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IMPROVING THE QUALITY OF MANUFACTURING AND REPAIRING BLADES OF GAS TURBINE ENGINE

Manufacturing of rotor parts of gas turbine engines is an expensive and complex progress of achieving a high reliability product at a minimum cost. It includes high precision 5-axis machining; a huge variety of non-destructive examination methods such as ultrasonic, magnetic and penetrant inspection, logistics and assembling, long and thorough testing and repeating until the final products meets the customer demands.

In mass production, one of the main problems is still a huge waste of metals in machining such as Ti or Ni-based alloys. To reduce the tendency worldwide, manufacturers use different and sometimes experimental methods in technical processes, which allow them not only to produce faster but also to increase an overall quality and quantity of a newly made or repaired part.

A relatively new method of manufacturing by laser brazing-joining was proposed by Rolls-Royce Deutschland Ltd & Co KG (patent #8242406) to produce BLISK turbine engine components. Using brazing powder that is jetted into the laser beam and shields the blade ensures that only the brazing metal is heated and melted. The disk material is molten in the joining area and alloys with the similar brazing metal; the blade material is not melted and connects to the solidifying, dissimilar brazing metal by adhesion. Despite the fact that this is a relatively new method with a small number of real-life operations, it may apply mainly in repairing separate parts or modules that are not considered to be replaced by newly made ones and therefore be the one to repair the fastest.

Another method that is widely used in production is electro chemical method (E.C.M.). The machining process done by electrolysis where voltage is applied between a form electrode (cathode) and the part to be manufactured (anode) through an electrolytic liquid. For both production and repair, this may optimize parameters and allow for a better accuracy to be obtained. Moreover, for BLISK-type parts this can be one of a few solutions because of complex geometry and material of a part itself: the machining process is performed without thermal and mechanical stresses, thus material properties are not disturbed, so there is no presence of white layer. Still there are a few other disadvantages presented by this process such as a higher machine investment and lower cutting feeds (~0.5 mm/min).

Besides, a new method has appeared – additive manufacturing (AM) – which has become a competitive alternative or compliment technology in such exact sectors as aeronautical and automotive. The main challenges reside on good heat dissipation generated during the process and reduction of distortions. On the contrary, AM offers advantages as the good powder utilization reduces material waste and increases the possibility of generating complex geometries, which are impossible to other technologies. It achieves tolerance for Ti and Ni-based super alloys with material components to the order of 100 μm or higher. One of the methods of AM that may be applied in repairing or even manufacturing from the blank is 3D laser method deposition (LMD). Its main applications are direct blades fabrication for small blisks and repair for damaged areas. For repairing operations, LMD process requires following stages: component damaged area inspection, repairing tool-path strategy definition, studying repairing necessities and feasibility and, finally, a measuring and control stage for the final obtained geometry and the material properties. In both, directed blade manufacturing and damaged component repair through LMD, a posterior stage of machining is required to achieve the final desired geometry accomplishing tolerance requirements. Hence, this additive manufacturing process provides an initial geometry closer to the final geometry, so it is embedded inside the "Near-Net-Shape" concept. Unfortunately, one of the main disadvantages of most of AM methods is that the process still doesn't have the capability of achieving the tough finishing dimensional requirements, the finishing stage is needed for a material removing manufacturing process.