Finishing surface treatment of GTE parts with dry electropolishing

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Abstract. One of the major problems in GTE production is ensuring high performance of compressor blades. Existing methods of surface polishing have a number of disadvantages and, cannot ensure a high-quality surface of gas turbine engine blades. The most advanced method of polishing parts is the technology of dry electropolishing in the medium of granules (DEPG). However, the use of the DEPG method during polishing leads to defects. The study of the defect causes during DEPG allowed the authors of this paper to develop a brand new technology of dry tape electropolishing. This method made it possible to eliminate the disadvantages of DEPG and to ensure the specified geometric parameters of the blade airfoil.

1. Introduction

One of the major problems in GTE production is ensuring high performance of compressor blades. It is widely known [1] that the parts specified parameters greatly depend on the properties of the materials their surface is made of. The surface is majorly formed during finishing stages of the technological process. One of the crucial quality evidence of the part material surface is surface roughness and homogeneity of its physical and mechanical properties [1].

The quality evidence claims that the process impact on the part surface is required to be delicate and steady enough. This means that the force and electricity impacts should not be of different intensity while the part surface is being formed. Methods of high-energy protective and strengthening treatment of GTE blades tend to improve. In regards to this fact, it is vital to consider homogeneity of the surface properties [2].

GTE compressor blades polishing allows to improve their performance. This is one of the main operations aimed at preparing the surface for protective and strengthening treatment [3]. As a rule, parts surface polishing technologies rely on mechanical, chemical and electrochemical methods [4]. However, the mentioned polishing methods have a number of disadvantages that affect the part surface quality. Chemical methods cannot make treatment, equal; it is complicated to match reagents. In addition, these methods are considered environmentally unfriendly. Mechanical polishing engages force impact on the surface. This may affect the formation of properties of parts with a complicated surface. Electrochemical methods including electrochemical and plasma electrolytic polishing are considered some of the most promising technologies. However, they cause shielding effects and unwanted layers on the surface. Therefore, these methods do not allow a high-quality treatment of GTE parts.
2. The dry electropolishing method in the medium of granules
Polishing parts with ion escape or the dry electropolishing method in the medium of granules (DEPG) [5] ensures a superior treatment of parts surface. However, when it is used for treating complicated surfaces, it may cause a range of process defects, such as micro-elevations (Fig. 1).

![Figure 1](image)

**Figure 1.** Micro-geometric irregularities formed on the blade airfoil surface made of titanium alloy after DEPG treatment (1 - blade airfoil, 2 - surface defects (micro-elevations)).

It was important to find out why these defects appear. It was found that these defects appear after DEPG application because granules stick to the treated surface of the part (Fig. 2).

![Figure 2](image)

**Figure 2.** Process of defects forming on the surface (a - granules contact the treated parts surface, material escapes; b - micro-elevation being removed; c - surface relief after the micro-elevation was removed; d - granules sticking to the micro-elevation, e, f, g - process when the granule has stucked; h - part surface after treatment with the formed defect where the granule stucked; 1 - part, 2 - micro-elevations, 3 - free granules, 4 - granules interacting with the part material; 5 - ion escape, 6 - electrode (cathode), 7 - granule with a removed piece of the micro-elevation, 8 - part surface after treatment, 9 - sticking granule, 10 - surface defect).
Another drawback of DEPG method of GTE blade treatment is that it is impossible to ensure the specified dimensional and geometric parameters of the blade surfaces, because granules interact with the part surface in a chaotic manner. In order to eliminate the drawbacks of the DEPG method for treating parts of a complicated shape, the authors of this paper developed and studied a new technology of dry electropolishing [6].

3. Technology of dry electropolishing with an anion tape

According to the approach suggested by the authors of this paper in [6] parts electropolishing 1 (Fig. 3) is carried out with electrochemical processes (part material ion escape) between the part 1 and the outer electrode 2 through the tape 3. The tape is made of anion fiber soaked in electrolytic solution. This would ensure tape 3 conductivity, metal ion escape from the part 1 surface and removal of micro-elevations.

![Figure 3. Treatment of the blade airfoil with tape electropolishing method. (1 - treated part; 2 - outer electrode; 3 - anion fiber tape soaked in electrolytic solution; 4 - clearance between the electrode and the part; 5 - baffle plate).](image)

An outer overlapping electrode 2 is installed around the part (Fig. 3). It is important to make sure that the tape 3 touches the entire part 1 polished surface and that the tape 3 touches the electrode 2. Then the tape 3 is put in motion and moved through the clearance 4 at the vibration. It is important to make sure that the tape 3 is intercepted with the baffle 5. The electric potential is supplied onto the part 1 and the tape 3. This ensures metal ion escape from the surface of the part 1 when it is being treated. This also ensures its polishing until the wanted surface roughness is reached. In case a turbo-machine blade is treated, the part is additionally moved back and forth along its longitudinal axis without touching the outer electrode 2. Tape anionites are made of ion-exchange resins. They are results of copolymerization of either polystyrene or acrylate polymer and divinyl benzene. Using an outer electrode that is equidistantly overlapping the treated blade airfoil with the clearance, allows eliminating defects such as micro-geometric irregularities. It also ensures geometric parameters of the blade leading edge (Fig. 4).

![Figure 4. Photomicrograph of the compressor blade leading edge made of BT-6 titanium alloy after tape electropolishing.](image)
When the dry electropolishing method was used, the surface roughness was Ra DEP 0.04 mcm. The input roughness of the surface was Ra input 0.32 mcm (Fig. 5).

4. Conclusion

- The conducted studies determined the cause of defects on the surface of the parts of a complicated shape that appeared during DEPG polishing;
- The authors of this paper suggested electropolishing involving an anion tape of a titanium alloy. This method eliminated the cause of the defects and allowed finishing treatment that results in the wanted geometric parameters of the blade airfoil.

5. References

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