THE HIGH SPEED SPINDLE UNITS INSIDE GRINDING MACHINE FOR PRECISION PROCESSING DETAIL OF FLYING MACHINERY

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The article reveals the construction of a high-speed spindle block with a front gas and magnetic bearing and a back gas-static one. The results of spindle block service tests are given. Exposed perspective type bearings of spindle units for high speed processing-created experimental industrial model high speed spindle units with front gas-magnetic bearing for inside grinding machine. Operational tests spindle units showed high quality processing materials.

Keywords: high speed processing, spindle units, gas-magnetic bearing

Labour-intensiveness of details mechanical operations on belt grinders is known to constitute a major part of total labour-intensiveness of product manufacturing. Thus the problem to increase mechanical operation efficiency is becoming more and more urgent nowadays, and its solution contributes to reduce labour and maintenance costs and to improve the productivity of separate operations.

High speed processing is the perspective way to reduce the amount of finishing work together with manufacturing cost of details and improve the productivity and precision as well. As a result belt driven grinding spindle blocks should meet different requirements in terms of precision and parameter reliability which, according to the latest research works [3], appeared to determine up to 80 % of a detail mechanical operation precision. As the motion of shaping is accomplished with a spindle and spindle bearings, they make the capital contribution to the output properties of a grinder.

The work of spindle blocks on a rolling-contact bearing is accompanied by an unstable trajectory of a spindle motion as well as thermal displacement of a spindle bearing blocks and their periodic changes in the rigidity, connected with the change of an angular displacement of a bearing cage and solid of revolution set etc. Application of hydrostatic bearings in high-speed spindle blocks results in the limitation of spindle rotational frequency (as a result of losses caused by friction) and complication of bearing block structure. Electromagnetic bearing spindles have not found wide application in a construction of spindle blocks due to the high cost, complexity of spindles and automatic control system. Gas lubricated spindle bearing blocks don't have all disadvantages mentioned above but their relatively low cutting force results in restricting their application. The research work carried out at Komsomolsk-on-Amur State Technical University [1] proved the fact that different ways of organization of gas supercharging into the clearance of a gas-static bearing do not result in a considerable increase of spindle blocks output characteristics.

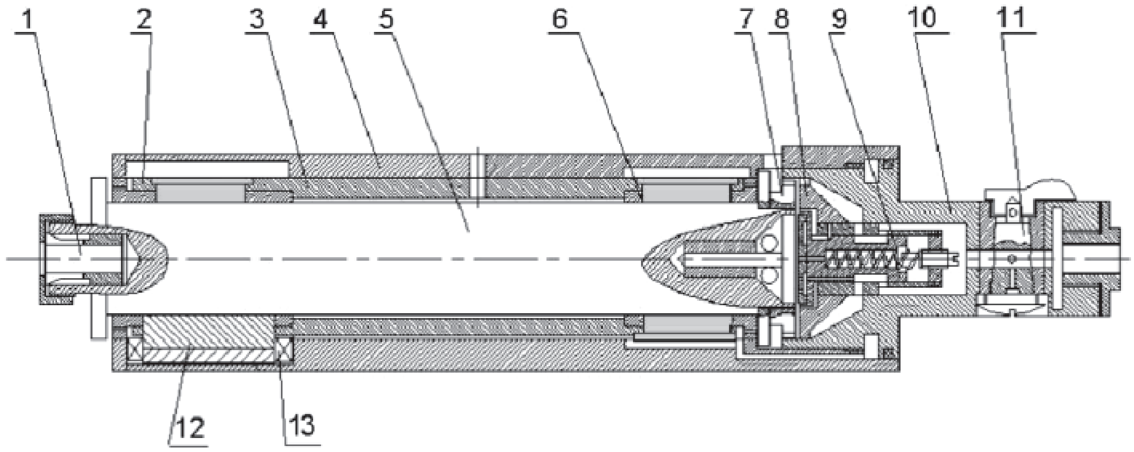
The further improvement of characteristics of spindle blocks with contactless bearings is the application of a combined bearing into their structure. A constructive solution may be a combined gas and magnetic bearing, suggested at Komsomolsk-on-Amur State Technical University [2], it combines the advantages of gas and magnetic bearings. A wide complex of theoretical and experimental researches let the researches make a conclusion about prospects of using such spindle blocks as a part of different metal-working equipment.

The result of Komsomolsk-on-Amur State Technical University research assistants work is the creation of experimentally industrial model of a high-speed belt driven spindle block with gas and magnetic bearings for grinding machines.

The construction of a high-speed spindle block for model 3A228 of a grinding machine is shown on the Figure.

Spindle block body has the length of 310 mm and a 70 mm internal diameter. There are some drillings to supply compressed air to gas bearings. Air tap is provided with a 5 mm air outlet. In the upper part at the side of an inlet device there is a window to get waste turbine air stream off.

A spindle, being 400 mm in length with 50 mm diameter is made of 38ХМЮА steel elaborated with nitrogen into 0,4 mm in depth and HRC 50–55 hardness. It has stable dimensions, and it is stable to corrosion. In a spindle nose there is an axial drilling in order to assemble split terminal by means of which a grinding roller is fixed. Alongside with the spindle there is also an abutment of gas-lubricated thrust bearing in a spindle face. The opposite end of a spindle has a drilling made to assemble crossing and a regulator rod of rotational frequency cutoff as well as a thread for fixing a 70 mm diameter turbine operational roller.



The construction of a high-speed belt driven spindle:
1 – split terminal; 2 – gas and magnetic bearing; 3 – an insert; 4 – spindle body; 5 – spindle; 6 – gas-static bearing; 7 – operational turbine roller; 8 – turbine nozzle device; 9 – a regulator rod of rotational frequency cutoff; 10 – input device; 11 – starting valve; 12 – magnetic core; 13 – solenoid

Spindle block has 2 support and thrust bearings: the front one is a gas and magnetic bearing and the back one is gas-static. Bearing backings are provided with spline porous limiters of gas consumption which are 5 mm in width and 40 mm in length, placed in a circular series in a number of 6 inserts. Bearing backings are made of Br010 bronze. In order to provide maximum supporting property the clearance between spindle and its bearing backings is 35 mkm. The front bearing is provided with magnetic cores, having 6mm width and 40 mm length. One supporting bearing in a gas-static mode of operation can bear the load of nearly 180 N under relative eccentricity ε = 0,5 and overpressure of 5 MPa. The front gas and magnetic bearing can bear radial load up to 450 N. PID controllers with spindle position pickups, made on ferrite semi-rings are used as a control system.

Both front and back bearings react upon axial force. Thrust bearing combs have 16 axial supplying holes, placed in a circular series. Feeder diameter is 0,5 mm. Each bearing bears axial load of 60 N.

Supporting and thrust gas bearing backings are fixed in a common bearing bushing on fixing sites by means of pasting in. The glue with epoxide resin in its composition is used for this purpose. Practical work has shown that this compound is effective in operation and simple in performance.

Spindle block operates in a following way. Under its connection to a pneumonet and a closed starting valve compressed air is supplied only to support and thrust bearings, it gives the opportunity for spindle «to emerge». Voltage being supplied to solenoids output, additional force is created thus attracting spindle to a corresponding pole. The starting valve being opened, air stream simultaneously flows to bearings, then through a nozzle device goes to a turbine impeller, thus making a spindle rotate. Turbine wasted air stream flows out of a spindle block through a window and used in bearings air stream goes out of them through a through drilling of 5 mm diameter which is in a bearing bushing and bearing body.

Under air stream overpressure of 0,5 MPa spindle block has the following characteristics:

Spindle operational rotation frequency, min^{-1}	30000
high-speed $d \times n$, mm/min	$1{,}5 \cdot 10^6$
Grinding hole diameter, mm	20–200
Length of grinding, not more mm,	200
Compressed air mass consumption, kg/sec	$15 \cdot 10^{-4}$
Weight, kg	12

Service tests have proved effective operation of spindle blocks, no lubrication with grease of a grinding roller as well as no need for spindle warming-up. Having been tested, product samples with 25 and 40 mm diameter, made of 20×13 steel, the following results have been obtained: non-roundness accuracy of holes are not more than 0,8 mkm, corrugation-up to 0,15 mkm, roughness of surface R_a – not more than 0,06 mkm.

References

1. Kosmynin A.V., Vinogradov V.S. A high-speed belt driven spindle block gas bearings. – Vladivostok: Far eastern science, 2002. – 326 p.

2. Kosmynin A.V. Shchetinin V.S. Bearing Unit and Its Operation Mode // Patent of Russia №2347960.2009. – Bul. № 6.

3. Push A.V. Spindle Units: their projects and research. – M.: Stankin, 2000. – 107 p.