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Modernized Tool for Producing Regular Reliefs on Inner Cylindrical Surfaces with GR63x25 Motor (24 V DC) and Angular Gearbox

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ABSTRACT

The article presents the design and development of an improved modernized specialized tool for forming regular reliefs on the internal cylindrical surfaces of test metal samples. The method is based on Surface Plastic Deformation (SPD), which contributes to improving the structure of the surface layer and increasing operational properties. The tool was modeled and assembled using Solid Works software.

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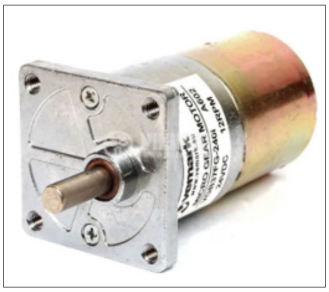
Introduction

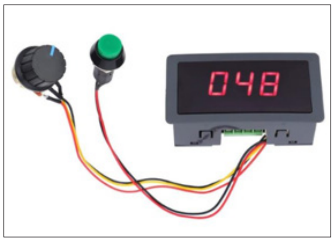
The modern development of mechanical engineering and high-precision surface processing is increasingly focused on improving the operational characteristics of products by modifying the condition and structure of the material's surface layer. Such approaches significantly increase the service life of parts, reduce the coefficient of friction, and increase wear resistance [1]. One promising technology is the formation of regular micro-reliefs, which improve functional properties and surface durability.

While such solutions are highly effective for flat or external cylindrical surfaces, internal surfaces remain underexplored, especially for parts with high assembly and mounting requirements. Their processing is complicated by limited access to the working area, the need for precise centering of the tool, and the difficulty of controlling clamping force [1,2]. Traditional methods such as abrasive machining or laser texturing are not always applicable [3,4]. A literature review shows that publications dedicated to forming regular reliefs on internal cylindrical surfaces by the SPD method are limited to experimental work and do not go beyond laboratory research. Few works involve real-time process parameter control or application in serial production [5-7]. However, the potential for using SPD in internal processing is significant both for increasing the durability of parts and ensuring high process adaptability. Therefore, an urgent task is the development of a specialized tool capable of forming regular microreliefs on internal cylindrical surfaces with the ability to adjust processing parameters in real time [3,8].

Research Objective

Within the framework of developing a parametric design of a tool for forming regular reliefs on internal cylindrical surfaces using the (SPD) method, two options were considered. The first version is a tool with a VGA60FHH-72i motor (24 V DC, 56 rpm) and a potentiometer with digital display (figure. 1).





Electric motor, direct current, with gearbox, 24VDC, 12rpm, VGB37FG-240i Storage voltage: 24 [VDC] Nominal speed: 12 [rpm] Power: 1.1 [W] Torque: 1.2 Nm] Rated current: 0.5 [A]	DC speed controller with PWM control capability. Input supply voltage: 6-30 VDC Output current: 5A nominal, 8A maximum (short-term) PWM frequency: 13 kHz Adjustable duty cycle: 0-100% Indication: digital duty cycle display

Figure 1: Electric Motor VGA60FHH-72i (24VDC, 56 rpm) and Potentiometer with Digital Display

(Figure. 2) shows the construction of a tool with an electrical motor VGA60FHH-72i and a potentiometer with a digital display.

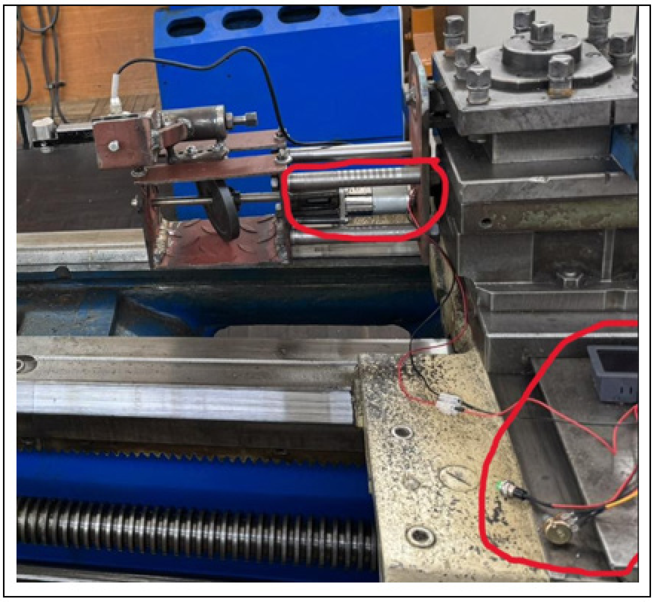
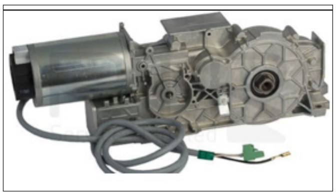


Figure 2: A Real Tool Designed with a VGA60FHH-72i Electric Motor and a Potentiometer with a Digital Display in the Working Position

The second version is a modernized tool with a GR63x25 motor (24 V DC) and angular gearbox, powered by a CYBERLIFE HY3020E supply. The main focus is on accuracy, repeatability, controllability, and real-time parameter adjustment.

	
Electric motor GR63x25 (24V DC) with angular gearbox	Power source CYBERLIFE HY3020E

Construction and Features of the Modernized Instrument

Within the framework of developing a parametric design of a tool for forming regular reliefs on internal cylindrical surfaces using the SPD method, two options were considered. The first version is a tool with a VGA60FHH-72i motor (24 V DC, 56 rpm) and a potentiometer with digital display. The second version is a modernized tool with a GR63x25 motor (24 V DC) and angular gearbox, powered by a CYBERLIFE HY3020E supply. The main focus is on accuracy, repeatability, controllability, and real-time parameter adjustment.

The modernized tool uses a GR63x25 motor with an angular gearbox, providing higher torque at the same voltage. Rotation speed is controlled by the CYBERLIFE HY3020E power supply, allowing precise adjustment of the tool's reciprocating motion parameters. This solution increases load stability and the accuracy of micro-relief formation.

For the GR63x25 motor with a 43:1 angular gearbox ratio and nominal current up to 16 A at 24 V, a high torque is achieved, improving accuracy and force in reciprocating movements.

Advantages of the Modernized Design

- Increased torque thanks to the angular gearbox.
- More precise speed control with CYBERLIFE HY3020E.
- Improved stability and repeatability of formed reliefs.
- Higher energy efficiency and structural stability.

Table 1: Comparison Table of Characteristics

Parameter	VGA60FHH-72i	GR 63x25 with angle reducer	Advantage
Voltage	24 V	24 V	Same
Speed	56 rpm	≈35 rpm	Smooth operation at low speeds
Torque	Low	High	Better for PPD
Gearbox type	Planetary	Angle (worm)	Compactness and effort
Adjustment	Potentiometer	CYBERLIFE HY3020E	Precise adjustment

Construction and Description of the Instrument

The modeling process began with the creation of simplified 3D parts, in real dimensions, of the main components the strain gauge model RSB2 and a diamond tool with a sphere of 1 mm radius which were subsequently assembled in SolidWorks (Figure. 3).

The strain gauge (Figure. 3 – pos. 25) is designed to function as a sensor that detects deformation by converting the mechanical load into an electrical signal for operational control of the contact force in the processing zone.

The diamond tool is a rectangular body with a fixed sphere at its end, forming a regular relief through plastic deformation of the workpiece. The tool consists of the following parts: the sleeve (Figure. 3 – pos. 7) and the support tool (Figure. 3 – pos. 8) with the diamond ball (Figure. 3 – pos. 13). The rotation angle of the diamond ball is provided by the swinging mechanism (Figure. 3 – pos. 9).

The U-shaped support (Figure. 3 – pos. 3) is equipped with side mounting sockets for two radial bearings (Figure. 3 – pos. 2), through which passes the shaft (Figure. 3 – pos. 1) connected to the drive flange (Figure. 3 – pos. 5). The latter is mechanically connected to the electric motor (Figure. 3 – pos. 21). The motor is connected to an angular gearbox with a gear ratio of 43:1 (Figure. 3 – pos. 16), providing rotary motion.

Thanks to an eccentric (or crank) mechanism, the rotary motion is converted into reciprocating motion, allowing the tool to move along the Y-axis of the lathe. The sleeve and tool block are mounted on a support (Figure. 3 – pos. 4) which provides both support and guiding functions. The adjustable sleeve (Figure. 3 – pos. 7) allows precise adjustment of the tool penetration depth into the workpiece and is fixed with a screw (Figure. 3 – pos. 14).

The stand is mounted on an L-shaped support (Figure. 3 – pos. 10), fastened with nuts (Figure. 3 – pos. 17), ensuring the correct positioning of the entire system when installed in the working area of the lathe. The L-shaped support is mounted on a metal plate (Figure. 1 – pos. 20) of 7 mm thickness, which is securely fixed to the surface by welding to the U-shaped support (Figure. 3 – pos. 3).

The deformation force is monitored and recorded using the RSB2 strain gauge (Figure. 3 – pos. 25), located in the reaction zone of the tool contact. When material resistance occurs, the diamond ball deflects, and the resulting elastic displacement is recorded by the sensor. This enables feedback in the control system and ensures the repeatability of the parameters of the formed surface relief.

The entire structure is attached to a rigid stand by pins (Figure. 1 – pos. 18), in a standard 25×25 mm tool holder (Figure. 1 – pos. 19).

The frequency of the reciprocating motion of the electric motor (Figure. 1 – pos. 21) is adjusted by the CYBERLIFE HY3020E power supply, which indirectly monitors the drive parameters, enabling interactive real-time regulation. In this way, the tool has a high degree of adaptability and is suitable for both experimental and serial processing.

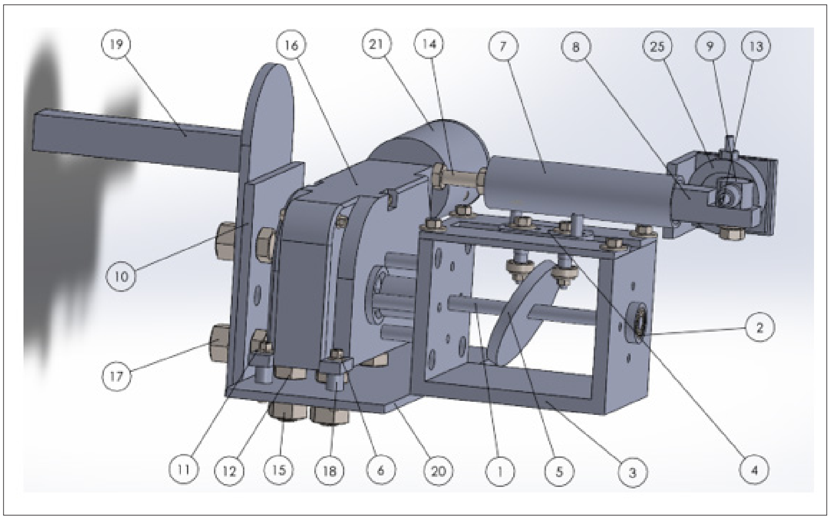
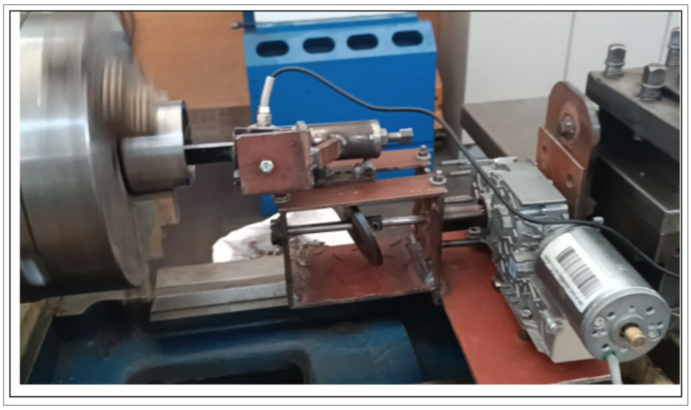


Figure 3: Three-Dimensional Model of a Modernized Tool in Solid Works

Figure. 4 shows the actually constructed tool for obtaining regular reliefs on internal cylindrical surfaces in working position mounted on a lathe model SU-502.



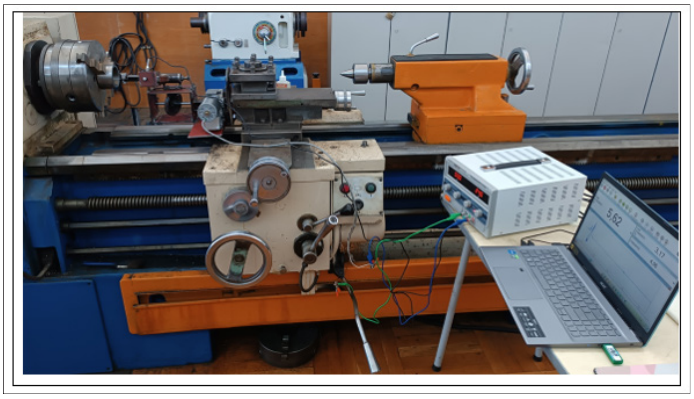


Figure 4: A Real Constructed Tool for Obtaining Regular Reliefs on Internal Cylindrical Surfaces Using the Surface Plastic Deformation (Spd) Method in Working Position

As can be seen from Figure 4, the designed tool allows universal installation on other different lathe-type metal-cutting machines, regardless of the specific manufacturer.

Conclusions

Experiments have confirmed that the use of a GR63x25 motor with an angular gearbox and a CYBERLIFE HY3020E power source provides significantly higher accuracy, controllability and adaptability in the process of forming regular microreliefs on the internal cylindrical surfaces of the parts. The increased torque of the motor contributes to stable and controlled deformation, and the ability to fine-tune the parameters provides high reproducibility of the results.

Experimental studies have shown that the developed design of the surface plastic deformation (SPD) tool allows for effective control of the process parameters in real time. The system provides the ability to precisely adjust the spindle speed, the linear feed of the support, the parameters of the reciprocating motion of the tool, thanks to the use of a separate electric drive, as well as the deformation force monitored using the RSB2 strain gauge.

The test results show high accuracy, stability and adaptability of the process, which makes the tool a universal solution for both scientific research and serial production. Its use ensures the formation of correct microreliefs with specified characteristics on internal cylindrical surfaces, meeting modern requirements for functional processing of parts.

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