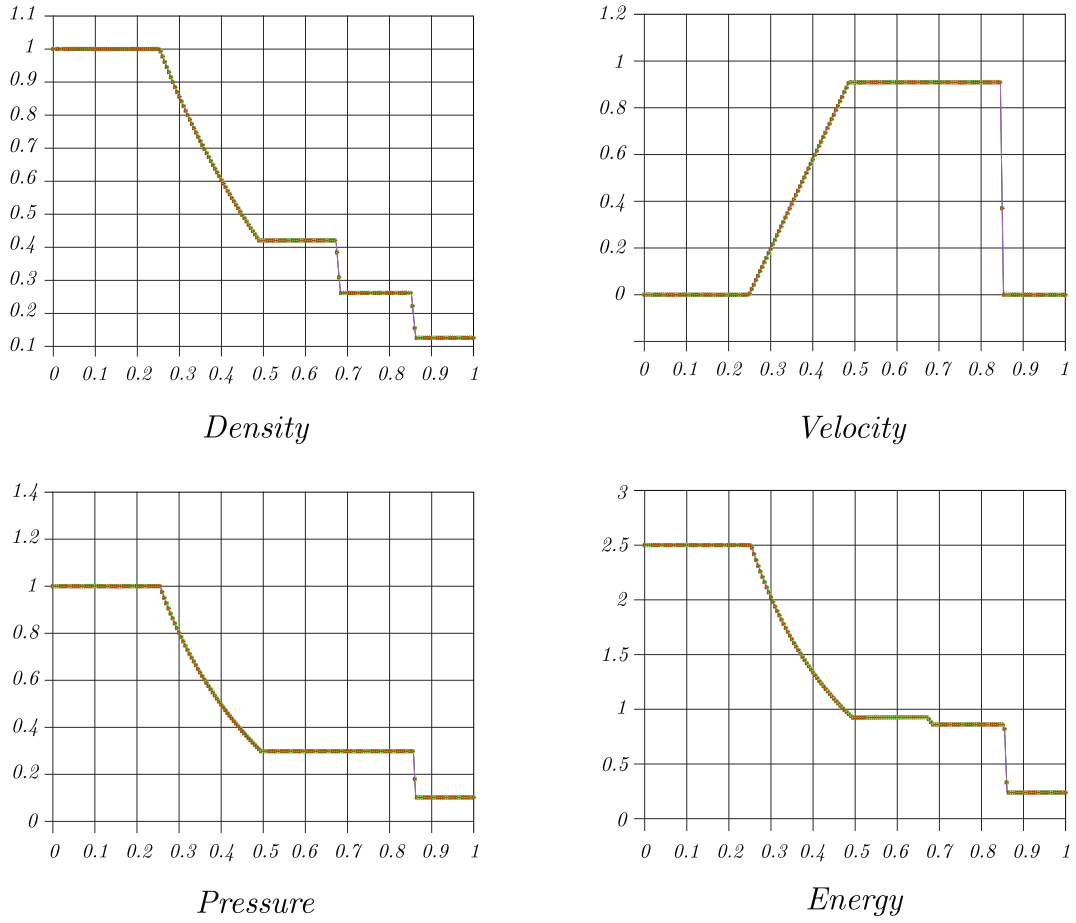


Fig. 13. Euler equations 1D based on sod's shock tube problem (t = 0.2)

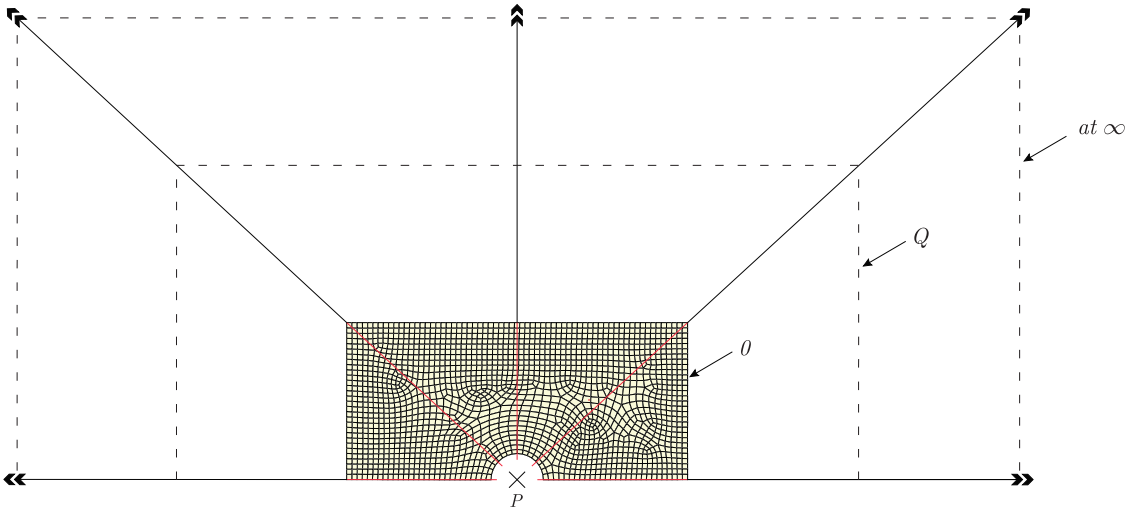
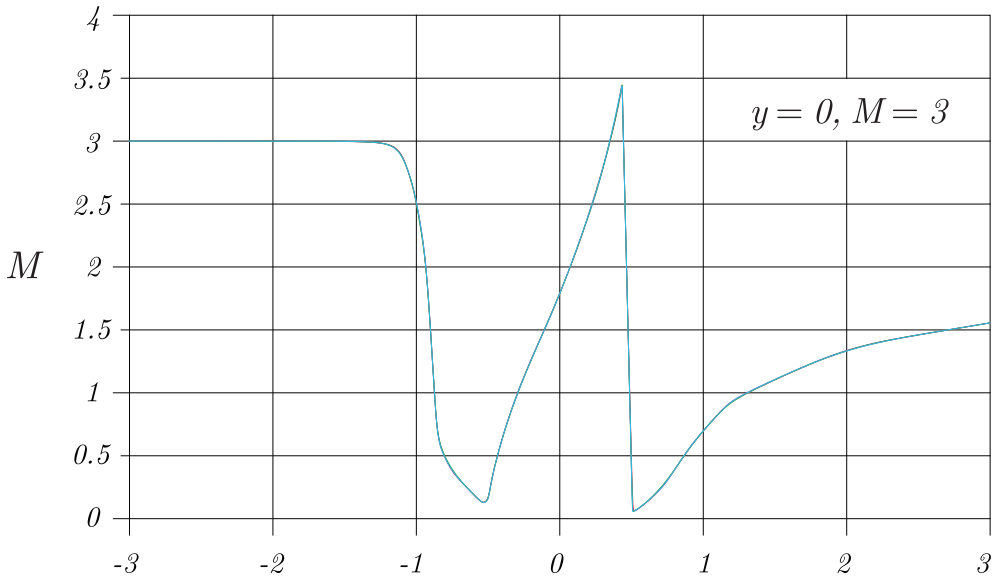


Fig. 14. Grid for flow around a cylinder



p=4
b = 1 (FUDS)
δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0
Shape function; Standard (Bezier)
Weight function; Point Collocation Method
Reference function; Eq (40)

p=4
b = 1 (FUDS)
δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0
Shape function; Hierarchical (Chebyshev First Kind)
Weight function; Galerkin Method
Reference function; Eq (40)

p=4
b = 1 (FUDS)
δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0
Shape function; Standard (Lagrange)
Weight function; Subdomain Collocation Method
Reference function; Eq (42), p = 4, e = -3, w = ∞

p=4
b = 0
δ; -10.0
Shape function; IGA (Eq (48))
Weight function; Point Collocation Method
Reference function; Eq (40)

Fig. 15. Flow around a cylinder (steady-state Euler equations)

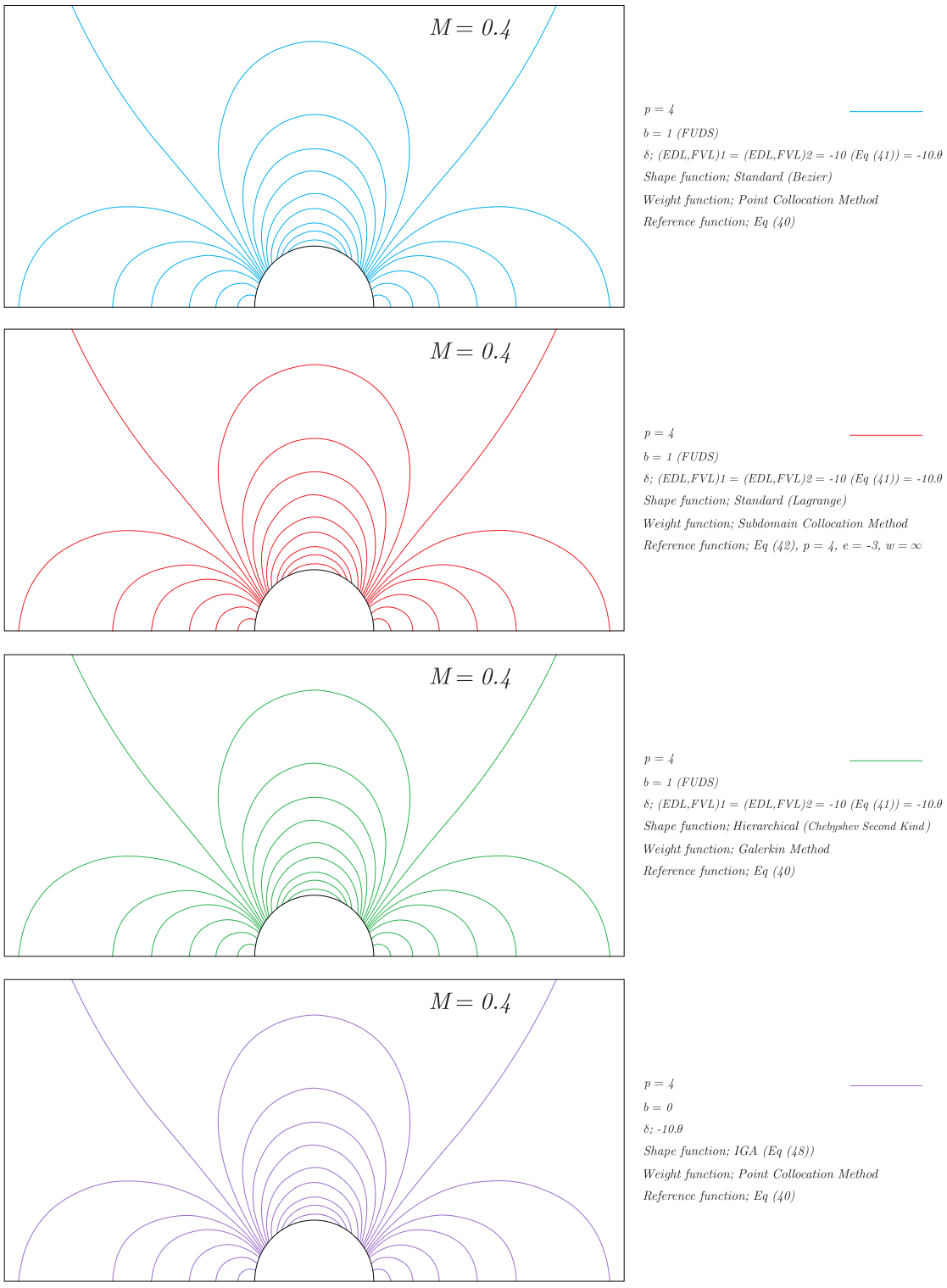


Fig. 16. Mach contours for flow around a cylinder (steady-state Euler equations)

Solutions and Examples

In this section, some examples that have been solved by standard shape functions that are including functions of the Lagrangian and Bezier and hierarchical shape functions that are including functions of the Legendre, Chebyshev (first and second kind) and Fourier Sine Series are presented. It explained that the volume

examples were solved to test RFEM is very high and here are just a few of them select and presented. Examples include 1D advective equation, 1D and 2D Euler equations, 2D Navier – Stokes equations and1D convection equation. Here details of the solution of these equations due to the length of paper and be less important are not presented and only the results are shown. Note: All examples are RFEM (the results for the NFFEM is almost identical). I used the infinite elements for non-solid boundaries in all examples were solved.

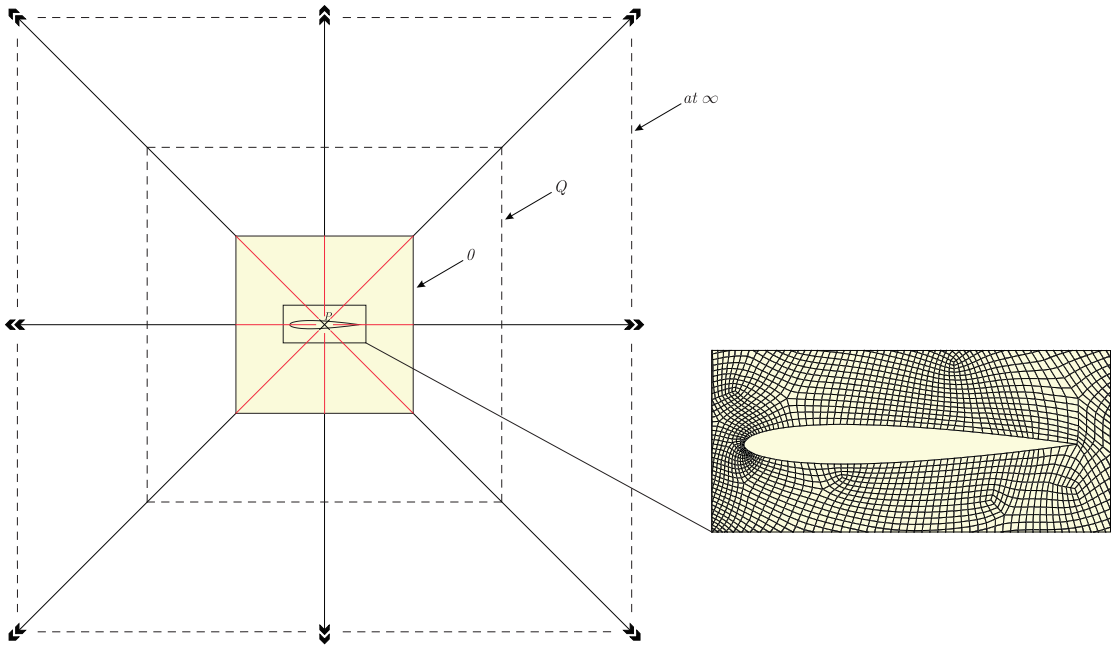


Fig. 17. Grid for flow over a NACA 0012 airfoil

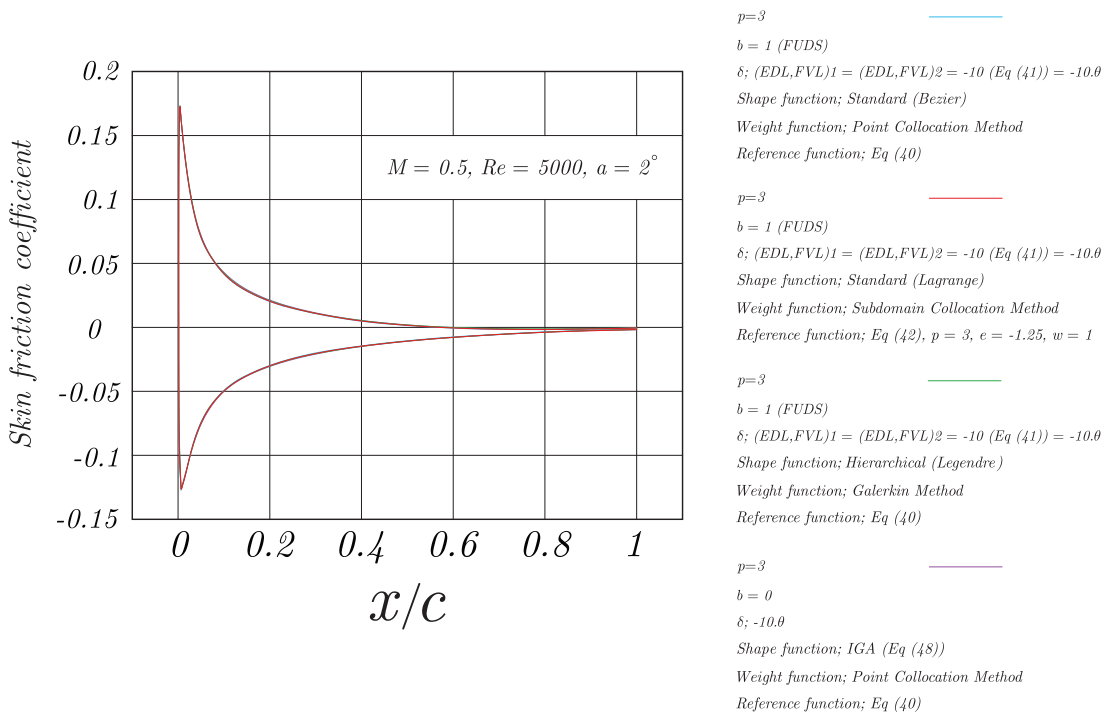


Fig. 18. Surface skin friction coefficient distributions on NACA 0012 airfoil (steady-state Navier-Stokes equations)

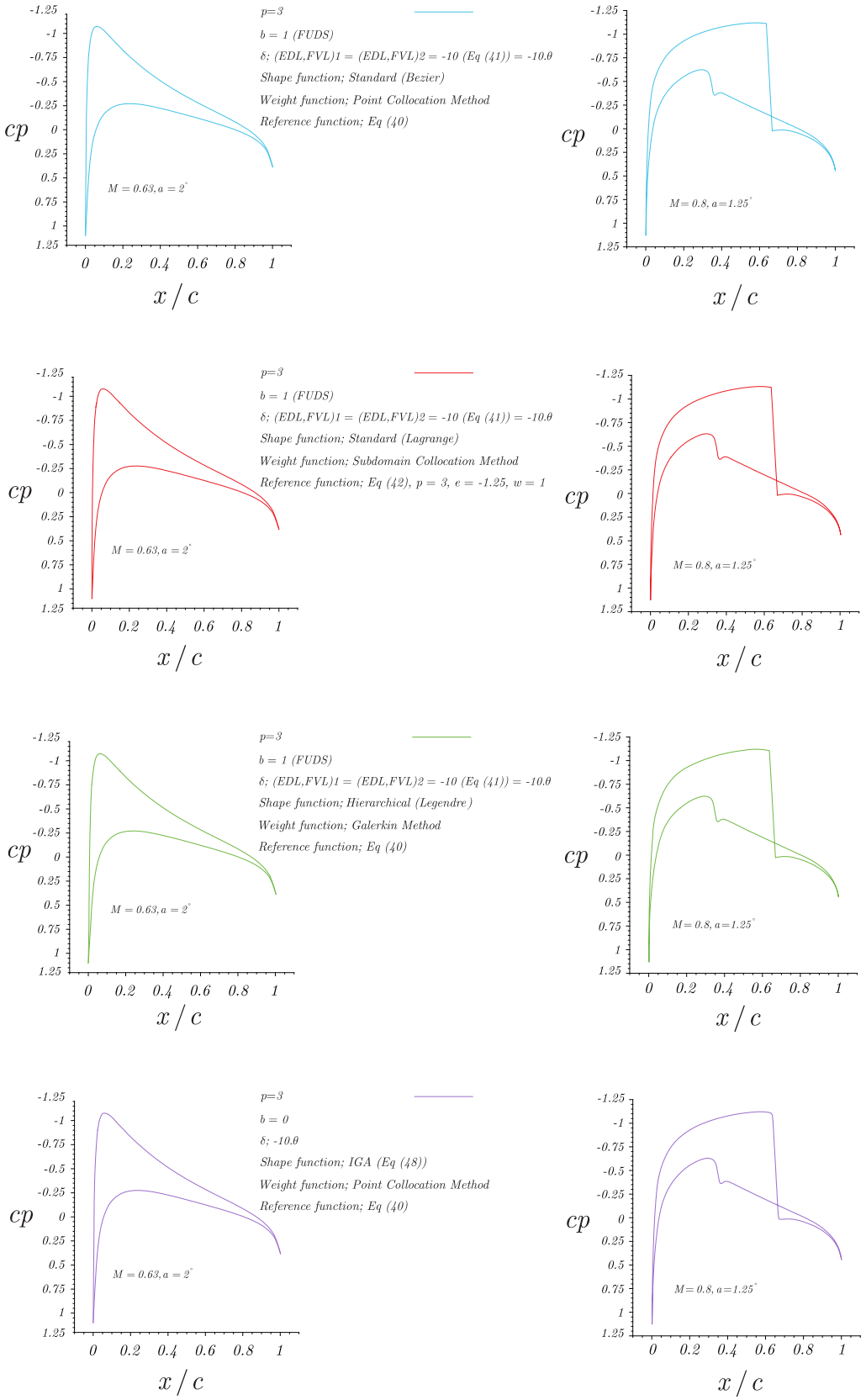


Figure 19. Surface pressure distribution for subcritical NACA 0012 airfoil (steady-state Euler equations)

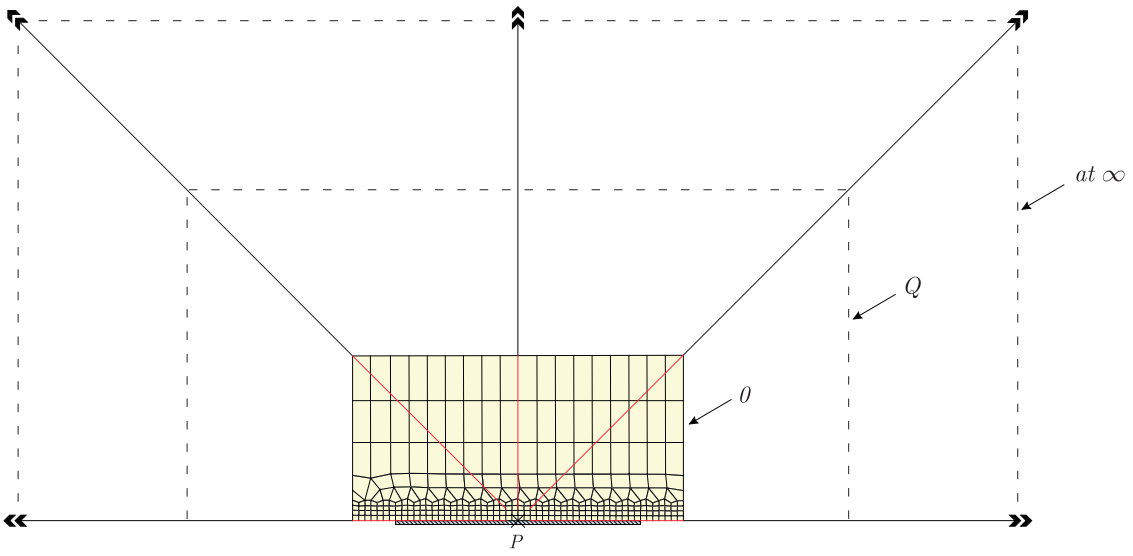
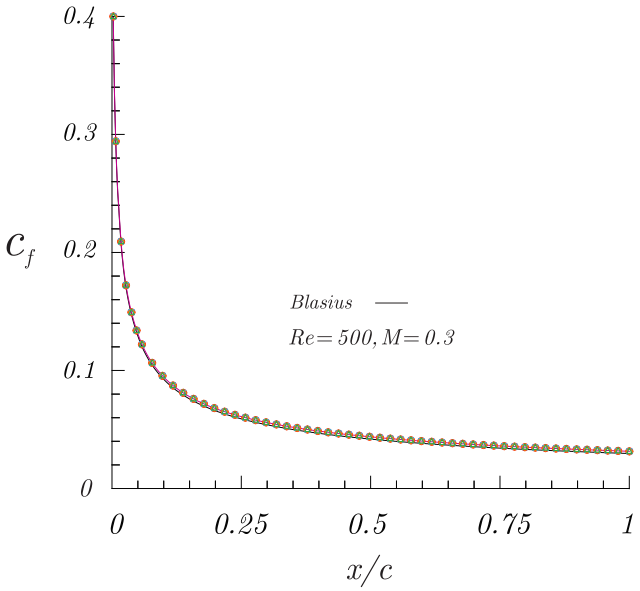


Fig. 20. Solution domain and lines grid for flat plate flow



p=4
b = 1 (FUDS)
δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0
Shape function; Standard (Bezier)
Weight function; Point Collocation Method
Reference function; Eq (40)

p=4
b = 1 (FUDS)
δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0
Shape function; Hierarchical (Fourier Sine Series)
Weight function; Galerkin Method
Reference function; Eq (40)

p=4
b = 1 (FUDS)
δ; (EDL,FVL)1 = (EDL,FVL)2 = -10 (Eq (41)) = -10.0
Shape function; Standard (Lagrange)
Weight function; Subdomain Collocation Method
Reference function; Eq (42), p = 4, e = -3, w = ∞

p=4
b = 0
δ; -10.0
Shape function; IGA (Eq (48))
Weight function; Point Collocation Method
Reference function; Eq (40)

Fig. 21. Skin friction distributions for flat plate flow (steady-state Navier-Stokes equations)

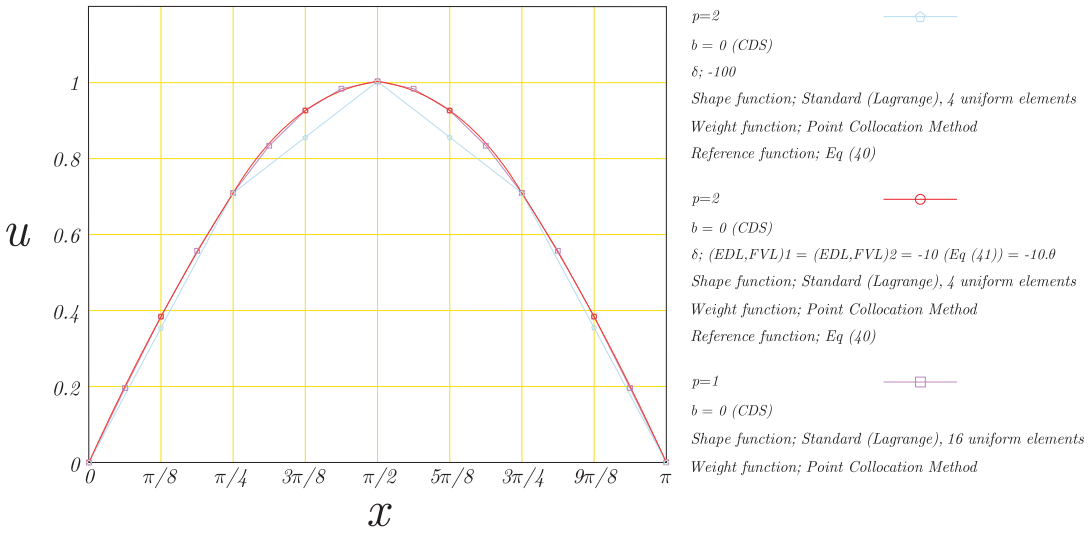


Fig. 22. 1D convection equation with source term, $au_x = \cos(x)$ on $[0, \pi]$ and $a = 1$

Conclusions

The best criterion for evaluate a numerical method is the results of the method and as can be seen in the examples were solved, the result of RFEM comparable to the best results were obtained by other methods is (for these examples, because of the small size of the elements, the difference between the results from different methods can not be seen) and given that the system of equations resulting from this approach similar (in terms of density) Finite Difference Method (FDM) is its efficiency can be compared with finite difference methods (although the use of the Legendre shape functions gives an efficiency much higher than FDM) so do not think other methods that are used in CFD be able to compete with it. Also, due to the similarity of relations many of the techniques used in the FDM can be used to RFEM [Hoffmann, and Chiang (1998)].

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RESEARCH OF INFLUENCE OF MICRO-ARC OXIDATION MODES ON OXIDE COATING PROPERTIES

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Currently search for new efficient coatings with high wear resistance, corrosion resistance, thermal resistance for spare parts of machines and mechanisms of different purpose is an ongoing process. Due to the above a comparatively new method for treatment of valve metals surface – micro-arc oxidation method – is of interest. This method allows obtaining fundamentally new coatings, which are characterized through different physical, chemical and mechanical properties. Pulse mode of performing micro-arc oxidation is of great interest. When forming oxide coating under the pulse mode by micro-arc oxidation method the value of current anode pulse duration has a significant impact on roughness of the coating. The work studies influence of current anode pulse duration on properties of oxide coating obtained by micro-arc oxidation method.

Aluminum, titanium, zirconium alloys and other materials are widely used as structural materials in modern engineering and airspace industry. Search for new efficient coatings with high wear resistance, corrosion resistance, thermal resistance for spare parts of machines and mechanisms of different purpose is an ongoing process. Due to this micro-arc oxidation method (MAO) [1–3], which is comparatively new method for treatment of valve metals, is of interest. The method allows obtaining brand new coatings with unique complex of properties characterized through high performance indicators. The

peculiarity of micro-arc oxidation method is that the process runs under high electric field intensity and is accompanied by formation of micro-plasma and micro-regions with high pressure due to appearing gases, which leads to developing of high temperature chemical transformations and transportation of the substance in the arc. Micro-plasma charges activity results in formation of coating layer consisting of oxidized forms of metal elements of electrolyte basis and components. The coating basis predominantly consists of α-Al_2O_3 (corundum) [3].

Topical is the issue of obtaining oxide coating in MAO mode with low roughness in order to exclude additional mechanical treatment of surface layer.

In this regard research of influence of current anode pulse duration on properties of oxide coatings obtained by micro-arc oxidation method is of interest.

Materials and methods. Samples for application of oxide coating were made out of A0 aluminum with dimensions of 2x2 cm and thickness of 3 mm, area of the surface to be treated was 8 cm^2. The samples prior to application of oxide coating by MAO method underwent mechanical polishing and had roughness of Ra = – 0,098 μm.

Oxide coating was formed in electrolyte solution consisting of, g/l: $Na_2HPO_4 \cdot 12H_2O$ – 40; $Na_2B_4O_7 \cdot 10\ H_2O$ – 30; H_3BO_3 – 20, NaF – 10. Electrolyte was prepared out of distilled water and analytically pure and chemically pure reagents. Micro-arc oxidation was carried out in a 700 ml capacity tub made of stainless steel. With the purpose of cooling the electrolyte the tub was provided with water cooling system. Tub body served as cathode in the process of MAO.

MAO process was performed using pulse power source, which allowed obtaining voltage pulses of rectangular, trapezoidal form with pulses flow frequency of 50 Hz and current density of 114–130 A/dm^2.

Roughness of coatings was measured with application of proximity MICRO MEASURE 3D station 3D-profiler. Micro-hardness of coatings was identified by means of Nano Hardness Tester by indenting the penetrator with diamond tip under maximum load of 20 mN. Wear resistance of coating was measured on high temperature friction gauge THT-S-AX0000. Identification of coating durability was based on friction principle of ball indentor made of BK alloy against surface. Whereas the load was equal to 1N, linear velocity – 2,5 cm/s, measurements were taken under temperature of 250 °C, 50% air humidity. Durability value was identified by track area measured on three-dimensional profiler using Mountains Map Universal software and obtaining three-dimensional images of sample surface with track. For each sample 9 values of track area were obtained and arithmetic average was found. Coatings thickness was measured on QuaNix-1500 thickness gauge. The thickness was calculated as an average among 15 measurements, from both sides of the sample. Porosity, form, distribution of pores by dimension were analyzed by processing microphotos of surface of samples being studied, which photos were obtained on Quanta 200i 3D raster type electronic microscope using planimetry, secant and dots methods as a ratio of pore image area to total area of a section under observation [4].

Discussion of results. Conducting of MAO process in constant current mode causes intense warming up of near-electrode layer, which leads to formation of partial melting on the sample surface, destruction and peeling of coating, formation of coatings with high roughness.

It is known that when forming oxide coating by micro-arc oxidation method in the pulse mode the value of current anode pulse duration has a significant impact on coating roughness [5]. In case the process is carried out with small values of current anode pulse duration the micro-arc charges arise during short period of time. In this case the material under treatment is not overheated and in the interval between pulses the heat is able to flow to the solution. Small values of pulse duration lead to appearance of small oxide buildups and to significant quantity of pores per unit of area. This facilitates formation of uniform coatings with low roughness.

Voltage value influences final thickness of the coating. Values of current anode pulse duration influences coating quality, in particular, roughness thereof, whereas pulse amplitude influences the coating formation rate. Changes of thickness and roughness of coatings formed under polarizing voltage Up = 300V under different duration of current anode pulse are in table 1.

As it is seen from the obtained data with increase in current anode pulse duration the coating thickness grows, coating roughness increases. The latter is related to the fact that with growth of coating thickness increases power, intensity of micro-plasma charges. Whereas increase in dimensions of individual micro-arc charges is observed, warming up takes place in near-electrode layer of the solution.

In the process of study of these coatings for wear resistance (durability) three dimensional images of samples surface with track were obtained; on these pictures it is seen that track width of initial sample without coating exceeds the width of tracks of samples with oxide coating obtained under different current anode pulse duration.

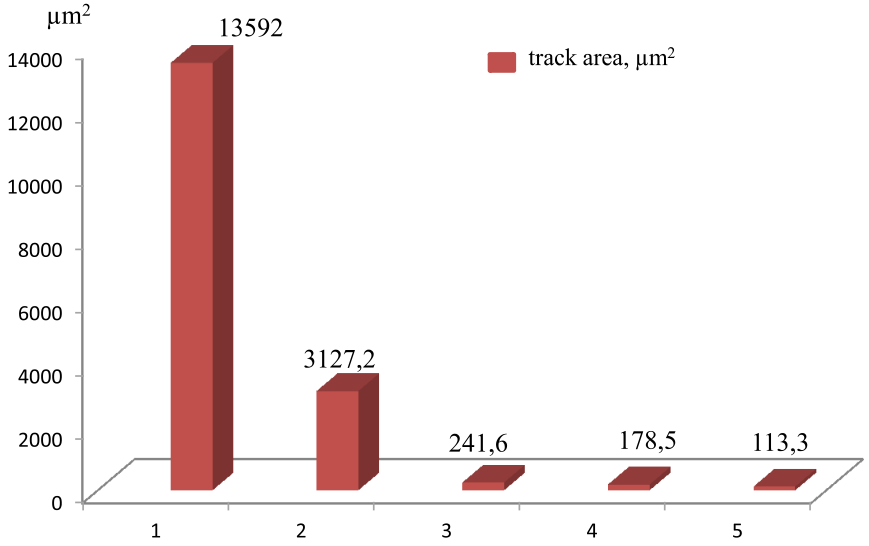
Track areas values for samples without coating and with oxide coating are shown in form of a diagram in figure.

As it is seen from the diagram track areas of samples with oxide coating are significantly less than track area of initial sample, which testifies of high wear resistance of samples with oxide coating. As anode pulse duration increases with coating thickness growth the coating wear resistance increases. Since coating roughness is related to friction ratio, along with roughness increase friction ratio increases as well (table 2).

Table 1

Dependence of thickness and roughness of coatings on current anode pulse duration

№	Current anode pulse duration, ms	Time, min	Coating thickness, μm	Roughness Ra, μm
1	50	20	7,8	0,34
2	100	20	11,1	0,57
3	150	20	19,7	0,92
4	200	20	26,5	2,21



Track areas values when performing durability test of samples without coating and with oxide coating obtained under different durations of current anode pulse. 1 – initial sample; 2 – 50 ms; 3 – 100 ms; 4 – 150 ms; 5 – 200 ms

Table 2

Micro-hardness of coating

№	Polarizing voltage, V	Current anode pulse duration, ms	Micro-hardness, MPa	Friction ratio
1	300	50	1522,7	0,85
2	300	100	1888,2	1,12
3	300	150	3775,7	2,16
4	300	200	33543,9	3,68

An important physical and mechanical feature of coating is its micro-hardness. Micro-hardness values on surface of samples depending on coating obtainment modes are shown in table 2.

Study of micro-hardness deep into the sample showed that in the MAO process a transient layer deep into the metal is generated from oxide layer with gradual decrease of micro-hardness value. For instance, when pulse duration is 100 ms the micro-hardness of transient layer gradually decreases from 1047,4 MPa to 846,2 MPa when measuring at depth of 15 to 40 μm deep into the metal. Micro-hardness of initial material is equal in this case to around 150 MPa. In this depth interval also Young module increase is observed, which is below 89 GPa in average, whereas initial material has Young module of 70 GPa.

Research of coating surface morphology by means of raster electronic microscope showed that with 50 ms anode pulse duration a thin coating is formed due to low productivity of the process. Whereas formation of basic external functional layer is not complete, coating is formed in spots. With current anode pulse duration of 50 ms formation of significant quantity of round shaped pores per unit of surface area is observed. As current anode pulse duration increases to 200 ms the nature of micro-plasma charges change. Small spark charges are replaced with large ones. Coating thickness growth leads to of refilling pores, quantity of pores decreases. As a result of spark charges enlargement the average dimension of pores increases with current anode pulse duration of 200 ms. Surface porosity values are shown in table 3.

Table 3

Surface porosity of oxide coatings

№	Current anode pulse duration, ms	Coating thickness, μm	Porosity ΔS, %	Quantity of pores per 1 cm2 of coating	Average diameter of pores, μm
1	50	7,8	6,4	$1,1 \cdot 10^6$	2,72
2	100	11,1	11,7	$7,3 \cdot 10^5$	4,5
3	150	19,7	5,6	$3,5 \cdot 10^5$	4,5
4	200	26,5	8,7	$3,02 \cdot 10^5$	6,06

Conclusions

Impact of current anode pulse duration on properties of oxide coatings has been studied. It has been shown that current anode pulse duration has significant impact on coating roughness. As pulse duration increases coating roughness, friction ratio increase as well.

Tribometric research of coatings showed that as a result of micro-arc oxidation durable coatings are formed, whereas with increase of anode pulse duration and thickness of coating the durability of the coating increases. Micro-hardness on coating thickness of 19,7 and 26,5 μm is equal to 3,8 and 33,5 GPa respectively. It has been found out that as a result of micro-arc oxidation a transient layer is formed deep into the metal with high value of micro-hardness in comparison with untreated aluminum. Micro-hardness of transient layer is gradually decreasing deep into the metal.

Authors of the article express thanks to Professor Mamayev A.I. as well as to the Center for material properties research of the physical-technical institute of Tomskiy polytechnic university, to Kazakhstan national university named after Al-Farabi for conducting tests of obtained oxide coatings.

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Short Reports

A VERY POWERFUL TECHNIQUE TO CREATE LIFT FORCE (THRUST) ON VTOL AIRCRAFT

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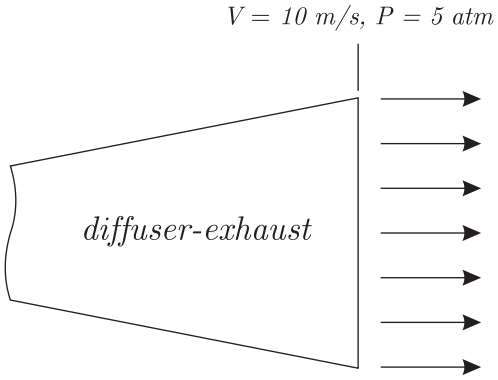
To create a high lift force (thrust) with low power consumption and small size of power unit is very important for the aviation industry. In military aircraft vertical takeoff and landing is usually done with an extra engine (like the fighters Yak-36, Yak-38 and Yak-141) or an extra fan (like fighter F-35). The thrust equation for VTOL engine can be written as follows:

$$Thrust = mV_j + A_j(P_j - P_a)$$

First section of the equation is called the gross momentum thrust and second section is called pressure thrust, where m is mass flow, V_j is the jet velocity, A_j is exit area, P_j is exit pressure and P_a is atmospheric pressure. In the fighters mentioned above, the second section of the equation is zero ($P_j = P_a$) and all thrust is created by momentum thrust, but this method is not efficient, because high weight and volume and also high fuel consumption. If we can get more power by pressure thrust and minimal thrust by momentum thrust we will have a very efficient system for creating lift force (thrust) for using on VTOL aircraft.



Flow in outlet of diffuser (exhaust)

In this paper, I am going to introduce a very powerful technique to create lift force (thrust), in this technique I used a stream of air (gas) at very low velocity (10 m/s) and very high pressure (5 atm) in outlet of diffuser which is an exhaust, see figure, in these circumstances outlet gases of diffuser (exhaust) are highly unstable, to stabilize the flow and fix this problem, I used an innovative technique that I have called it False Wall Technique (FWT), by FWT we have the quite stable flow and diffuser-exhaust create very high lift force (thrust) with very low fuel consumption by very small power unit.

PRACTICAL TRAINING IN INNOVATIVE ENGINEERING ACTIVITY

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The recently declared modernisation of Russia's industry and its new stage of industrialisation based on an innovative approach is impossible without the development and improvement of engineering education as the latter sets the goal of raising the level of students' training, prepared to embrace innovative engineering activity (IEA). To enhance efficiency of such training, the Russia's government awarded to a group of higher education institutions a specific status – national research universities (NRU). It enables to strengthen and integrate a university's scientific, technical and educational potential and to turn it towards inventing a comprehensive strategy for the country's innovative development. On the one hand, such universities offer new and unique opportunities for effective learning, on the other – set new advanced requirements to university's students, teaching staff and researchers [9, 10].

Keywords: innovative engineering activity, competency, competence, elements of competency, national research university, summer science schools, tangible innovative product, intangible innovative product

The above IEA includes certain stages of the full innovation cycle: analysis of the current technical level, the synthesis of a new technical solution, development, production of new equipment and technologies available as commercial output, presented by intangible innovative products (IIP) in the form of documents of title for results of intellectual activity, scientific and technological documentation, as well as tangible innovative products (TIP) in the form of goods, works and services ensuring economic, social or other impact and thus being competitive [1, 2, 7]. Therefore, preparing students for the IEA should be based on their involvement, during training, in all these stages of the innovation cycle. This paper is concerned with extending bachelor training efficiency in IEA at research-intensive universities based on hands-on training i.e. obtaining TIP, in the framework of the regional summer science schools for students, postgraduates and young scholars.

In our earlier papers [6, 8, 11] we explained that for the practical training in innovative activity it is advisable to teach how to obtain tangible innovative products through summer science schools. Such schools have been held by the Chair of mechanical design of mechanisms and machines at Ogarev Mordovia State University since 2001 [11] and the accumulated experience allows us to conclude the following: "1) summer schools studies enable to fully develop competence in innovative engineering activity because this form of active study combines active recreation and intensive learning; 2) creation of academic environment for learners in summer time is efficient not only for students but also for a region in general as young people is the most open and proactive part of society and to use their potential in solving topical issues quite often allows to work out new ideas and mechanisms for putting them into practice; 3) choice of regional summer science schools for students, postgraduates and young scholars as a second (practical) stage of broadening IEA's competences ensures the enhancement of efficiency of students' training in IEA; 4) enhancement of efficiency of summer schools is ensured by the use of teaching methodology based on integrated pedagogical technology where cooperative pedagogy is underlying" [6, P. 88–89].

As stated earlier and proved by the researches of E.P. Groshevoi, N.I. Naumkin and other authors [3, 4, 7, 10, 13, 14] innovative engineering activity is mainly carried out in the framework of the innovation cycle. Therefore, the most successfully development of competences through summer school will be performed if we organise the learning process in a way when students go through all stages of practical work being engaged in IEA modeling with further obtaining an innovative product in the form of industrial sample (prototype). In our opinion, such training can be conducted by using digital technologies for the fabrication of innovative products [5, 12], which began to develop rapidly approximately from 80-ies of the last century and are being widely used worldwide. Their main difference from previous technologies pertaining to creation of three-dimensional objects is that they are not based on the removal of material (lathe turning, milling, EDM etc.) or change of a rough workpiece shape (such as forging, stamping, pressing), but on the gradual growth (adding) of material or change of the phase state of matter in a given area of space.

Today these technologies are known as [5]: SFF (Solid Freeform Fabrication), FFFF (Fast Free Form Fabrication) or CARP (Computer Aided Rapid Prototyping); (STL – stereolithography); (SGC – Solid Ground Curing); (FDM – Fused Deposition Modeling); (BPM –

Ballistic Particle Manufacturing); (SLS – Selective Laser Sintering); (LOM – Laminated Object Modeling); (MJM Multi Jet Modeling); immersion centres or virtual reality systems. All these technologies require the presence of a three-dimensional computer model of a workpiece being fabricated and the process of obtaining products has received a generic name – rapid prototyping.

Considering the great possibilities of the above technologies Institute of Mechanics and Power Engineering of N.P. Ogarev Mordovia State University, in complience with the development programme of a national research university has created, on the basis of the Centre for digital production, the division of rapid prototyping [12], where one of the abovementioned technological schemes is used: 3D model – 3D printing – prototype – copying.

Of all available means of digital production for summer science school we have chosen as an innovative technology teaching aid a 3D printer BFB 3000 which represents a unique, modern model from the company Bits From Bytes. With its performance and functionality similar to full-printers, it has the advantage of a light weight and compact dimensions and can therefore be installed in a regular office, any room or premises, not mentioning the off-site nature of a science school, and is operable 24 hours a day. The device has a simple and easy-to-understand interface, in some cases, it can be used without connecting to the computer, downloading all the necessary data via removable media. The device allows you to model objects with cross dimensions of up to 30 cm and with a speed of up to 15 mm^3/ sec. Important feature of this model is the capability of color printing. Due to this, it allows you to get the most complete picture of the design characteristics of the facility and to pay due attention to the experiments in this area. The models obtained in this printer, are characterised by the required quality, reasonable accuracy and the highest level of detail, conditioned that quality supplies are used. It is using this 3D printer that enabled all summer school learners to prepare models of tangible innovative products (TIP).

Teaching IEA in the above schools, as noticed in our early papers [11], is carried out in the form of a business game "Firm-2" (Figure), an upgrade of the business game Firm-1, containing the 2nd practical stage with additional *teaching aids* (3D printer, collection of scripts for creative competitions and sporting events) and advanced content (creation of TIP), which allows you to simulate all stages of IEA innovation cycle, engaging students. The Figure shows that in comparison with the previous business game "Firm-1", this game is carried out in several stages:

1) team building;
2) establishment of a company, the choice of company's activities and brand name;
3) formulation of the problem to be solved;
4) finding technical solution;
5) development of a 3D workpiece model;
6) development of the product using a 3D printer;
7) submitting applications for RIA;
8) defence of the project.

A group of students (6–7 persons) independently turns into a firm (company), which operates throughout their studies and includes an intermediate and final assessment, but, in contrast to the traditional activity, the teamwork is carried out not only during studies but also during all creative competitions, sporting and other events. Members of the group choose a leader who assigns roles (director, technical director, chief designer, patent engineer, economist, marketing manager). He/She then holds a meeting devoted to the choice of activities of the newly-formed "company", development of a "brand name" as the object of intellectual property. For the fulfillment of the main stage of the game (obtaining intangible and tangible IP) the team independently defines a problem in the chosen field of activity, formulates a clear objective to be gained to solve a problem, synthesises technical solutions (TS).

Of all available TS the team has to choose the most eligible one for registration, submits the documentation for a RF patent to protect the obtained solution. Next assignment for the "firm" is to develop a trademark or service mark for the anticipated release of the product (product, service) and to submit applicant materials for registration and issuance of a trademark certificate. Along with the above assignments each team received another task: to develop a 3D model of one of the main work pieces based on the obtained technical solutions, print it out using a 3D printer and demonstrate it when the project is being defended. This ensures the efficient development of the students' ability to synthesise and to design the product, to use knowledge of CAD and information storage, facilitates the development of creative imaging [15]. Obtaining the finished product, in turn, encourages the ability to commercialise the solution and to possess production technologies, the ability to follow up on to the decision. All this altogether forms a positive motivation in obtaining an IP. Defence of the project, as well as in the game "Firm-1" is carried out in the form of slide presentation prepared by each "firm" in front of a group of experts and members of other teams. Each participant has the floor in accordance with his/her position who presents the RIA, developed and fabricated IP (brand name, trademark or service mark, invention, utility model, industrial prototype), describes its potential application and the expected effect.

Attendees can ask questions and participate in discussions. Experts take the final decision based on the results of the defense (preparation of patent application, publication of scientific papers, recommendation for implementation). Additional participation of summer school learners in competitions and sporting activities was aimed at team building when solving problems, at identifying the true leaders, creating the ability to act and make decisions quickly and be responsible for them afterwards. Moreover, creative competitions contribute to the development of creative students' potential which is the essential element of the IEA.

Throughout the game cumulative points system (individual and team) was used when each team member was responsible for his/her actions before the team and for the team as a whole, under conditions of the need for mandatory decision-making in extreme situations (stress, lack of time, responsibility and so on). To demonstrate the amount of accumulated points there was a wall-mount record of learners' and teams' activity to be constantly filled in. It was also one of the main motives of active, responsible and effective work. Therefore, theoretical and practical training in educational innovative engineering activity (EIEA) simulates all stages of the innovation cycle, providing effective preparedness to carry out IEA.

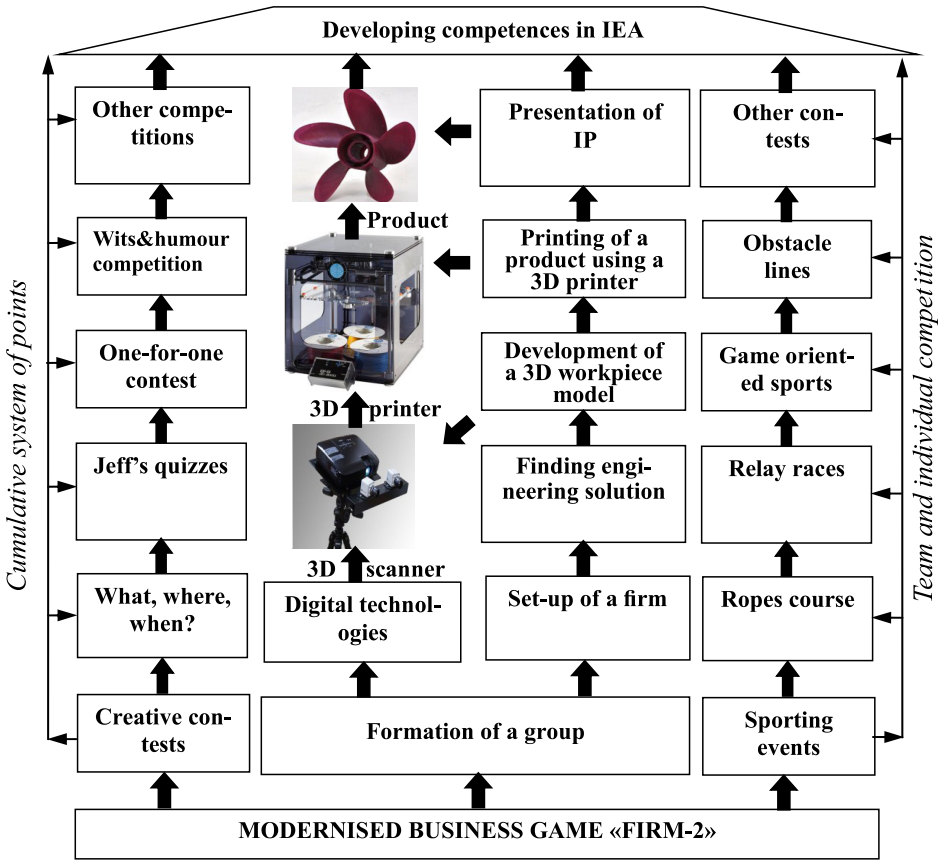
Apart from qualitative results of the pedagogical experiment the effectiveness of summer schools is proved by quantitative indicators:

1) learners participation resulted in over 50 publications, including peer-reviewed publications;

2) 10 patents for utility models and inventions were received and proposals for technical improvement were made;

3) from 2012 to 2014, three students from N.P. Ogarev Mordovia State University became the laureates of the Presidential programme of support for talented young people;

4) a grant totaling 2 million rubles for the competitive selection of one and two-year projects pertaining to implementation and development of programmes encouraging student design bureaus and similar public associations of students in the framework of the clause 2,4 under the Federal earmarked programme "Science and pedagogical staff of innovation Russia" was won;



Implementation diagram of a business game "Firm-2"

5) annual victories of students in international and nation-wide student academic Olympics in Agro engineering;

6) 4 students won presidential and governmental scholarships.

In view of the foregoing it can be concluded that high efficiency of summer schools is achieved by modeling all stages of innovation, a proper organisation of its operation mode, an intelligent combination of studies and recreation, a rational distribution of studies timetable aimed at fruitful creative work.

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Materials of Conferences

SOME METHODOLOGICAL STRATEGIES OF THE STUDENTS' INTEREST FORMATION TO THE SCINTIFIC RESEARCH

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The analysis of the factors, having influenced the students' tendency formation to the scientific research, has already been conducted. Moreover, it has been shown, that the environment is practically affected the motivation formation to the scientific research, in which the student is found himself. The formation technologies of the scientific skills in the teaching and research laboratories, having created at the enterprises on the chairs' initiative, are being provided. The methodical questions of the final subject conferences, laboratory practical and independent work organization, with due regard for the programs of the students' personal creative growth are also being considered.

The raw orientation of the Russian economy, the law social status after the thesis defending, the low percentage of the theses defending after the post – graduate course, – all this is practically led to the students' motivation decrease to be engaged in the scientific work. So, the State programs of the Russian further development for the 2013–2020-es are being focused on the use of the obtained scientific research achievements. Then, the poor school training, the priorities change in the life, the age peculiarities, the specific engineering training are practically the main factors, having influenced the students' motivation to the scientific research.

Purpose of the Study. The factors study, having influenced the motivation formation for the scientific research.

Material and research method. The factors' study, having influence the students' inclination to the scientific research, has been conducted by the students' groups interviewing from the various Institutes of the Higher Education, Colleges and Universities in the Tomsk city, the teachers, the heads of the teaching, educational, scientific and research laboratories, the students' parents.

Research results and their discussion

The Degree Influence of the Discipline Mastering. According to the research, the interest to the scientific research is practically appeared just after the discipline mastering at the level of about 75 % of the curriculum volume. The hybrid training and blending learning are the most promising ones, having combined practically all types of the training and learning, that can be further improved the materials presentation for any students' type. So, the hybrid training and blending learning – these are the lectures, practices and laboratories parallels. All levels of the development is suggested the master – class, video – fragments, laboratory practice conducting discussion and demonstration directly in the teaching and research laboratories. The testing trajectory, in which all the learning methods are practically intertwined, has already been shown, that psychological barrier is being reduced to the complex technology at the students.

The Group Project Learning – this is the fragment scientific research decision by the small team of the students from two or three people – this is the source of the students' creative applications. So, the democracy in the group project is practically allowed the students, as how to be participated and to be engaged in the scientific and initiative works, well as to offer their projects. Thus, the other Institutes of Higher Education, Colleges and Universities experience (e.g. TPU, TGU, TGASU) has been shown, that about 40 % of all the students are being engaged and involved in the group projects. So, the Group Projects – this is the communication between the treatment courses, the opportunity to see the work of others and to be weighted oneself. The practice – oriented learning function, the humanitarian and aesthetic one, and the educational one are being assigned on the group projects. Thus, the students are given the opportunity: "to be expressed themselves in the team", "to be felt the leader's occurrence situation", and to be played "the role of the manager or the subordinate".

The Interdisciplinarity. Currently, the science – is the sum of physics, chemistry, mathematics and many other areas of the knowledge. The introduction of such interdisciplinary subjects and courses, as "Patenting", "History and Methodology of Science", "Applied Engineering Tasks", and others is practically further developed the students' interest to the scientific research.

The Laboratory Practical Training Session. The studies have been conducted at the laboratory practical workshop on the technical disciplines oriented (e.g. Technology, Electronics, Optics). So, the interest excitation in the scientific research can be practically realized at the laboratory practical workshop, through the compulsory modules partition on the creative tasks [1]. Thus, the student has the right to choose the creative development of any fragment of the compulsory modules, which is developed the interest to the work and, it, moreover, is created the necessary reserve in the scientific and research, and practical activity of the student.

The approximate scheme of the laboratory workshop building has been presented in the Figure.

a) level; b) laboratory works at the enterprise; c) No. lab.;
d) creative task; e) gifted ones identification;
f) courses' fragments and VKR; j) projects coordination;
h) planning, restructuring, service fragments; i) multi – variance;
g) equipment study, emulation, master-class; k) individual statements; l) No. group.

The Laboratory Practical Training Session Building Scheme

So, the laboratory practical training session is practically conducted by the three – level scheme. Then, the students' activation is laid in the increasingly individual task and the operational "final review" just after each session. The excitation level of the program of the creative growth is practically based on the student's opportunities agreement and the degree of confidence. The laboratory practical training session, in the form of the physical experiment [2] is caused the most popular and the students' motivation.

The Teaching and Research Laboratories. The teaching and research laboratories and the student design office are practically allowed to realize the most advanced to date "the hybrid training and blended learning". So, the students' intercourse interaction in the scientific work is acted, as the factor of the support for the senior ones the undergraduate students. The stimulatory effect of the assignment has the title of "The Activist NIRS" and "The Excellent NIRS".

Thus, the experience has been shown [3], that the successful integration of the research, educational and industrial activity is quite possible only with the involvement of the employees of the firms and companies, as the teachers of the special subjects and disciplines of the curriculum and the use of the laboratory and technological base, as the chair, well as the production partner. The motivation is being increased at the students, that it is quite allowed to organize the full practices passage, the real coursework and projects implementation, the final qualifying works and the master's theses preparation, as well as the scientific and technical publications preparation, The variety of the interactive technologies are being practically implemented in the teaching and research laboratories. These are included the following: the meetings with the scientists and scholars, the heads of the departments, the works presentation at the conferences of the different, (e.g. especially, international) level and more et. al. The leading specialists and experts of the educational and scientific laboratories, having attracted to the educational process, contribute the increase of the quantitative and qualitative assessments of the management level by the students during the practice, the course design, or the final graduate works implementation.

The Creative Activity in the Discipline. Just after the main modules completion of the discipline, the student can get the creative task. So, the scientific research, having conducted by our chair, have already been shown, that any creative task, no matter, how attractive externally it did not seem the students, it cannot be entered into the training until, they have the necessary skills for its implementation. So, the series of the successive creative tasks is converted to the results, which are worthy of their further publication, and then, it is being transformed into the student's creative further growth program. That is why, many graduates are grateful to the chair for the submitted creative tasks, having already grown into the occupation and vocation.

The Personal Creative Growth Program [4] is practically suggested the creative tasks continuity, in relation to the student's inclination. So, in the process of the creative tasks carrying out, the student is practically led to answer the question: how and where does he see himself in a year (e.g. 12 months), two years (e.g. 24 months), three years (36 months)? The Personal Creative Growth Program in the first year – this is the ways development to be overcome the difficulties: communication with the curator, the resources mobilization. Along with the "Introduction to the Occupation" educational discipline, the laboratories tours and the meetings with the teachers are the significant elements. The motivators to the learning – are the history of the discoveries, the history of the graduates (e.g. the positive, negative ones). The goals formation and the program content are taken their place in the subsequent courses. The students are usually given the right to study the disciplines "by their choice", and to be developed the communication type "one with many". So, the participation in the scientific and research projects implementation within the group of a few people is practically being formed the special space for the engineering activity. It is quite necessary to the head of the group project, that "it is come" at the student, as the students are at such age, that they work by their interest, and not by their debt. Thus, "notebook" with the work plans records, experiments schemes, and the references to the literature is the significant element.

The Subject Conference. The conference is practically held on the basis of the creative and

independent assignments by the disciplines. At the end of the semester, each student practically performs at the subject conference on the final results of his "creative" activity. So, the presentation is consisted of the separate modules: the challenge state, the solution method, the simulation studies, the carried out scientific research, the obtained results and the conclusions. So, the presentation quality is practically reflected the local and the promising level of the creative growth program realization. Thus, the preliminary discussion of the works is encouraged the student a higher level of the accountability.

Conclusions

Thus, the conducted monitoring has already been shown, that the specialists and experts formation, having passed the track data, is usually occurred in 3–5 years (e.g. 36–60 months). About 50% of them defend the theses for the graduate school. So, the bad students do not happen. There are only the bad conditions. Those students, who are not capable of the creative activity, work successfully in the scientific and industrial sector, and they are often become the heads of the departments of the promising technologies.

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EFFICIENCY OF SMALL-VOLUME TECHNOLOGY OF CULTIVATION OF TOMATOES IN THE GREENHOUSE OF THE PREARAL AREA (KAZAKHSTAN)

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This article is devoted to research of efficiency of cultivation of various hybrids of tomatoes by a method of a small-volume hydroponics in the greenhouse in the conditions of the PreAral area of Kazakhstan.

Relevance of the research. Currently the key problem of saturation of the domestic market of Kazakhstan for fruits and vegetables is associated with a pronounced seasonal nature of vegetables and fruits.

However, if we compare Kazakhstan with countries that have similar climatic conditions, the availability of greenhouse area per an inhabitant in the country is several times lower than the world average and is only 0,1 % of the total vegetable production.

The situation is compounded by a lack of existing facilities of closed ground and their technological backwardness. Deficit areas of protected ground in different parts of Kazakhstan range from 4 to 35 ha, in the PreAral area – 5 hectares [1].

As a result, there is a seasonal lack of fresh vegetables in the country every year; therefore, the prices are increasing in the offseason.

Solving the problem of providing the population with vegetables throughout the year cannot be done without the intensification of the horticulture industry of protected ground which main and decisive factor is the development and implementation of scientific and technological progress.

A world trend in greenhouse production development is almost universal shift to intensive technologies and methods for growing plants in protected ground.

To date, these requirements are satisfied by small-volume system technology – growing plants on soil substrate using a drip irrigation system [2].

Insufficient level of development and the relevance of many of the issues of improving the efficiency of production of a protected ground, including the question of selection of new indeterminate tomato hybrids with generative type of development and the development of high-quality technology elements determined the direction of research.

Purpose and objectives of the research The aim of research was to conduct variety trials of indeterminate tomato hybrids such as small volume elements and rationale of their cultivation techniques adapted to the climatic conditions of the PreAral region.

Objectives and methods of research The object of the study is a full low-volume process of growing vegetables, tomato hybrids.

The studies included the consistent implementation of laboratory semi-industrial and industrial experiments using conventional methods in vegetable protected ground.

The scheme based on the method of split plots with randomized placement of options within each block was chosen for the experiment.

Because now all the production of vegetable crops in the greenhouses of Kazakhstan is based on the cultivation of hybrids of foreign selection, so 7 indeterminate tomato hybrids were chosen for this study: three Israeli selections – Sharlotta F1, Garem F1, Franchesca F1 and four selections – Dutch – Sample F1, Lilos F1, Favorita F1, Grace F1.

Cultures were grown in the extended circulation (Fig. 1) on a substrate of sawdust.

For mineral nutrition of plants the nutrient mixture, fully balanced in all macro- and micronutrients was used (Table 1) [4].

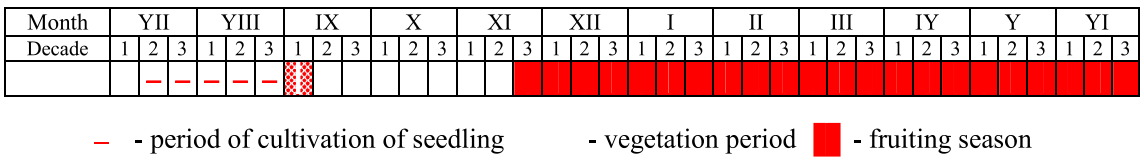

Fig. 1. Extension of the cultivation of tomatoes in a greenhouse

Table 1

Composition of nutrient mixtures for growing tomatoes, ppm

N	P	K	Ca	Mg	Mn	Fe	Cu	B	Zn	Mo
200	55	300	200	55	0,5	3,0	0,12	0,09	0,2	0,12

Watering and feeding of tomato plants was carried out by drip method. Plants were watered every hour from 7.00 a.m to 17.00 p.m. so that a certain percentage of the nutrient solution was withdrawn from the substrate through the drain with every watering (total drainage per day – 30%).

Power level was maintained depending on the phase of plant development from 0,5 to 3,0 Ms /cm, a pH of the nutrient solution was 5,5 – 6,5.

During the growing season the following stages were performed:

– phenological observations of plant growth and development,

– control of greenhouse microclimate parameters,

– monitoring of phytosanitary condition of landings and preventive measures,

– measures to build the plant, – measurement of the volume and concentration of the nutrient solution and drainage (daily),

– yielding and accounting.

The disperse analysis of variance results for their yield results was performed to test the statistical null hypothesis H0 that there are significant differences in the productivity of the studied hybrids and validation [3].

Results of research. Research has shown that the use of small-volume technology of growing indeterminate tomato hybrids in greenhouses adapted to the climatic conditions of the PreAral region allows to obtain a high yield of quality products. The investigated hybrids of tomato were significantly different in terms of yield from each other.

Under the experimental conditions in terms of yield the tomato hybrids were located in the following descending order: Franchesca F1> Lilos F1> Grace F1> Garem F1> Sample F1> Favorita F1> Sharlotta F 1.

The highest yield was demonstrated by a hybrid Franchesca F1 11,2 kg /plant. Enough fruitful hybrids were Lilos F1, Grace F1, Garem F1.The lowest yields compared with other studied hybrids were shown by Sharlotta F1 hybrids, Sample F1 and Favorita F1.

Such parameters as the number of mature fruit, the average weight of one fetus and uniform crop returns during the period of cultivation influence on tomato yield (Table 2, Fig. 2).

Since the highest yield of Franchesca F1 hybrid is explained by the fact that during the vegetation period of the plants at a hybrid the largest amount of 112 fruits was formed, though fruit weight was even lower than that of other hybrids – 100.0 g.

Sufficiently high yield of Lilos F1 and Grace F1 hybrids was identified contrary not by amount of fruits and a high average of one fetus weight. The same dependence of yield had the rest of hybrids:

– amount of fetus — Garem F1 = Favorita F1 = Sharlotta F 1; Grace F1 = Sample F1

– average weight of 1 fetus — Garem F1 > Favorita F1 > Sharlotta F 1; Grace F1 > Sample F1

– yield — Garem F1 > Favorita F1 > Sharlotta F 1; Grace F1 > Sample F1

Table 2

Yields of hybrid tomatoes grown by small-volume hydroponics

Hybrid	Number of fetus of 1 plant, pieces	Average mass of 1 fetus, g	Yield of 1 plant, kg
Sharlotta F 1	86	91,0	7,8
Garem F1	88	106,5	9,4
Franchesca F1	112	100,0	11,2
Sample F1	73	124,6	9,1
Lilos F1	80	126,2	10,1
Favorita F1	85	113,3	8,5
Grace F1	75	129,3	9,7
LED_{05} = 0,37			

An important role in obtaining high yields of vegetables under growing in the greenhouse has such a record as the uniformity of the crop. Dynamics yields results shown in Fig. 2 demonstrate that during the rearing period was uneven efficiency and yield was cyclical.

This is due primarily to the fact that the middle period of growing tomatoes in extended trade turnover is in the winter months, at a time when the main limiting factor is light.

The lowest yield of all hybrids was observed in February and March, as the flowering and the maturing of fruit was in the shortest day of the light period (December-January) and cloudy weather.

Most crop output was observed in all hybrids between April and June, because during this period the light factor ceased to be a limiting factor.

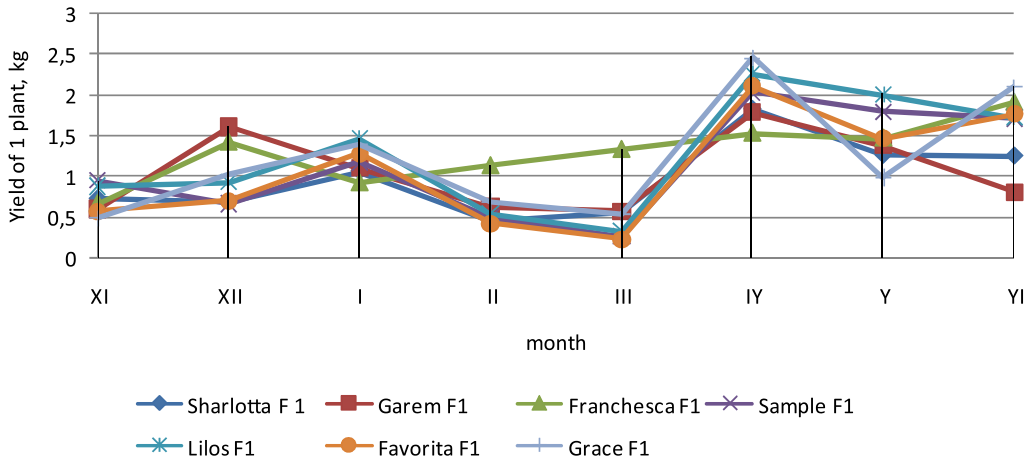

Fig. 2. Dynamics of the yield of tomatoes in the extended rotation, kg /1 plant

Table 3

Cost-effectiveness of small-volume method of growing tomatoes hydroponically on the substrate of sawdust

Index	Hybrids						
	Sharlotta F 1	Garem F1	Franchesca F1	Sample F1	Lilos F1	Favorita F1	Grace F1
Yield net, kg/1 plant	7,8	9,4	11,2	9,1	10,1	8,5	9,4
Cost, $ USA/ kg	1,08	0,98	0,66	1,10	0,84	1,16	0,98
Cost, $ USA/ 1 plant	8,42	9,21	7,39	10,01	8,48	9,86	9,21
Price, $ USA /kg	1,59	1,59	1,59	1,59	1,59	1,59	1,59
Total sum of sell, $ USA	12,40	14,95	17,81	14,45	16,06	13,51	14,95
Profit, $ USA	3,98	5,74	9,88	4,49	7,58	3,65	5,74
Profitability, %	47,3	62,3	124,6	44,3	89,4	37,0	62,3

This is due primarily to the fact that the middle period of growing tomatoes in extended trade turnover is in the winter months, at a time when the main limiting factor is light.

The lowest yield of all hybrids was observed in February and March, as the flowering and the maturing of fruit was in the shortest day of the light period (December-January) and cloudy weather.

Most crop output was observed in all hybrids between April and June, because during this period the light factor ceased to be a limiting factor.

Uniform crop out within the growing season was demonstrated by hybrid Franchesca F1 that explains its high yield compared to other hybrids.

Indicators of economic efficiency of small-volume method of growing tomatoes hydroponically on substrates of sawdust demonstrate that the intensification of production of tomatoes in the greenhouse through the introduction of smallvolume technology of cultivation of high-yielding hybrids significantly increases the profitability of industry and guarantees getting profit.

Conclusion

A fundamental factor in increasing the efficiency of tomatoes production in greenhouses is the use of small-volume hydroponics technology adapted to the conditions of a particular region and enterprises, as well as to the requirements of a particular genotype varieties (hybrid).

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STATE OF COLLAGEN SYNTHESIS IN GASTRIC MUCOSA AND RENAL TISSUE IN INDOMETACIN GASTROPATHY IN ANIMALS WITH EXPERIMENTAL RHEUMATOID ARTHRITIS

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It was established that reparation of ulcer defect heals by cicatrization. Main element of cicatricial tissue is collagen having amino acid oxyproline in its structure. Results of studying the latter in biologic fluids adequately reflect process of collagen formation [1,2]. Therefore studying content of this amino acid in tissues it may be predetermined a state of collagen formation and regeneration processes of ulcerous-erosive disorders in mucosa of gastrointestinal tract (GIT). As regards renal tissue a content of oxyproline specifies a state of inflammation process accompanying by sclerosis of renal tissue [3, 4, 5, 6, 7].

Aim of research: was to study a state of collagen synthesis in gastric mucosa and renal tissue in indometacin gastropathy in animals with experimental rheumatoid arthritis.

Materials and methods of research: Experimental studies were carried out on 21 male rats of mixed population with mass 160-200 g that were on common ration of vivarium. Animals were divided into 3 groups of 7 animals each. The 1st group was intact, the 2nd group with experimental rheumatoid arthritis (ERA), the 3rd group – animals with ERA and indometacin gastropathy (GERA).

Experimental model of rheumatoid arthritis was reproduced by a single administration of 0,2 ml Freund's adjuvant into posterior right leg of animal [8]. Indometacin induced gastro- and nephropathies were produced by administration of indometacin per os as water suspension at a dose 2,5 mg/kg during 5 days [9]. All painful procedures were performed in accordance with the WMA Declaration of Helsinki. To perform biochemical studies all the animals were single-stage decapitated under etherization. Stomach was extracted, then purified, washed with a cold physiological solution, proventriculus was removed. Mucous layer then was scarified, weighed and slurried in distilled water at a rate 30 mg/ml.

Kidneys were crushed and homogenized in a glass homogenizer with Teflon pestle in 3-4-fold volume of excretion medium consisting of 0,25M saccharose, 0,05M KCl in 0,05M solution tris HCl buffer (pH 7,4). To precipitate nuclei, mitochondria and disordered cells homogenates were centrifuged in 9000 g during 20 minutes. Content of oxyproline in supernatant fraction of homogenate was determined by a method of A. Steven and coauthors [10].

Results obtained were treated with using of Student's t-criterion by a statistically standard package of Microsoft Excel. Differences considered valuable in $p < 0,05$.

Results and their discussion: Results of studying a content of oxyproline in gastric and renal tissue are given in the table.

How it is seen from the presented data a content of oxyproline in gastric mucosa in ERA is practically not differed from control group, whereas it is reliably increased 35,6% from index of control group. Reduction in content of oxyproline noted to be in gastric mucosa 79,3% from control group in using of indometacin (GERA). Content of oxyproline in renal tissue was increasing 174,8% in this group. Probably, suppression of regeneration processes by indometacin in gastric mucosa was caused by abnormalities in functioning of numerous intercaused cytoprotective factors that leads to lowering of post-epithelial factors of protection, which principal element are "cytoprotective" prostaglandins. It is established that prostaglandin E_2 implements its protective potential on suppression of formation of gastric acid, increase of mucus and bicarbonate secretion, stimulation of regeneration.

Unlike to stomach a considerable increase of oxyproline in application of indometacin observed to be in kidneys. It is likely to be caused by some

Content of oxyproline in gastric mucosa and renal tissue in indometacin gastropathy in animals with experimental rheumatoid arthritis.

№	Group of animals	Oxyproline, nmol/mg			
		Stomach	p	kidneys	p
1	Control	2,12 ± 0,077		5,28 ± 0,180	
2	ERA	1,95 ± 0,062		7,16 ± 0,315	
3	GERA	0,44 ± 0,019	0,001	14,51 ± 0,384	0,001

N o t e : p – reliability from indices of control group.

inter-related mechanisms. Block of synthesis of renal prostaglandins by indometacin increases and prolongs vasoconstrictive action of angiotensin II playing a key role in progressive lowering of renal function by means of hemodynamic and "non hemodynamic" mechanisms [11, 12]. Renin-angiotensin-aldosteron system actuates when release of renin by juxtaglomerular cells of kidneys occurs. The latter catalyzes transformation of angiotensin in angiotensin I in the liver. Then locally in tissues occurs transformation of angiotensin I in angiotensin II (active form) – under participation of angiotensin I converting enzyme. Production and release of aldosteron, proximal canalicular re-absorption of sodium, shortening of afferent and efferent arterioles, heightened saline appetite, inhibition of parasympathetic nervous system, stimulation of β-adrenoreceptors, intensification of proteinuria – it is not complete list of effects provoked by angiotensin II. Mechanisms considered prove involvement of both glomerular and tubular-interstitial apparatus in damage of kidneys by indometacin.

Conclusions

1. Indometacin considerably reduces a content of oxyproline in gastric mucosa that confirmed suppression of regeneration processes.

2. Preparation increases a content of oxyproline in renal tissues in indometacin gastropathy that exhibited appearance of inflammation process leading to renal tissue sclerosis.

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Short Reports

DYNAMICS OF STEPPE VEGETATION AFTER FIRE IN TUVA

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Currently, the issue of conservation of biological diversity is one of global environmental problems [1, 2]. Fires are an important ecological factor influencing species composition, functioning, seasonal and long-term dynamics of inland ecosystems. Especially significant is the role fires play in the formation and maintenance of biodiversity of the Eurasian steppes, the prairies of North America, the savannas of Africa, downblended New Zealand and other ecosystems.

In recent years, in the steppe zone of the Republic of Tyva (RT) increased unregulated fires. The main causes of fires is the anthropogenic factor, reducing grazing pressure, in which there is an accumulation of dead aboveground biomass. In addition, the emergence of steppe fires contribute to climatic conditions of the region, with frequent periods of summer drought. Dry the mortmass steppe grass is flammable during droughts. The fire spreads quickly, covering large areas. Often used by the population fire as land treatment to improve the quality of steppe grassland herbage.

For the conservation and management of biological diversity of natural ecosystems should be explored in detail the impact of fire on natural ecosystems. In our work the results of studying the influence of different timing of fires on vegetation component of steppe ecosystems of Tuva.

The aim of this work was to study the influence of different timing of fires on dry steppe plant communities of Tuva.

Study areas and Methods. The study was carried out on grasslands within Tuvinian steppes (48°–51° N 91°–99° E) of Central Asia. The climate of this area is characterized by a rigorous cold and late spring. The yearly mean temperature is – 5°C (1975–2010). The coldest month is January with a mean temperature of – 37°C. July is the warmest month with 17°C. On the basis of definition of the growing season as the period over which the daily mean temperature remains above + 5°C [3].

Steppes are linked to chestnut soils. Their species composition is dependent on relief, soil and anthropogenic load.

The soil at the study sites have developed on chestnut with sand material. The humus profile is 10–20 cm deep and roots grow down to 50 cm.

To study the effect of different terms has fallen on above-ground phytomass and species composition of the steppes us was founded experimental plots in Tuvinian dry steppes district RT. To bookmark the site was chosen ecologically homogeneous areas of steppe grass with minimal anthropogenic impact. The study area was divided into 5 variations of experience 100 m^2. Around the plot was laid down protective fire lane width of 3 m. the Burning of herbage produced in the following order: in mid-April 2009, in mid-may 2009, in the middle of June 2009, the middle of October 2009. Control plot action the fire has not been. In 2009, the experiment was expanded and similar versions of the experiments were planted on the South and North of RT. The distance between the Northern and southern areas within 250 km. The Study was conducted in 2009–2014.

Records of the aboveground biomass produced in mid-July 2009–2014 by cutting the plants at a height of 1–2 cm from the soil surface at sites 1 m^2 in five replications. In addition, each site was collected litter. The cuts were sorted into fractions of green plants and rags.

The biomass of living plants was dismantled by agro groups. The biomass samples were dried until totally dry condition and weighed on an electronic balance accurate to 0,01 g. According to the five replicates was calculated the average value and standard deviation.

Data on aboveground biomass of steppe grass were subjected to univariate analysis of variance. In our calculations we adopted a significance level of 0,95. According to the results of univariate analysis of variance was determined by the strength of influence of factor on Snedecor:

$$h_x^2 = \frac{s_x^{\,2} - s_e^{\,2}}{s_x^{\,2} + (n-1)s_e^{\,2}},$$

were $s_x^{\,2}$ – intergroup dispersion;
$s_e^{\,2}$ – intra-group dispersion;
n – number variant in a separate gradations dispersion complex [4].

The objects used the same versions of the experiments, and in the study of productivity. Geobotanical descriptions of the experimental variants was carried out in mid-July by using Braun-Blanquet method [5]. In this case, fixed all the species of higher vascular plants. Latin names of species are listed by Cherepanov S.K. [6].

The similarity of geobotanical descriptions of the variants of the experience was determined by the method of P. jacquard [7]. The coefficient of similarity jacquard (K_J) is calculated by the formula: $K_J = N_{A+B}/(N_A + N_B - N_{A+B})$, where N_{A+B} – total number of species in compared the descriptions of A and B, N_A and N_B is the number of species in each of the descriptions.

Results. Experimental data on post-fire dynamics of common stock of the aboveground biomass of steppe grass in the survey area dry

steppe indicate that fires, regardless of application deadlines, significantly affect the stock of total aboveground biomass. While post-fire dynamics of common stock of the aboveground biomass in different years varies considerably. Changes in aboveground biomass of steppe grass after burning, are confirmed by the results of analysis of variance. It is seen that in 2009 between the data of the total aboveground biomass on the experimental variants where used fire and control there is a significant difference. The force of the impact factor on the April version is 91 %, the may – 92 %, in June – 93 %. It should be emphasized that the April fire has no negative impact on the accumulation of aboveground live biomass. At a later date fire has a devastating effect on the living above-ground phytomass. In particular, the June embodiment, the force of the impact factor on live aboveground phytomass is 87 %. Fire significantly affects the accumulation of dead aboveground biomass of all variants. The strength of the factor in the first year and reaches 94 %.

Conclusions

So, after fire in mid-may live aboveground phytomass of steppe grass cover is reduced. Thus from the fire significantly damaged grains, legumes, sedges. It should be emphasized that the June fire exerts a most pernicious influence on the regrowth of aboveground live biomass. With steppe species of legumes and sedges stop the formation of the aboveground biomass to the end of the growing season.

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Materials of Conferences

MYOCARDIAL REVASCULARIZATION IN PATIENTS WITH ADVANCED ATHEROSCLEROSIS: TACTICAL ISSUES

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In order to assess the efficiency of CABG using nonlinear venous bypass grafts (experimental group) we compared its outcomes with linear venous bypass grafts-only CABG (control group). A total of 272 coronary arteries were bypassed in experimental group vs. 217 arteries in control one. Using sequential venous bypass grafts, we managed to restore blood flow in a total of 145 coronary arteries (53,3 %). Most bypassed were left margin artery 48 (33,1 %), circumflex artery 33 (22,7 %), diagonal artery 28 (19,3 %), posterior interventricular artery 17 (11,7 %). Using naturally bifurcated venous bypass grafts, we restored blood flow in 68 (25 %) coronary arteries. Most bypassed were CA 18 (26,4 %), left margin artery 16 (23,5 %), diagonal artery 15 (22 %), and posterior interventricular artery 11 (16,1 %). Using composite and combined bypass grafts, we restored blood flow in 12 (4,4 %) coronary arteries. The incidence of intraoperative injury to the aorta in both groups differ dramatically: 2 % vs. 11,1 %, respectively. Such a difference in intraoperative injury to the aorta is due to a lesser number of aortic anastomoses in experimental group where nonlinear versions of venous grafts were used. Acute heart failure was also notably higher in the control group: 14,8 % vs. 3,9 %. Acute heart failure caused death in four (7,4 %) control patients. Acute cerebrovascular event rate was higher in controls: 14,8 % vs. 2 %. One patient in the control group succumbed to acute cerebrovascular event. Also, there was reported high rate of respiratory failure (25,9 %) among controls compared to experimental group (11,7 %). Infective complications as represented by mediastinitis in all cases were noted in 3,9 % of experimental cases, which was almost twice as less than in controls (9,2 %). Postop hemorrhage mandating resternotomy was almost equal in both groups (3,9 % vs. 3,7 %). Significant difference in the rates of acute heart failure, acute cerebrovascular events, respiratory insufficiency, and infections is secondary to the length of pump and aorta cross-clamping times in both experimental, and control groups: 116/71 minutes vs. 138/85 minutes, respectively.

So, using the algorithm developed for nonlinear venous bypass graft CABG in multivessel coronary lesions, combined with atherosclerosis of the ascending aorta, we managed to reduce the number of aortic anastomoses and achieve complete myocardial revascularization, reduce pump time and aorta cross clamping time.

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RESULTS OF APPLYING A NEW TECHNOLOGY FOR MEASURING THE LEFT ATRIUM VOLUME DURING ATRIOPLASTY

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Johnson Jetal, 1967, Barnhorst D.A. et al. 1975., Deeg P. et al. 1977, Kawazoe J. et al, 1983). Piccoh G.P. et al. (1984) made a comparative analysis of outcomes of surgically treated patients who underwent mitral valve replacement. They found total mortality at 8,5 %, with mortality in a group of patients with giant left atrium (GLA) being as high as 20 %. Many researchers were able to demonstrate that the repair of atriomegaly would have positive effect on both early, and late postoperative period with improved life expectancy in such patients.

The purpose of the study was to reliably measure the LA volume and specify indications for atrioplasty. To achieve this goal, the following tasks were set:

1. Develop a new method for measuring the LA volume.

2. Compare the obtained data with those in the control group where measurements were made using echocardiography.

Material and methods. From 2005 to 2014, 176 patients suffering from mitral valve diseases complicated with atriomegaly and atrial fibrillation were operated upon at the cardiac surgery unit, National Scientific Center of Surgery. Seventy-three were male (41.5 %) and 103 were female (58,5 %), with median age of 41,5 ± 27,5 years. The breakdown of patients by the degree of heart failure was as follows: 124 (70,4 %) patients were in NYHA Class III, the remaining 52 (29,5 %) in NYHA Class IV; 119 patients (67,6 %) were in ACC 2 stage with remaining 57 (32,3 %) in ACC 3 stage. All patients had the history of atrial fibrillation in excess of three years. The LA sizes were obtained using the heart ultrasound (see Table).

Echocardiographic indicators

Parameters	EDS, cm	ESS, cm	EDV, ml	ESV, ml	LA, cm	EF, %
Before operation	6,7 ± 0,1	4,9 ± 0,5	258 ± 30	127 ± 1,5	7,8 ± 0,3	50,8 ± 1
After operation	5,9 ± 0,5	4,1 ± 0,3	173 ± 48,5	72 ± 10,5	4,8 ± 1,0	58 ± 1

N o t e : EDS – end-diastolic size, ESS – end-systolic size, EDV – end-diastolic volume, EDV – end-systolic volume, LA – left atrium, EF – ejection fraction.

We performed mitral valve replacement with suture ligation of the left atrial appendage in 111 patients (63 %), Another 62 patients (35,2 %) received the Kawazoe atrioplasty, three patients (1,7 %) had Mercedes type atrioplasty, and in five cases, we performed additionally the maze procedure. The LA cavity was measured in 27 control patients (41,5 %) using echocardiography: LA volume was 270 ± 60 mL preoperatively, and 140 ± 25 mL postoperatively.

Intraoperatively, we measured the left atrial volume in 38 (58,5 %) patients in Group 2 using the methodology developed in our clinic: 520 ± 50 mL before and 175 ± 20 mL after the operation. We would question the reliability of the echocardiographic measurement of the LA volume when the preoperative reading had been 265 ± 40 vs. 140 ± 15 mL postoperatively.

The method we developed is as simple as that: a surgical glove would be placed into the left atrium preoperatively, then filled with saline, and the volume of fluid instilled would be accurately measured. The same manipulation would be done after the completion of atrioplasty.

Results: Left atrioplasty resulted in shrinkage of the left atrium from 8,6 cm to 5,4 cm, on average (Group 1). In immediate postoperative period, only 87 (49,3 %) patients required inotropic support with Dopamine up 5 mg per kg body weight per minute. The remaining patients did not need any cardiotonic agents. Atrial fibrillation disappeared in 94 (53,4 %) patients.

Conclusions: 1. Left atrioplasty does result in a marked reduction in the LA size, resolves the left postero-basal left ventricular compression syndrome, reduces the tracheal bifurcation angle, and decompresses the left main bronchus and the lower lobes of the right lung. This explains the drop in frequency and duration of acute heart failure early postoperatively.

2. Secondary to decompression of the left main bronchus and the lower lobes of the right lung, the length of postoperative lung ventilation would shorten, the lungs would spread better; hence, the incidence of postoperative pulmonary atelectasis, pneumonia and tracheobronchitis would drop. As a result, the patients would have a shorter stay in the ICU, rehab quicker and generally, have a shorter length of stay in the hospital.

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THORACOTOMY APPROACH IN REPLACEMENT OF TRICUSPID VALVE: TACTICS AND OUTCOMES

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Objective of the research: define surgical tactics for replacement of tricuspid valve.

Material and methods: From 2007 to 2014, eighteen patients underwent tricuspid-valve replacement (TVR) at the National Scientific Center of Surgery named after A.N. Syzganov. In half (nine patients), TVR followed prior operations on repair of acquired heart diseases. Six patients (33,3 %) had Ebstein anomaly, two were drug addicts with infective endocarditis, and another one had traumatic tricuspid regurgitation. Four were male, 14 female (22,2 % vs. 77,7 %). Two (11,11 %) were in ACC stage B, with remaining sixteen (88,9 %) in ACC stage 3. Four (22,2 %) patients were in NYHA class III, while 14 (77,7 %) were in NYHA class IV. Fourteen had regurgitation Grade 3 to 4, two patients had combined heart disease, while two had stenotic tricuspid valve with calcified cusps.

Results: All eighteen patients underwent tricuspid-valve replacement: four (22,2 %) were implanted with *MedInge*-2 33 sized prosthesis (Russia), while fourteen (77,8 %) were implanted with bioprostheses (*Pericor*, *Comcor,* Russia). In nine patients (50 %) who previously underwent mitral and aortic valve replacement and were on continuous anticoagulation, the following tactics was chosen: right sided thoracotomy approach through the 4th intercostal space was attempted in 6 (66,7 %) patients, CPB was initiated in a standard way, though a 9-size cuffed intubation tubes were used instead of venous cannulae through the pericardium, without any cardiolysis. This helped us avoid circumventing the venae cavae, thus considerably reducing the bleeding. In three patients, the heart prostheses were implanted under parallel perfusion, using continuous Prolene 2/0 suture, with 2 or 3 mattress sutures in the bundle of His area.

In 8 of 18 cases the aortic cannula was inserted in the ascending aorta, while in the remaining cases the left femoral artery was cannulated. In nine patients, we were lucky not to release the heart of cohesions and had a routine operation. Four patients (22,2%) required inotropic support with Dopamine (5 mg/kg body weight per minute), another four (22,2%) needed up to 10 mg/kg body weight per minute. The rest of the patients did not require any cardiotonic agents. No deaths or complications were observed. The patients were discharged on day 12 to 14 post-op.

Coclusions: In patients with previously implanted mitral or aortic prostheses and on VKA anticoagulation, tricuspid-valve replacement should be performed via thoracotomy, under parallel perfusion, with 9-size cuffed intubation tubes used instead of venous cannulae. This does not deteriorate the pump and contractile function of the left ventricle, while improving the respiratory dysfunction. When performing primary tricuspid valve repair, the surgical approach and all the rest is done a routine fashion.

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ANALYSIS OF THE HEALTH STATUS OF THE STUDENTS ENROLLED IN THE MAJOR HIGHER EDUCATIONAL INSTITUTIONS OF THE ALTAI TERRITORY IN THE 2014–2015 ACADEMIC YEAR

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In recent years, modern man is increasingly looks narrowly at the state of their own health and of their children. He began to undergo regular medical examinations to monitor the quality of the food, engage in physical culture, he giving up bad habits.

According to the Federal State Statistics Service, since 2000 on average number of born alive per year, 36,6% children born sick with various diseases, 3% – with congenital anomalies, 50,3% – with individual adverse conditions originating in the perinatal period. To 7 years almost 33% of children diagnosed with chronic diseases, and to 14 years - variations in health status have almost 60% of adolescents [2]. According to the chairman of the Public Chamber of Russia Yevgeny Ochkasova in 2013 only 10% of high school graduates can be called healthy [1].

If only 10% of high school graduates can be considered relatively healthy, what happens to them in higher educational institutions (later in universities)? Obviously, the health of students during the years of education only gets worse: suffering mental health, musculoskeletal system, cardio – vascular and respiratory system, digestive organs, deteriorating eyesight and other organs and body systems.

As a result of the medical examination first-year students, by health workers, all students of educational institutions for physical training, depending on the state of health, physical development and functional training are divided into three groups: primary, preparatory and special. Separately distinguished students who are fully exempt from the practical lessons on discipline "Physical training".

In order to determine the state of health of students of the Altai Territory, we have analyzed the results of the medical examination of freshmen 2014–2015 academic year, the five main universities of Altai Territory: Altai State University (AltUni), Altai State Technical University the name of I.I. Polzunov (AltTechUni), Altai State Agricultural University (AltGAUni), Altai State Pedagogical University (AltGPUni) and the Altai State Medical University (AltGMUni). A total of 5532 analyzed the results of the medical examination of first-year students of full-time academic year 2014–2015 (Table 1).

The obtained results showed, that to the primary group of health for physical training, there are 3478 students, accounting for 62,87% of the total number received, the preparatory – 817 students, accounting for 14,77%, to a special medical group there were 1061 students (19,18%).

It is worth noting, that according to the results of the medical examination, to the primary group of health belong practically healthy students with minor deviations in health, good physical development and physical preparedness.

Table 1

The distribution of first-year students on medical teams for the physical training

Indicator	Medical teams			
	Primary	Preparatory	Special	Exemption
Number of students	3478	817	1061	176
% o students	62,87	14,77	19,18	3,18

Table 2

The results of the medical examination of the full-time first-year students, enrolled in the major universities of the Altai Territory in the 2014–2015 school year

University	Medical teams, %			
	Primary	Preparatory	Special	Exemption
AltFMU	29,34	33,09	36,56	1,01
AltGTU	68,86	13,85	15,6	1,69
AltGAU	70,24	2,35	23,29	4,12
AltU	55,52	20,05	20,23	4,19
AltGPU	87,84	2,85	4,27	5,05

Thus, 37,13 % of the students, of the total number received in all the relevant universities have varying degrees of deviations in health status (preparatory, special medical group and released from physical training). Of these 176 students, which is 3,18 %, they have a serious illness, including disability, and fully exempted from practical lessons on discipline "Physical training".

In the Altai State University, according to the results of medical examination admitted roughly equal number of students belonged to preparatory and special medical group – 20,05 % and 20,23 % respectively of the total number admitted to this school, and in the Altai State Technical University – 13,85 %, and 15,60 %, respectively (Table 2).

In AltGAU and AltGPU the preparatory medical group on the results of a medical examination referred smallest number of students compared to other universities – 2,35 % and 2,85 % respectively. As a result of the medical examination of the first year students of AltGPU also recorded the lowest number of students assigned to special medical group – 4.27 % of the total received by the Academy. Among the other distinguished universities AltGMU, which, in the period under review, received the largest number of students with different variations in health status. The preparatory medical group medical university enrolled – 33,09 %, in special medical groups – 36,56 % of the students.

Based on the findings, we can say that in AltGPU in the 2014–2015 academic year admitted the maximum number of relatively healthy students, compared to other universities – 87,84 %, and the largest number of students exempt from practical physical training – 5,05 %. In AltGMU there was recorded the lowest number of relatively healthy students – 29,34 %, and 1,01 % – exempt.

From the results of medical examination we can say that the quality of health of highly qualified graduates desired to be better, because today's freshmen, will be graduates "tomorrow". In this connection, in our opinion, we have to not just be in the active search for new effective means and methods of physical education aimed at the preservation of health and prevention of major diseases, but already starting to use them in the educational process.

The main diseases of young people in Russia are cardio – vascular, respiratory, nervous system, musculoskeletal system, and organs of sight [2]. Given this fact, we believe that it is necessary to include in the content of each physical education classes for students of preparatory and basic health group corrective exercises aimed at disease prevention and health promotion. Exercises that bear such a nature, has long included in the content of the classes of special medical group, but as a rule, are not compulsory in primary and preparatory group health.

If today the teachers of secondary schools and teachers of higher and secondary specialized educational institutions of physical education in their classrooms will apply corrective exercises aimed at disease prevention and health promotion, then tomorrow we will see a completely different data.

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THE ADVANTAGE OF EXOSOMES AS VECTORS OF DRUGS

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The article considers the advantages of exosomes as vectors of medications over artificially constructed vesicles.

The main problem of modern therapy is the low pointness of drugs and obsolescent over time medicines. In connection with this it is necessary to create new delivery agents providing direct delivery of

the medical product in the pathological process area in the required therapeutic concentration, to reduce the adverse effects on the body of toxic compounds, which can extend the life of existing drugs, and more fully realize their potential.

Currently, work is underway on the construction and improvement of artificial vectors, which main problem is the lack of focus, not investigated biocompatibility, the labor intensiveness, high cost of production and consequently expensiveness drugs. By focusing on this complex process, we forget about the existence of biological containers – exosomes.

Exosomes – natural microvesicles consisting of a lipid shell by diameter of 30-100 nm secreted into the extracellular space by the various cells of the body, which fundamental function is intercellular communication [1, 4].

Compounds, included in the exosomes (micro-RNA, proteins, lipids annexins, and other) is determine their properties. Exosomes are able to protect the medical product from degradation, implement its directed transporting, protect the organism from the effects of highly toxic medical product, penetrate through all kinds of barriers, opening the possibility for the treatment of previously inaccessible pathological centers, they are not captured by cells of the reticuloendothelial system, and remain invisible to the immune system cells [2, 3].

To achieve the pointness there is necessary to attach specific ligand to the surface of exosomes for which there is a specific receptor or other object to be linked. Under the influence of annexin there occurs endocytosis of exosomes with a cell, and under the action of intracellular enzymes drug is release, which modifies the functions of the target molecules.

A potential problem of using exosomes as vectors may be the presence of the major histocompatibility complex on their surface, but the solution to this problem, as well as the source of the mass production of exosomes may serve as mesenchymal cells with suppressed synthesis of major histocompatibility complex [5].

Getting exosomes does not require complicated methodics and the availability of expensive equipment. Why use a time-consuming and expensive production of drugs, where there is the possibility of an alternative use of natural biological delivery system that does not require global costs?

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ETIOLOGY OF FEBRILE SEIZURES AT CHILDREN

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In recent years, we see increasing attention of pediatricians, neurologists, epileptology problem attracted febrile seizures (FS). Febrile seizures are paroxysms different duration, including other forms of tonic or tonic-clonic seizures in infants, young and school-age children with body temperature of at least 38 °C (except convulsions in neuroinfection). FS can be transformed into afebrile seizures and epilepsy. FS are not epilepsy, but may be the cause of epilepsy and forming a stable intellectual and neurological deficit. To date, there is no clear understanding of the causes of FS, but as an opportunity to consider several factors. It is assumed that any infection can trigger the development of attack. In the structure of infectious diseases in children are leading acute respiratory infections (ARI).

Purpose – the study of FS etiology in children aged from 3 till 36 months (3 years old) with ARI.

Methods and patients. We observed 58 patients with FS on the background of ARI in the Krasnoyarsk Inter-District Children's Hospital №1 (October 2013 – February 2014). In order to decipher the underlying disease etiologic research was conducted from nasal swabs in the reaction immunofluorescence antigen detection of respiratory viruses, identification markers herpesvirus (HSV types 1 and 2, HHV-5 (CMV), HHV-6) in serum by enzyme immunoassay with the definition of the index of antibody avidity. We study determination of DNA viruses in blood lymphocytes, nasopharyngeal mucus and urine by PCR.

Results. The average age of the patients was 24,6 months: 56,9 % of boys (33 pers.), 43,1 % girls (25 pers.). Among the children surveyed we have found the following etiological structure FS: antigens of influenza A virus (H3N2) – 15,5 % (9 people); respiratory syncytial virus, adenovirus and parainfluenza virus type 1 accounted from 7 % till 9 % of FS cases. Along with the respiratory virus group, one of the leading agents in subjects herpes viruses were the 5th and 6th type. Determined by

enzyme immunoassay Ig G titers to HHV-6 type at 22.4% (13 pers.) In the study of blood serum enzyme immunoassay were detected CMV Ig G antibodies in 25.9% (15 people.) Observed patients have antibodies CMV Ig M and Ig G were detected in 1 child. At 5.2% (3 pers.) enzyme immunoassay surveyed registered a high titer of Ig G HSV types 1 and 2 (1:3200). Among all surveyed virus viral mixed infections (ARI + infections caused by herpesviruses 1st, 5th and 6th type or combinations thereof) are installed in 36,2% (21 pers.)

Conclusion. The results of the study confirm the diversity of etiological structure of ARI, as well as high herpesvirus infection of children with FS development. FS are actual problem of modern pediatrics. For proper diagnosis, choice of causal treatment and dispensary observation of this group of patients is necessary to continue research in this area.

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MODALATION OF VERBAL ADVERBS IN THE RUSSIAN LANGUAGE

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The article provides a comprehensive description of the process and result of modalation of verbal adverbs with dependent words in the Russian language. It reveals the cause of this type of transposition, lying in the enhancement of the subjective factor in the language, the speaker's intention to give a multidimensional assessment to disclosures, identifying its authenticity / non-authenticity (by referring to the source); speaker's own attitude towards style of speech, way of expression of thought, its place in the discourse; assessing the speech in terms of adherence to various communicative features i.e. pureness, accuracy, simplicity, integrity, etc., as well as in the context of synchrony / diachrony , scope of use, etc. The authors draw attention to the fact that modalation of verbal adverbs causes the appearance of grammatical homonyms, which can be differentiated, on the one hand, by verbal adverbs and their verbal properties (adjunctive action, perfective/imperfective aspect, relative time and voice, function of the secondary predicate, etc.) and on the other hand – by modal words and their characteristics (semantics of subjective modality, function of parenthetic part, invariability, a certain degree of clause phraseologisation with verbal-adverb modalate, a special type of intonation characterised by falling tone and a more accelerated pace of speech, introductive relation with the utterance or its part, the ability to participate in the actual division of a sentence, pinpointing its comment or topic, the opportunity to use it in the informal conversation in comparison with sentences with verbal adverbs, etc.).

Among the transpositional processes occurring in the grammatical structure of the Russian language a special place is occupied by modalation of words belonging to different parts of speech: verbs in different grammatical forms – gerunds (*говоря, выражаясь – speaking, expressing,* etc.), infinitives (*знать, видать, признаться – to know, to see, to admit oneself,* etc.), short participials (*видимо, не в обиду будет сказано – apparently, no offense meant,* etc.) and finite forms (*признаюсь, говорят, кажется – I confess, they speak, it seems*, etc.). Verbal adverbs, unlike other verbal forms, are transposed in the semantic-syntactic category of parenthetic-modal units only in combination with other words.

The reason for modalation of verbal adverbs within the parenthetic construction lies in the enhancement of the subjective factor in the language, the speaker's intention to give a multidimensional assessment to disclosures, identifying its authenticity/non-authenticity by referring to the source (*судя по имеющимся у следствия доказательствам; говоря словами – judging by available evidences; putting it in the words of ...*); the speaker's attitude towards style of speech, way of expression of thought, its place in the discourse (*рассуждая философски, здраво; иначе говоря; кстати говоря – reasoning philosophically, maturely; otherwise speaking in other words; speaking of which*); assessing the speech in terms of adherence to various communicative features i.e. purenes, accuracy, accessibility, integrity, etc., as well as in the context of synchrony / diachrony , scope of use, etc (*выражаясь правильно, грамотно; образно; точнее; популярно; грубо; современным языком; высказываясь кратко; изъясняясь проще – speaking accurately, properly, competently, metaphorically, more precisely, in lay terms, roughly; in modern language; speaking concisely; speaking in simple terms.*

The subject of the modus assesses the reported information from the point of view of a responsible / irresponsible approach to something; compliance / non-compliance with the laws of logic or life experience, awareness / ignorance about the real state of things, objective / subjective approach to something; in terms of any theory or anyone's opinion; taking into account official / unofficial nature of speech; in terms of the norms of ethics and morality, etc. (see also [1–2, 4–5]).

As a result of modalation verbal adverbs lose, except for rare cases (such as *Пользуясь случаем, хочу сказать – Relishing this opportunity I would like to say...*), basic grammatical properties of the verb – semantics of adjunctive action and means of its expression – aspect, relative time and voice, function of the secondary predicate, preserving, at the same time, syntactic relations with dependent words in an isolated structure and semantic relation with the source verb-predicate. Keeping some of the syntactic attributes of the verb, verbal adverbs in parenthetic-modal use lose their semantic relationship with the subject of dictum in the predicative nucleus of the utterance, not allowing to fulfill the verbal function of the secondary predicate.

As it is known, sentences in which verbal adverbs have no relation with real or potential subject, correlated with the position of logical subject, are on the verge or beyond the grammatical norms of modern Russian literary language. Cf.: **Проезжая по мосту, у меня слетела шляпа.* **Riding through the bridge, I lost my hat.* It is hardly legitimate to discern a verbal adverb in impersonal sentences with parenthetic phrases such as *Говоря откровенно, его там вообще не было – Frankly speaking, he was not there at all.* Moreover, verbal-adverb modalates like *говоря – speaking*,

being uninformative as metatextual operators, can be removed without any damage to the general meaning of the statement. Cf.: *(Говоря) откровенно, его там вообще не было. (Speaking) honestly, he was not there at all.*

The morphemic structure of verbal-adverb modalates such as *(собственно) говоря (properly) speaking* has an "obscure" character, hindering the identification of separate morphemes, in particular the formative suffix *–я/уа*: it loses grammatical function, i.e. the ability to express the relative temporal values of simultaneity (adjunctive action with basic action), turning into an "empty" morpheme, a structural component of the word stem. A similar picture can be observed when the functional predicativation of short passive participles occurs in impersonal statements, such as *Ни одного письма еще не отправлено – Not a single letter has been sent so far* where flexion *–о* has lost grammatical meaning of neuter gender, singular and was transformed in a nonsemantic, structural element of the word, similar to some extent to the suffix *–о* in short passive participles involved in the transpositional processes of functional adjectivation and predicativation in such contexts as В *купе не убрано, не проветрено – The compartment is not cleaned, not aired* (about two combined types of transposition of short passive participles – adjectivation and predicativation see [3]).

Modalation of verbal adverbs in the Russian language, which has a purely grammatical character, nevertheless, occurs in the framework of the source verbal lexemes, without violating the semantic identity of the word. As a result of this type of transposition of linguistic units grammatical (not lexical!) homonyms appear such as *выражаясь – swearing* (verbal adverb) (1a) – *loosely speaking* (modalate) (1b):

(1) (а) *Он размахивал руками, грубо* ***выражаясь*** *при этом в адрес собеседника He was gesticulating and at the same time* ***swearing*** *at his opponent* (verbal adverb from the verb to express oneself);

(б) *Иди ты, грубо* ***выражаясь****, подальше… Get, loosely speaking, lost* (verbal-adverb modalate, functioning within verb lexeme *выражаться – to express oneself*).

It is important to underscore that along with verbal-adverb modalates Russian language speakers also use verbal adverbs that cause appearance of those modalates. This means that, for example, the existence of modalates *говоря, выражаясь, рассуждая, мысля, судя – speaking, expressing oneself, reasoning, thinking, judging* in the position of parenthetics does not exclude the existence of verbal adverbs *говоря, выражаясь, рассуждая, мысля, судя – speaking, expressing oneself, reasoning, thinking, judging* that function as secondary predicate and/or modifier. To differentiate them, one can apply to, on the one hand, verbal adverbs and their verbal properties and on the other hand – modal words and their characteristics (semantics of subjective modality, function of parenthetic part, invariability, (cf. the forms of active and passive voice of verbal adverbs: *судя по… / будучи судимы по... judging by / being judged on...*), a certain degree of clause phraseologisation with verbal-adverb modalate, a special type of intonation characterised by falling tone and a more accelerated pace of speech, introductive relation with the utterance or its part, the ability to participate in the actual division of a sentence highlighting its comment and topic, the opportunity to use it in informal conversation in comparison with sentences with verbal adverbs, etc.].

The absence in the analysed word form the most important semantic-grammatical characteristics of the verb, such as the semantics of adjunctive action and means of its expression – aspect, relative time and voice; function of the secondary predicate and the presence of the main characteristics of modalates – subjective modal meaning expressing the subject of modus' attitude to what is said, the function of parenthetics, etc. speak for its parenthetic-modal nature, i.e., that before us is a specific parenthetic-modal type of using word-forms such as *(честно) говоря, (грубо) выражаясь, судя (по всему) – (honestly) speaking, (roughly) speaking, judging (by everything)*. Verbal adverbs and verbal-adverbs modalates are similar in distinctive features such as the identity of the lexical meaning; the ability to collocate with objective and adverbial modifiers; to be part of unattached phrase which is enclosed in commas, or – less often – hyphenated; the presence of condition-effect relationships between the unattached clause and predicative nucleus of the utterance. Cf.:

(2) (а) *Честно говоря, он не ожидал такого развития событий* (≈ 'Если говорить честно, он не ожидал такого развития событий') *Honestly speaking, he did not expect such an outcome* (~ To speak honestly, he did not expect such an outcome);

(б) *Честно говоря о случившемся, он вряд ли мог бы рассчитывать на снисхождение* (≈ 'Если бы он говорил честно, то вряд ли мог бы рассчитывать на снисхождение'). *Telling the truth about the occurrence, he would hardly have counted on indulgence* (~ If he told the truth he would hardly have counted on indulgence).

The difference between condition-effect relations in the above statements is that in one of them the condition is linked with the position of the speaker – the subject of modus (2a) and in the other with the potential implementation of adjunctive, secondary action (2b).

Based on what has been said it follows that the process of modalation of verbal adverbs occurring within the parenthetic constructions is related to significant reduction of verbal characteristics and enhancement of subjective-modal principle, allowing the speaker (the subject of the modus) to assess the information or its part from different angles.

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