METHODICAL FEATURES OF DEVELOPMENT OF SOFTWARE FOR CONTROL OF PRECISION OF THE GRINDING MACHINES

Hassan Ahmad Huseynov, Sahib Abbas Bagirov, Tunzala Rza İmanova
Azerbaijan Technical University
Baku, Azerbaijan

ABSTRACT
In article the technique of development of program devices for management of the accuracy of grinding operations of various look is considered. In particular program devices were developed and used on production: for flat grinding by a circle end face, for flat grinding by the periphery of a circle, for round external grinding and for round internal grinding. Program control by accuracy allowed to increase the accuracy of a geometrical form of polished surfaces and 1,8 times by 3-4 times to reduce the main technological time. It is established that the developed program devices are ergonomic, are easily built in the control panel of the machine without reducing its technological capabilities.

KEY WORDS: *surface grinding, granularity, grinding disk, abrasive, technological primitive, attribute.*

I. INTRODUCTION

The required accuracy in grinding is traditionally provided in three ways: trial passes, automatic acquisition of size when processing until bumping and control over the course of the process. When processing by the method of trial passes, the accuracy of the size, shape and relative position of surfaces of the parts depends largely on subjective factors caused by an error of installation of the tool and the workpiece, the accuracy of measurements, and so on. The objective factors that lead to a violation of the laws of the kinematic coupling of the motion of the grinding wheel and the work piece affect the precision of shape of the machined surface of the work piece. This method is unproductive and only applies to single and small batch production.

A method of automatic provision of accuracy largely depends on the wear and change of the cutting ability of the circle. In cases where during the period of resistance the dimensional stability of the circle is below the period of its resistance by cutting ability, this method is not sufficient to ensure the required accuracy [1]. Automatic acquisition of size is used in processing larger component batch sizes.

The third way to ensure accuracy by controlling elastic pressing of the technological system is more versatile, both in terms of applications in various types of production and provision of the required accuracy of the values of various parameters: size, shape and relative position of the surfaces of the parts.

The extensive analysis of automatic tracking systems (ATS) in the field of grinding, which allows for their classification by dividing them into four main groups is described in the work [2]: adaptive systems operating on the basis of active control, adaptive optimization systems, adaptive systems of limiting regulation and adaptive software systems.

Article consists of sections: introduction, techniques of design of program devices, development of program devices for concrete grinding operations and conclusions.

II. METHODICAL

A certain part of the ATS grinders operate on the basis of the active control of the geometric shape of the treated surface. The essence of such functioning is that because of the wrong geometric shape the different amounts of metal are removed from every point of the treated surface of the part. It is proposed to manage the elastic pressing of the technological system so that stabilize them by the length and breadth of treatment.

The analysis shows that the self-tuning of the active control system can significantly (by 2-3 times) increase the precision of machining the parts while increasing productivity by 20-30% or more. The effectiveness of these systems is largely dependent on its ability to detect and measure the quantities of the various elementary components of total error of processing and make the appropriate adjustments in the course of the process. The implementation of these measures is associated with the difficulties caused by the manufacture and use of expensive equipment, which leads to an increase in the process cost of the carried out operations and make it economically unprofitable.

There are also systems with economic and technological criteria of optimization. The reason of great interest in the use of adaptive optimization systems consists in the fact that in the traditional adaptive systems of limiting regulation and active control, the optimization of the cutting process by conventional local criteria is not guaranteed. Meanwhile the decrease in the efficiency of technological systems, provided with secured microprocessor control because of underutilization of their technological capabilities is especially noticeable. The effectiveness of these systems is determined by the adequacy of the model to the real process, the error in the determination of the parameters and coefficients included into the original dependencies during their experimental determination, and the inaccuracy and non-versatility of the dependencies themselves. Note, however, that non-consideration of a number of specific features of the optimized process, the lack of knowledge of its theoretical foundations, lack of sources of information, inadequate logistics and others reduce the efficacy of use of the ATS on the grinding machines.

One of the basic versions of automatic control device (ACD) is an automatic control system (ACS), where the stability of the process is provided by automatic maintenance of a constant state of limiting parameter by means of the information obtained through feedback. The most difficult task in such systems is to provide a sensing element which must be a torque unit that converts an elastic deformation of one of its units which is proportional to the radial force, into electrical signals.

However, the idea of ACS is not fully justified [4], since the control is carried out, not by the deflection, but by the perturbation, when a number of important factors are unaccounted for. When controlling the elastic pressing only the deformation in one of the components of the technological system is accounted for, while the size of the closing link is determined by all links of the dimensional chain. Determining how to build an adaptive control system and the development of the technological foundations of its application, including the calculation of its main technical characteristics are based on the knowledge of regularities of implementation of the cutting process.

III. ELABORATION

In recent years, there is a trend in mechanical engineering for the development and improvement of systems of software management of changes made in the processing system during the formation of the accuracy of the geometric parameters of surfaces of parts in the course of their processing. In particular, single-circuit and double-circuit programming device for surface grinding machines working by the butt end, respectively (Figure 1) and by the periphery of the circle (Figure 2) [4] and programmable device for internal grinding machines (Figure 3) [5] have been developed and implemented.

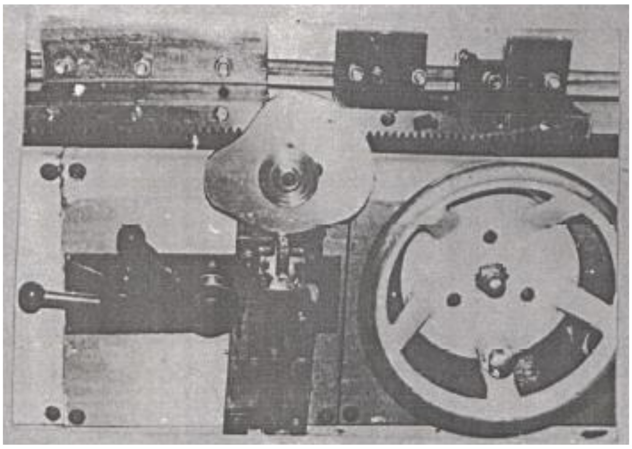

Figure 1: Surface grinding machine with vertical spindle and rectangular table of ZB732 model, equipped with a software device

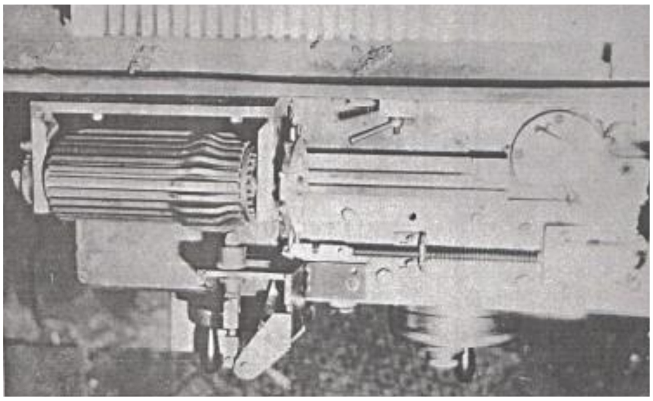

Fig.2. Surface grinding machine with rectangular table and horizontal spindle of ZG71 model, equipped with a software device

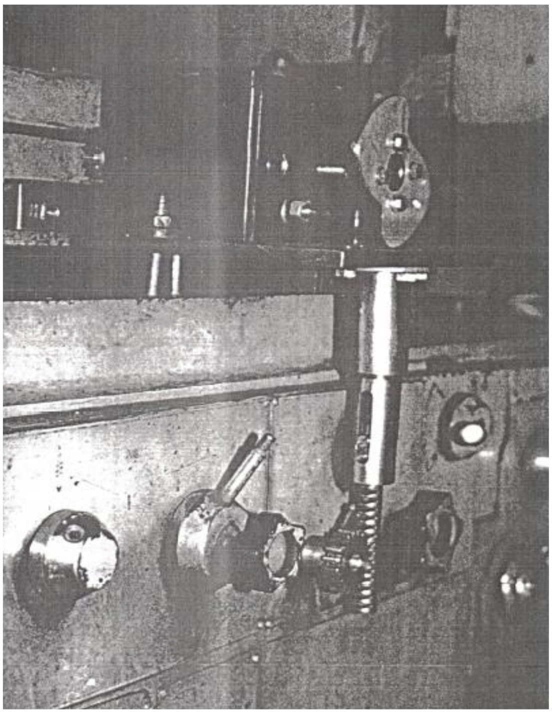

Fig.3. Internal Grinding Machine of ZA227 Model, equipped with software device

The accuracy and scope of approvals of the results of these studies provide a basis to apply the experience of program control of precision surface grinding as design and technological base during the development of software devices for other types of ground machines, in particular for external cylindrical grinding. The Study [4] shows that design features and character of the software devices are dictated by the architecture of the machine, its ergonomics, including the location and layout of the controls, and their availability, the nature of a particular grinding operation, including the configuration and size of the treated surface of the part, the size of the grinding circle, etc.
The main disadvantage of software control of elastic pressing of technological system is its determinism, which excludes random components of processing error. However, experience from previous studies shows that the effective preventive measures can reduce the influence of random components of the factors on accuracy during grinding. In this case, the important factor is the high efficiency and adequacy of a mathematical provision of software accuracy control system to the real process.
Our studies of the conditions of formation of the surfaces treated with various types of grinding allowed for making fairly significant adjustments to the mathematical provisions of these systems, record keeping of which could lead to an adjustment of existing accuracy control programs and thus to further improvement of the accuracy of the geometric parameters of the ground surfaces.
By applying the same methodical approach to development of software unit for the round grinding machines, let’s conduct the analysis of the technical, technological and ergonomic conditions of the technological operation system of the round outer grinding.
The grinding machines of ZA151, ZA161, ZB151, ZB161 models are widespread in the post-Soviet region. As established in the previous chapters, for external cylindrical grinding one of the disturbing factors causing uneven elastic pressing of technological system is uneven abrasive effect on the treated surface within technological primitives of steady grinding, input and output, as well as non-uniform stiffness of the front and rear pasterns and parts changed by grinding process in accordance with the output parameters, the error of geometric shapes in the form of deviations from: roundness, straightness and cylindrical shape of the treated surface.

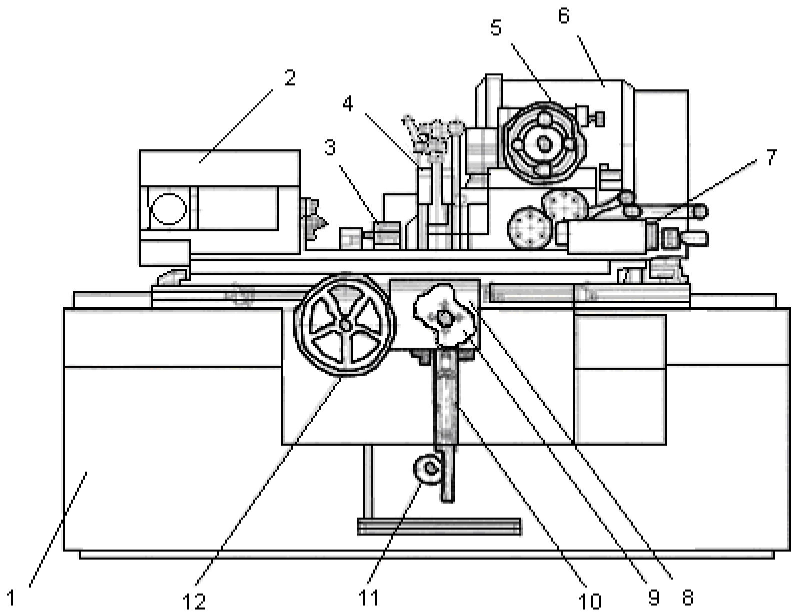

Figure 4. The overall layout of the external cylindrical grinding machines with a programming device

Cylindrical grinding machine equipped with a device for software control of processing accuracy (Figure 4) consists of the following main components: base 1, wheel head 6, hydraulic control 8, the mechanism for the cross-feed 5, headstock 2, tailstock 7 and devices for wheel dressing 3. The table’s motion is reciprocating. It is carried out by hydraulic system of the machine, and the change in the direction of motion of the table is made by turning the lever by means of dowel handle. In addition to the longitudinal rails, on the bed there are also cross rails for mounting and movement of grinding head. The spindle of wheel head is driven by a separate electric motor through V-belt transmission. Headstock rotates the work-piece during machining. The tailstock supports the right end of the details during processing in the centers. The machine is equipped with a software device that works with the sequence described below. The part is installed in the centers in a certain position. By means of the gear section 11, the speed is set to a value corresponding to the established process, according to the desired precision and the roughness and treatment conditions of processing without burning. After that, by the rotation of the cam 7 the follower 10 is brought to the upper position. When moving the table, along with the part against the grinding wheel through the rake-wheel gear clutch the straight line table motion is converted into rotational motion of the pusher 10 and thereby the motion of the table speed control spool.

Grinding machines, produced by engineering industry of CIS countries, which are widely represented on engineering plants, as well as the plants in our country have only a few types of hydraulic panels identical in structure and consisting of standard components: working cylinders, hydraulic panels of reverse, spools, chokes' panels, gearboxes, etc., which promotes the use of a modular principle of design of software devices for them.

The very existence of the hydraulic drive on the machine creates favorable conditions for the development of software devices, such as:

- Simplicity of the infinitely variable speed of the grinding wheel head;
- Simplicity of the rectilinear motions;
- The ability to control the grinding modes during operation of mechanisms and pressure control;
- The possibility of acquisition of a lot of effort and capacity for small size and weight of the mechanism;
- The possibility of automatic control of grinding modes for a given program;
- Self-lubricity of mechanisms of the machine with working fluid;
- Ergonomic controls and a high degree of standardization of hydraulic drive units.

The presence of the hydraulic drive on cylindrical grinding machines is also fraught with some of the negative moments for software control of grinding precision:

- The lack of stability of supply due to heating oil;
- The difficulty in establishing an accurate supply and obtaining a high rate of movement of the machine until the machine warms up;
- The lack of smoothness of moving at low speeds.

In the methodological support of the developed system, a number of preventive and service measures helping to reduce the impact of the above-mentioned drawbacks on the results of software control over precision are provided, in particular: the use of the throttle with controller, ensuring smooth movement of working components; maintenance of pressure in the hydraulic systems of up to 72 kg / cm 2 regardless of the load on them; the selection of the working fluid with the corresponding chemical composition having good chemical resistance, maintaining a stable quality at the changes in temperature and pressure, having optimum viscosity, etc.

Let us analyze the three most suitable technical proposals for the constructive design of these bonds, which differ from each other by the kinematics of the playback of the program:

- A copier executing reverse movement together with the table of the machine is used as program carrier;
- The program carrier is a cam, which makes two shuttle revolutions during a table reverse;
- The program carrier is a cam, which makes one revolution during the period of the table reverse.

Each of these options has its positive and negative sides. The first option has the greatest ease, due to the lack of kinematic pair between the table and the copier. In this case, the length of the copier software carrier is taken equal to the length of the stroke. It is fraught with two negative consequences. Firstly, with a small length of the treated surface, the effectiveness of sensing playback of program of control of speed of longitudinal movement is reduced. Secondly, due to non-uniform stiffness of the front and rear centers, and the non-identity of the abrasive action within the process input and output primitives, each reverse course requires a separate copier – program carrier. This complicates the design of the software product due to the need to interleave copiers after each stroke of the table reversal.

A second embodiment of the software device with the program carrier of cam type is efficient from the standpoint of reproducing the program at short length of processing. From the point of view of the efficiency factor, the mechanisms with rotating cam have advantages over mechanisms with a reciprocating cam. However, the design difficulties associated with the need to interleave the cams after direct and reverse stroke, due to their asymmetric form also arise in the second embodiment. Furthermore, change of the direction of rotation of the cam due to the inevitable falls in the system will contribute to errors in positioning.

The third embodiment of the software device is superior to previous ones from the standpoint of both the efficiency of program playback and the positioning accuracy. Some complications of design of software devices associated with the conversion of reverse movement of the machine table on unilateral rotational movement of the cam of program carrier, which has been successfully applied for a circular internal grinding, does not reduce the benefits of this option. For a rational constructive solution of the problem of transformation of movements, the third option is becoming more acceptable, which explains the choice of this option as a base.

The main unit of mechanic and hydraulic software device for control of grinding precision is hard software system consisting of a planar cam mechanism 11-13 and a transmission 10 for a reversible transformation of rectilinear motion of the table of headstock into unilateral rotation of the cam acting as program carrier.

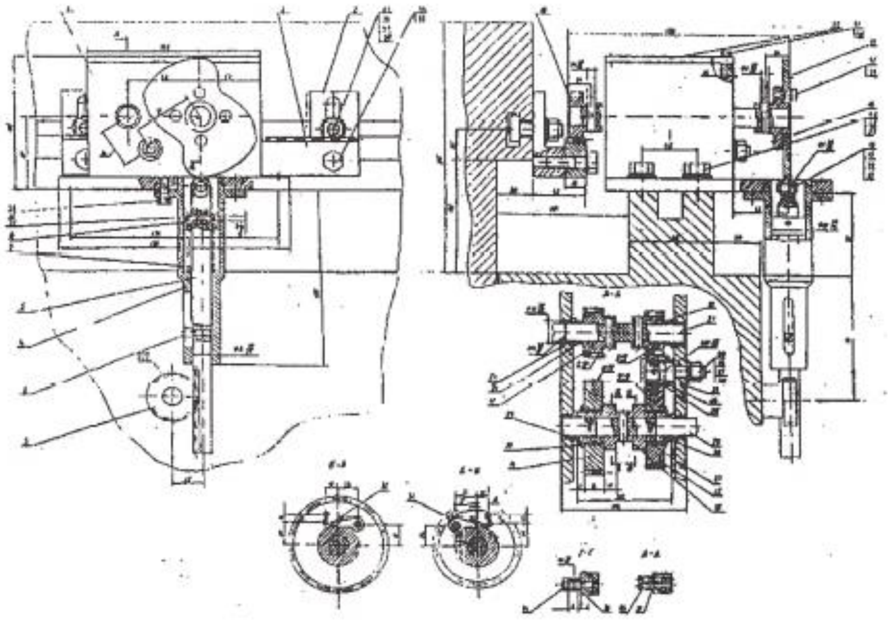

Figure 5. Software device for cylindrical grinding machine of 3A151 model

Assembly drawing of the software device is shown in Figure 5. It consists of the toothed rack 3 fixed with bolts 42 on two brackets mounted in a "T" shaped recess of the machine table and performing reciprocates together with them. The toothed rack 3 is engaged with the gear 20 mounted on the input shaft 21of the gearbox. Between the input shaft 21 and the output 22 of the cam of program carrier there is a double kinematic relationship through gearing 11-14 and 12-13-15. In direct course of the table, thanks to gearing of toothed rack 3 with the wheel 20, the linear motion of the table is transformed to a rotary motion of the input shaft 21. At a distance corresponding to the length of the forward stroke of the table, the input shaft makes one revolution. The gear ratios of the gearing are made so that during a complete revolution of spongy wheels 12 the wheels 14 and 15 would be rotated a half turn. The wheels 11 and 14 are mounted rigidly on input shaft 21, their positions are fixed with pins 36, and the wheels 14 and 15 are slipped on bronze bushings, allowing them to move freely. The transmission from the wheel 14 and the output shaft 15 is transmitted by pawls 31 acting on the opposite directions. During forward movement of the table the torque of the input shaft 21 resulting from the gear 20 through a gear pair 11-12 using the pawl 31 is transmitted to the output shaft 22 turning it on the half revolution. During return stroke of the table reversal the direction of rotation of the input shaft changes therefore the gear pair 11-14 runs idle. Meanwhile the gear pair 12-15 is functionally activated through the parasitic wheel 13, which serves to preserve the direction of time of rotation. The torque resulting from the gear wheel 15 and transmitted to the output shaft 22 is passed through pawls 31 acting oppositely to the first one. Thus, thanks to a kinematic connection between the input and output shafts, the two shuttle revolutions of the input shaft and one rotation of the output shaft are transformed. Meanwhile the first half turn of the cam 12 acting as software carrier corresponds to the direct course of the table of the spindle head, and the second half-turn corresponds to the reverse stroke of the table of the spindle head.

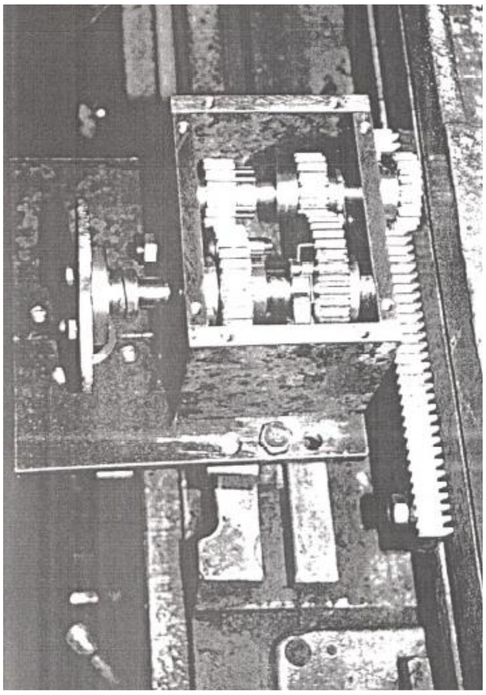

Figure 6. The mechanism of transformation of reverse movement of the machine table at the turn of the lever controlling the table speed

The cam mechanism is designed to play back the program of control of speed of longitudinal movement of spindle head table provided in the form of the cam profile 12. The rotational movement of the program carrying cam is converted into linear motion of the pusher 5 mounted in the two bores of the cylindrical body, on mobile seats F 11 H9 / J9 and F16 H9 / 9. The housing 4 by means of bolts 41 and 46 is fixed to the bottom plate of gearbox. The screw 8 counteracts rotation of the pusher 5 in relation to the profile of the cam. The groove in the housing which guides the screw 8 has a length greater than the stroke of the pusher. The toothed rack cut on the lower end of the pusher 5 comes into engagement with the gear 9 mounted on the roller of lever of control of speed of the table.

Thus, the developed mechanic and hydraulic software device is intended to improve the accuracy and performance of cylindrical grinding operations on account of stabilization of elastic pressing of technological system by software-aided changing the speed of the longitudinal movement of the part or wheel head during processing. It is characterized by simplicity, reliability and ergonomics, and it is easily configurable, while not limiting the technical capabilities of other organs and versatility of the machine as a whole.

IV. CONCLUSION

1. Are developed and introduced in productions one-coordinate and two coordinate program devices for increase of accuracy of flat and circular grinding operations. It has been established that the management of wrung resilient technological system software by changing the speed of the table to improve the accuracy and productivity. When this occurs the accuracy of the shape and location of surfaces increases for approximately (4-5) fold.

2. It is revealed that at program control peripheral grinding process it is necessary to ensure the change of speed of the machine table depending on two arguments, by applying spatial cam mechanisms - conoids.
3. It is established that when sanding errors of form and position of surfaces of systematic design subject to features of the construction of treated surface and the process have a dominant role in the total error. Within a single part, these errors have systematically changing, and in a kit of parts, systematically permanent character.
4. The analysis showed that software control of precise surface grinding process on the basis of stringent programs of carriers such as cams, copiers, etc. is characterized mainly for large-scale and mass production, where material and time costs associated with designing and manufacturing programs of carriers are paid back for each specific surface. .
5. It is revealed that in case of single and small batch production, one of the main requirements put forward to the programming devices is to ensure their invariance to the processes of high accuracy surface of details of relevant industry.
6. Program devices for mechanical as well as peripheral grinding differ for their simplicity, reliability and ergonomics, are easily installed on the control panel of the machine, in the meantime do not limit the technological capabilities of other entities.

The subsequent stage of development of idea of program control of accuracy of machining is development of systems of numerical program control of accuracy for universal machines with systems of the satellite navigation system CNC, having technological superiority in front of specially equipped machines and possessing high universality.

REFERENCES

[1]. Bazrov B.M. Process design basis for self-adjusting machines: M. Mashinostroenie, 1978, pp 216
[2]. Bagirov S.A. Process design for internal grinding program control system: Chasioglu, 2001, pp 123
[3]. Huseynov H.A. Program control of the mechanical processing accuracy: Baku, Chasioglu, 2000, pp 281
[4]. Bagirov S.A., Huseynov H.A. internal grinding program control: Baku, Chasioglu, 2001, pp 107
[5]. Kosov M.P., Protopopov S.P. Principles of designing intelligent technology: Vestnik mashinostryeniya (journal), 1991, #8 pp 39-41
[6]. Mikhelkevich V.N. Automated control of grinding: M.,Mashinostroenie, 1975, pp 304
[7]. Ratmirov V.A. Chubukov A.S. Adaptable – programmable systems for control of grinding machines through micro –computers: M. Mashinostroenie, 1982, pp 48
[8]. Solomentsev Yu.M., Protopopov S.P. and others Mitrofanov V.G., M. Mashinostroenie, 1980, pp 536

AUTHORS

Hassan Husseynov was born in September 7, in 1944 Jabrail city of the Azerbaijan Republic. In 1967, Huseynov graduated from the Azerbaijan Polytechnic Institute named after D. Ildirim, then worked as a chief engineer of Machine-Building Plant named after Sardarov. Since 1968-1968 he served at the Soviet Army. During 1968-1984 he worked as a chief engineer and is leading engineer of the All-Union Scientific Research Institute of Machine Building. In 1978, defended his thesis at the Institute "Moscow Oil and Gas" named after Gubkin, got the Doctor degree of Technical Sciences. Since 1978 has been working at the Azerbaijan Polytechnic Institute. In 1984-85 years did intensive French courses at the Moscow Institute of Foreign Languages named after M. Teresa and during 1984-87 years had worked in Madagascar State University as a professor. In 1990, Mr. Gusseinov was elected to head the Department «ATS in mechanical engineering", in 1995 he defended his doctorate at the Moscow State University of Technology, in 1996, he was elected an academician of the Academy of Quality Problems of the Russian Federation and got the academic rank of professor in the department of "Computer-aided design in engineering. Gusseinov is the author of more than 150 published scientific and methodological materials. 4 inventions, 3 monographs and dozens of textbooks and teaching aids, 4 books in French, published in the Democratic Republic of Madagascar. Professor Huseynov prepared 6 candidates of technical sciences; some of them are leaders of European universities. In recent years, under the leadership of Mr. Gusseinov, three new specialties and purposeful work had been undertaken for establishing their educational methodological base. Also, a lot of work had been done on the formation of the material and technical base of the department. In 2005, at the initiative of Professor G. Gusseinov scientific and technical conference dedicated to the 55th anniversary AzTU. In the framework of international programs were held, Gusseinov has participated in an exchange of experience with leading European specialists. In 2013, under his leadership, a regional program Tempus was held and confirmed by the relevant agencies of the European Union.

Bagirov Sakhib Abbas was born in July 10, 1965 in the Sisiansky region of the Republic of Armenia. In 1988 graduated from the Azerbaijani Polytechnical Institute majoring in Technology of mechanical engineering machines and tools. Is the doctor of philosophy on equipment and the associate professor Technological complexes and special equipment of the Azerbaijani Technical University. Is the author of 65 scientific articles, two monographs and two patents inventions. Married, has two children.

Tunzala Imanova. was born in 1969 in the city of Baku. She is Candidate of Technical Sciences, the associate professor "Technological complexes and special equipment", has about 37 published articles.