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METHOD OF FABRICATING A TURBINE BLADE HAVING A LEADING EDGE FORMED OF WELD METAL

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Fig. 1

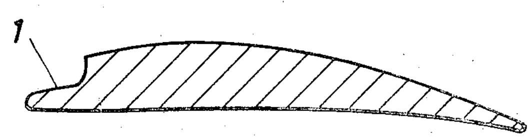


Fig. 2

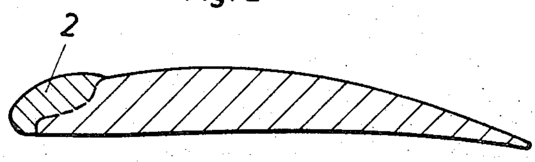
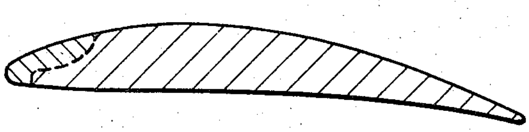


Fig. 3



Inventor:

J. HIRTENLECHNER

By Glascock, Downing & Seebold.

ATTORNEYS

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METHOD OF FABRICATING A TURBINE BLADE HAVING A LEADING EDGE FORMED OF WELD METAL

Julius Hirtenlechner, Kapfenberg, Austria, assignor to Gebr. Bohler & Co. Aktiengesellschaft, Vienna, Austria

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U.S. Cl. 29—156.8 3 Claims

ABSTRACT OF THE DISCLOSURE

The production of turbine blades in which a blade blank is provided in the area of the inlet edge with a steel weld portion, which, after smoothing of any uneven spots, is shaped together with the blade body to the final dimensions in a drop forge and finally subjected to heat treatment.

This invention relates to the production of turbine blades.

The development in turbine construction during the last few years has increasingly been directed toward larger constructional units. The required volume of the gaseous driving agents, particularly in the final stages, therefore becomes increasingly greater and, by the same measure, larger blade surfaces are required. The increase in dimensions of the final blades does not merely refer to length but, to an even greater extent, to the width of the blade so that its is necessary in many instances to develop new blade shapes. The likewise greatly enlarged boundary diameter, very high revolutions per minute, and consequential peripheral speeds of Mach 2 in the low-pressure stages, impose a considerable strain on the blades through strong centrifugal forces and oscillations. Especially in the case of steam turbines, considerable erosion and corrosion occurs mainly in the area of the inlet edges, because of condensation developing in the case of a lowering of the pressure.

The selection of raw materials, which should have sufficient strength, corrosion resistance and surface hardness at high operating temperatures, on the one hand, as well as the construction from the point of view of flow engineering and the correct shape of blades pursuant to the degree of strength, on the other hand, make the commercial fabrication of blades a problem difficult to solve.

Therefore, the invention relates to a process for the manufacture of turbine blades which will meet all these requirements which are the result of modern technological development.

It is customary to make the blades, for example, from a blank made through rolling or forging, by means of cutting or noncutting treatment, or through casting the blades in their final dimensions, or slightly beyond those dimensions according to wax-melting, form masking or other processes.

At the same time, raw materials must be used which have the following characteristics:

(1) Sufficient mechanical strength against strain on the blades with regard to tension because of very considerable centrifugal forces, and against bending due to the pressure of the driving agent which often has a vibrating effect (endurance bending strength).

(2) Creep strength at operating temperatures of 650° C. and beyond.

(3) Corrosion resistance against attack by the driving agents, particularly stress corrosion and vibration stress from corrosive agents.

(4) The resistance of the surface against erosion and cavitation by the driving agent.

(5) Workability by cutting processes during the shaping of the blade base.

Heretofore, one tried to meet all these requirements through the use of steels with a content of 13% chrome and 0.25% carbon, which steels in their improved state have a basic martensitic structure with areas of ferrite. For modern, high-speed turbines, however, neither the strength values nor the behavior in the case of alternating reversal, nor the toughness of these steels sufficed. Therefore, an attempt was made to achieve better characteristics by increasing the carbon content. At the same time, it was important to make the inlet edges, which are under the greatest stress, more resistant to erosion through local surface hardening by means of flame or induction heating.

The 13% chrome steels, which, in view of the partial surface hardening had been more highly carbonated at the edges of the blades, are less corrosion resistant when they are annealed in the area of 500–650° C. and, moreover, they show essentially no improved strength values in comparison with the low carbonated types if one wants to prevent unocntrollable annealing processes during the surface hardening, and if one increases the annealing temperature beyond 650–700° C.

Also, experiments with other alloys, especially with higher chrome contents, and Cr-Ni-Mo-V-Nb steels alloyed in a complex manner, failed because the toughness value led to dangerous embrittlement because of carbide and nitride segregation in the case of certain annealing temperatures. Also, stress and crack corrosion has produced very uneven values after the annealing treatments in the critical temperature ranges, just as did the fatigue limit in the case of simultaneous corrosive attack.

If, therefore, one wants to obtain improvement in the essential characteristics by means of metallurgical methods, especially through use of steels alloyed in a complex manner, application of those processes for the strengthening of the inlet edges which can lead, at the zones of transition, the annealing phenomena which decrease quality, will be out of the question.

In order to overcome the described difficulties, the invention proposes a new production process for turbine blades, which process is characterized in that a blade blank, produced in the customary manner, is provided at the area of the inlet edge with a steel plate portion that is welded in pre-prepared recess, for example, the weld material consisting of an alloy made of hard metal of high-speed steel, or something similar. The portion is built up by welding and any uneven spots in the welded portion are smoothed. The weld portion is shaped to the final dimension in a drop forge, together with the body of the blade, and the turbine blade is finally subjected to heat treatment.

This process according to the invention results in considerable advantages as compared to all processes proposed heretofore. Both in conjunction with the shaping, which takes place subsequent to the steel plate portion being welded, as well as the subsequent heat treatment, the formation of abrupt transitions from one shape of the structure to another will be prevented, and, as a result thereof, the development of critical deteriorations of the local characteristics of strength are decreased. Through this method it is possible to adapt the protective edges made of hard alloys to truly every desired blade profile without any disturbing welding joint. The blade profile runs completely and smoothly around the curvature of the inlet edge. Experiments by way of comparison with the turbine blade produced according to the traditional methods have shown that the ones produced according to the present process have a considerably longer holding time and that, moreover, during the end control, a considerably smaller amount of waste develops.

The process according to the invention will be explained in more detail with reference to the drawing on the basis of an embodiment by way of example.

FIG. 1 is a view showing a blade blank in cross-section produced, for example, through a forging or cutting treatment;

FIG. 2 is a cross-sectional view showing the blank with a welded steel plate portion; and

FIG. 3 is a cross-sectional view showing the turbine blade obtained after drop forging, precisely to measurement, and subsequent heat treatment.

From a billet, pre-rolled in the customary manner, a corresponding section is rough forged in such a manner that it can be shaped with as few strokes as possible in a preliminary drop forge without too great a flow of material. This blank is freed, in the customary manner, of the flash under a trimming press while retaining the forging heat, and which flash was formed from the excess material between the two halves of the drop forge around the contour of the blank. Subsequently, the preparation for a welded steel plate portion **2** takes place by cutting out a groove **1** in parallelism to the longitudinal extent of the blade blank on the leading edge area (FIG. 1). This groove could be provided during the drop forging; if not, it can be produced by material cutting processes, for example, a cutting treatment or an electro-erosive treatment.

One must be careful that the groove and the adjacent area of the blank are carefully descaled so that a good metallic interface, free from the inclusion of oxide, will occur with the hard weld alloy **2** that is to be applied. Prior to the welding process, and depending on the material characteristics of the basic raw material of the blank and portion to be welded, which must be taken into consideration, and also especially in consideraton of sensitivity to hot tears, a careful preheating will take place, such as by resistance or induction heating. The application of the welding material to form the portion is accomplished by means of known fusion welding processes, whereby, if need be, welding under a protective gas or under slag, with or without feeding of fluxing agents from the casing of the electrode or through a welding powder can be utilized if the alloys require it.

After a careful cooling of the welded blanks, and in any case after exposure to compensatory annealing for avoidance of tension cranks in the base material, or particularly on the surface of the hard alloy portion, the uneven spots resulting from the welding beads in the weld portion can be smoothed, for example, by grinding. The blanks is the again heated slowly and intensively, and is shaped to the final dimensions in a finishing drop forge of precise measurements. The slight flash developing during this step is removed through some mechanical process, for example, grinding, and the blade is then hardened by heat-treatment. After reheating to below the annealing temperature and, if need be, after interposing a leveling stroke in the final drop forge, a straightening step can take place for the elimination of any distortion (warpage) which may possibly have occurred through the hardening process. For sensitive raw materials, it is recommended that a special "Quette" be used for aligning. Insignificant deviations from the size tolerance, which still exists after removing (by polishing) the superficial accumulations of material, are eleminated by subsequent aligning in the cold state.

Compared to the processes customary heretofore, the

method of operation according to this invention has proven itself to be superior for the simple reason that by way of the heat-treament after steel-facing by welding, a uniform structure, free of cracks, will be achieved. Also, there is no danger that the tension in the material will have a disturbing effect during operation, such as leading to subsequent changes of shape during the heating of the finished blades to operating temperature. The inlet edge portions welded on according to the invention and shaped through subsequent forging, together with the basic blank, will have, in the case of the correct choice of the raw material, a superior surface, be free of cracks, corrosion resistant, and exceedingly resistant to the erosive stress resulting from the driving medium. Expansion joints or separation between the basic raw material and the hard alloy has been welded is impossible, so that underwashes can no longer occur at the surface interface made their effects disturbingly felt in the case of edges produced according to other methods, especially when soldering. It is particularly surprising that, contrary to all expectations corresponding to expert knowledge, forging of these blanks provided with a welded steel plate portion, precisely according to measurement, is possible without difficulties even if, for example, high-speed steels or hard alloys of the Co-Cr-W type are used, which in themselves are not considered forgeable. Another technical advantage which occurs, particularly with regard to the simplification and the lowering of costs for the production process, lies in the avoidance of a cutting treatment of the edges made of hard alloy, which is possible only through grinding and, even then, with difficulties and only by means of special equipment.

What is claimed is:

1. A method of producing turbine blades comprising the steps of preforming a steel blade blank having a recess along the inlet edge thereof; fusion welding with a hard alloy steel to apply said hard alloy steel in excess to said recess; carefully cooling to prevent tension cracks in said steel blade blank; mechanically smoothing any uneven spots resulting from welding beads; forging said steel blade blank and said welded hard alloy steel into a smooth turbine blade configuration of final shape; and then heating treating.

2. A method as claimed in claim **1** wherein said hard alloy steel weld material is of the Co-Cr-W type; and said forging is drop forging.

3. A method as claimed in claim **1** comprising the further steps of descaling said steel blade blank and especially said recess, as well as preheating said blank prior to said welding step.

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JOHN F. CAMPBELL, Primary Examiner

D. C. REILEY, Assistant Examiner

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