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Mykhailo Hrebennikov<sup>1</sup>, Valerii Kryvoruchenko<sup>2</sup>, Natalia Gonchar<sup>3</sup>,  
Nataliia Zhukova<sup>4</sup>

<sup>1</sup>PhD student NU «Zaporizhzhia Polytechnic»

<sup>2</sup>PhD student NU «Zaporizhzhia Polytechnic»

<sup>3</sup>PhD (Technology), associate professor NU «Zaporizhzhia Polytechnic»

<sup>4</sup>PhD (Philology), associate professor NU «Zaporizhzhia Polytechnic»

## **MECHANIZATION OF THE MANUFACTURING PROCESS FOR COMPLEX-PROFILED PARTS OF AIRCRAFT ENGINES**

Modern technological developments in world industry have created new challenges for mechanical engineering. These challenges include the implementation of innovative technologies that increase labour productivity, improve quality, and ensure the competitiveness of manufactured products. The need to maintain or reduce the size of machines and mechanisms while enhancing their reliability, accuracy, and performance has led to the increased use of parts with complex profile surfaces. These parts are commonly found in aircraft engines, internal combustion engines, and tooling for metallurgical and billet production.

Complicated movements of the machine's actuators or the use of complexly shaped tools are required to ensure the shape and manufacturing quality of compound surfaces. Currently, CNC machines are primarily used to machine complex profile surfaces, followed by finishing. In some cases, special casting methods or electrical discharge machining may be necessary for moulding. The selection of the finishing treatment is crucial as the surfaces produced by the aforementioned methods possess a flawed layer that is characterised by high levels of residual stress, non-uniform surface roughness, and deformation riveting. This reduces their strength, fatigue resistance, and consequently, their reliability in operation.

The accuracy of manufacturing rotor and stator blades, which are parts of aircraft engines with complex surfaces, is crucial for the formation of air flows and pressures. This, in turn, significantly affects the dynamic and vibration characteristics of the engine. The number of compressor blades used in a single aircraft engine can exceed 1400. The wide variety of blade sizes and tight profile tolerances, ranging from 0.06 to 0.16 mm, require precise billet production to meet the shape and accuracy requirements specified in the blade drawings. The combination of the use of such blanks in the milling process with the constancy of the selected cutting modes and the optimum shape of the cutting tool - the milling cutter, allows to obtain blades with the profile surface roughness up to Ra 0.5 and the allowance for finishing (to remove the traces

left by the milling cutter on the profile surfaces) up to 0.01 mm on each side along the main cross-sections.

Traditional mechanical machining methods are not commonly used for finishing complex profile surfaces due to the need for expensive special tools with cutting edge profiles that must match the surface topology. The required blade surface quality parameters specified in the drawing are achieved through manual finishing operations, which are labour-intensive and expensive. Polishing a single blade can take 80 to 90 minutes. To make the process more efficient, it is recommended to use special finishing technologies. These technologies use a flow of liquid carrying working elements as a tool, which come into contact with the surface irregularities as they move along the surface to be treated.

The method of vibratory processing with abrasive fillers of special shape (chips) is a widely used practice for mechanically polishing complex profile parts, including thin-walled ones. This processing method has several advantages over other types of polishing, such as magneto-abrasive, turbo-abrasive and others. It is simple to operate, and the processing parameters are reproducible and controllable. The process is environmentally clean and safe, and the equipment used is versatile. Additionally, it has low energy consumption and high productivity. The processing time achieved for high-pressure compressor blades made of heat-resistant alloy was 4 hours when using RXXD filler, and 3 hours for titanium alloy blades. After vibration treatment, it was found that the maximum layer removed from the blade profile surface was 0.01 mm per side, and 0.2 mm along the chord length (minimum distance between the inlet and outlet edges of the blades). The surface roughness achieved ranged from Ra 0.2 to Ra 0.3.

Confirmation tests were conducted by us at SE "Ivchenko-Progress" to determine the strength of the blades manufactured using the presented technology. The results showed that the use of high-performance mechanical abrasive processing after CNC milling operations obviates the need for manual polishing in the blade manufacturing process. This replacement significantly reduces production costs by reducing manufacturing time while maintaining a stable, high surface quality for complex-profile blade surfaces. Replacing manual polishing operations with mechanical polishing can eliminate the influence of random factors on the quality of manufactured blades and achieve consistency in geometrical dimensions and quality parameters of the surface layer in serial and mass production.