

Encasement for Locating Workpieces for Machining and
Method for Manufacturing the Encasement

This invention relates to an encased workpiece with parallel clamping faces for locating irregularly contoured metallic workpieces for machining, and to a method for manufacturing the encasement.

A cast-metal encasement of the above generic description has been disclosed in GB-21 66 070, where a metallic high-temperature, irregularly contoured workpiece, such as an engine blade, is partially embedded in a cast block of a low-melting metal to produce parallel clamping faces and so enable the workpiece to be machined. This technique of positioning workpieces has the disadvantage that during the pouring process, molten metal comes into contact with the surface of the workpiece and at least threatens to contaminate its surface with foreign metals. Also, when the workpiece is later operated at elevated temperatures, its mechanical properties may conceivably have been affected in areas where it had been encased. A further disadvantage lies in the

need for elaborate chemical or chemophysical cleaning of the surface of the workpiece to remove contamination. When cooling down, the metal melt of the encasement material may disadvantageously develop cracks. A further disadvantage is that the encasement block adds considerable weight to the encased workpiece and makes its handling more difficult. Also, the low-melting metal being softer than the high-melting hard workpiece, continuous machining of encasement material and workpiece material is prevented.

Another consideration is that the method disclosed in GB-21 66 070 is uneconomical at least from the repair aspect, for the reason that energy is needed to melt the metal and a complete metal casting process with its attending elaborate handling of metal melts and lengthy cooling phases is needed.

In a broad aspect of the present invention an encasement of the above generic description and a method for its manufacture and separation is provided to enable the encasement material and the workpiece material to be machined jointly, to eliminate the need for subsequent cleaning to remove contamination from the encasement material without jeopardizing the mechanical properties of the workpiece, and to make said contamination negligible. Also, the encasement is free from cracks in the material and the parallel clamping faces make for secure location of the workpiece. Another broad aspect of the present invention is to provide a method economical enough to warrant encasing service-exposed and damaged components for repair purposes.

The invention provides an encased workpiece as claimed in claim 1.

The fact that the encasement material is a thermoplastic material means that it can be used several times over, since it is hard and tough at low temperatures and softens at elevated temperatures. This qualifies it for environmentally benign encasing, for a thermoplastic material can be reused about 100% without requiring high-cost conditioning operations.

A preferred material for encasing is polystyrene. This material is hard and strong at room temperature, and able to envelope, in the shape of ribs, an irregularly contoured workpiece without cracking after it was injection-molded at fusion temperature and allowed to cooling to room temperature. Its strength is sufficiently high to permit

clamping the ribs in conventional location tools without causing deformation. Also, this plastic material can be machined using the same water-cooled tools as for the workpiece.

In a preferred arrangement of the encasement the ribs and webs have approximately the same cross-sectional area. This affords an advantage in that shrinkage stresses in transitional areas between the ribs and webs are minimized and in that the encasement will not crack when applied.

In a further preferred application of the method the workpiece is completely enveloped by the encasement in the areas between ribs. This makes sure, one, that the position of the ribs and webs on the workpiece is made more secure and that, two, the workpiece can advantageously be electroplated or machined electrochemically or chemophysically on unmasked, exposed surfaces.

A preferred use of the encasement is in the location of engine blades, where the webs at least partially envelope the leading and trailing edges of the airfoil. This advantageously protects the leading and trailing edges from mechanical damage during machining while fixing the position of the ribs on the airfoil.

The ribs are preferably arranged orthogonally or at an angle of from 45° to 90° to the centerline of the airfoil to envelope the airfoil completely. This provides an advantage in that the airfoil centerline can be trued more accurately and that the blade can be securely located.

In the production or repair cycle of an engine blade, the airfoil is first finished and clamped into position in its root area or, when an integrally cast shroud segment exists, to the shroud segment. Then, for finishing the shroud segment and/or blade root, the airfoil is enveloped in an injection-molded encasement to provide suitable parallel clamping faces. In a preferred arrangement of the encasement, therefore, the spacing between ribs in the blade root or tip area is narrower than at midspan.

At midspan the rib spacing is preferably wider than twice the rib thickness. With this rib arrangement the clamping forces can advantageously be spread over the airfoil in the absence of deforming clamping forces, especially so since airfoils in aircraft engines exhibit extremely thin wall thicknesses at midspan.

In a preferred method for manufacturing an encasement the workpiece is fitted into a locating mold of an injection molding machine and the plastic material for the encasement is injection-moulded on to the workpiece. This provides an advantage in that when polystyrene is used as a casing material, the surfaces to be machined, such as the blade root and shroud segment, can likewise be embedded, considering that both materials can advantageously be processed by water-cooled machining techniques using conventional tools. Provided the airfoil is completely enveloped by the encasement material, machining can advantageously be followed by electroplating in the shroud or root area and/or by electrochemical polishing or etching. Also chemophysical

processing operations like vacuum vapor depositing, sputtering or CVD will be possible, for which purpose the finished airfoil surface is protected by complete encasement.

To separate the workpiece from the encasement the encased workpiece is cooled to a temperature at which continuous shrinkage cracks will form in the encasement. Since the plastic material will embrittle at low temperatures and shrink to a greater degree than the metallic workpiece, continuous shrinkage cracks will form in the plastic material without deforming the workpiece. The encasement will advantageously detach from the workpiece without leaving any residues, and if thermoplastic, can be reused and reinserted in an injection molding cycle.

The invention is described more fully in light of the accompanying drawings, in which

FIG. 1 illustrates an injection-molded encasement of a workpiece before finishing,

FIG. 2 illustrates an injection-molded encasement of a workpiece in lateral view, and

FIG. 3 illustrates an encased workpiece after finishing.

With reference now to FIG. 1 an injection-molded encasement 1 of an irregularly contoured workpiece 2, such as a blade 3 for gas turbine engines, is shown before finishing. The workpiece 2 has been completely enveloped, except for a few positioning faces 4, by injection molding with a plastic encasement material. The plastic material here used is polystyrene, a thermoplastic material softening at temperatures between

80 °C and 150 °C and exhibiting sufficient strength at room temperature to absorb clamping forces through planoparallel clamping faces 5. These clamping faces 5 are arranged on ribs 6 spaced apart by means of webs 7 and 8. This spacing diminishes in the direction of the surfaces 9 and 10 to be machined. This ensures secure clamping near the machining areas.

In the case of a blade 3 the surfaces to be machined are in the blade root 11 and shroud segment 12 areas. Blade root 11 and shroud segment 12 form integral parts of a blade 3. Arranged between these is the airfoil 13, which has already been given its final contour before encasing. The web 7 simultaneously covers the leading edge and the web 8 the trailing edge of the airfoil 13, which is thus protected from mechanical injury. The cross-sectional areas of the webs 7 and 8 are approximately the same size as the cross-sectional areas of the ribs 6.

The airfoil surface between the ribs 6 and webs 7 and 8 of the encasement 1 can likewise be enveloped by a thin plastic layer to protect it during electroplating and/or electrochemical polishing or etching operations or during chemophysical operations, such as vacuum vapor deposition, sputtering or CVD, in the shroud area or root area.

The plastic encasement thus covers, as in this example, the entire blade 3, except for a few positioning surfaces 4. Said positioning surfaces are kept free of encasement material during the injection molding process to provide suitable reference surfaces for trueing the workpiece 2 for, e.g., milling planoparallel clamping faces 5 on the ribs 6 of the encasement 1.

In finishing the plastic material of the encasement 1 can be machined together with the workpiece 2 by water-cooled technique without requiring additional special tools.

FIG. 2 illustrates an injection-molded conformal encasement 1 of a workpiece 2 in lateral view. After the encasement 1 consisting of the ribs 6 and the webs 7 was injection molded, the clamping faces 5 and 14 on the ribs were milled for planoparallel alignment, after the blade had first been trued with reference to the positioning surfaces 4. The need for this milling operation is eliminated when the encasement 1 exhibits adequately accurately positioned, planoparallel clamping faces 5 and 14 on the ribs 6 after injection molding.

FIG. 3 illustrates an encased workpiece 2 after finishing, where during the finishing of the lower 15 and upper 16 workpiece area also the plastic encasement 1 was removed. If the item being finished was a blade 3, the blade root 11 and the shroud segment 12 with sealing fins 17 were machined with geometric reference to the clamping faces 5 such that the encasement 1 with its planoparallel clamping faces 5 in the area of airfoil 13 was allowed to remain. After finishing, the remaining portions of the encasement 1 are separated from the airfoil 13 by a cooling process. For the purpose, the encased workpiece 1 is cooled to a temperature at which continuous shrinkage cracks form in the encasement and the encasement detaches from the workpiece 2 in fragments without leaving residues.

To produce a conformal encasement 1 by the injection molding technique takes only fractions of a minute, and so does separating the encasement 1 from the workpiece 2 by means of a cooling operation without leaving residues. The plastic fragments arising during separation can be reused. This makes the encasement 1 a cost-effective aid that enables operations and repairs to be performed on irregularly contoured workpieces 2 at low cost and time expenditures, and that even warrants repair work economically.



Claims:

1. An encased workpiece, wherein the encasing is made of injection-moulded plastics material and comprises parallel clamping faces for locating the workpiece for machining thereof, and a plurality of spaced-apart ribs interconnected by webs, and

the encasing consists of a thermoplastic material.

2. An encased workpiece as claimed in claim 1, wherein the encasing consists of polystyrene.

3. An encased workpiece as claimed in any one of claims 1 to 2, wherein the ribs and the webs have substantially equally-large, cross-sectional areas.

4. An encased workpiece as claimed in any one of claims 1 to 3, wherein the workpiece is completely enveloped between the ribs by the encasing.

5. An encased workpiece as claimed in any one of the preceding claims, wherein the workpiece is an engine blade and the webs at least partially envelop the leading and trailing edges of the aerofoil.



6. An encased workpiece as claimed in claim 5, wherein the ribs are arranged orthogonally or at an angle of from 45° to 90° to the blade centreline and that they envelop the aerofoil.
 7. An encased workpiece as claimed in claim 5 or 6, wherein the spacing between the ribs is narrower in the blade root area or in the blade tip area than at midspan.
 8. An encased workpiece as claimed in claim 5, 6 or 7, wherein the spacing between the ribs at midspan is wider than twice the rib thickness.
 9. An encased workpiece substantially as herein described with reference to the accompanying drawing.
 10. A method of manufacturing an encased workpiece as claimed in any one of the preceding claims, wherein the workpiece is fitted into a location mould of an injection moulding machine and thermoplastic material is injection moulded onto the workpiece.
 11. A method of manufacturing an encased workpiece as claimed in claim 10, wherein the encased workpiece is cooled to a temperature at which continuous shrinkage cracks form in the encasing to allow subsequent separation of the encasing from the workpiece.
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