

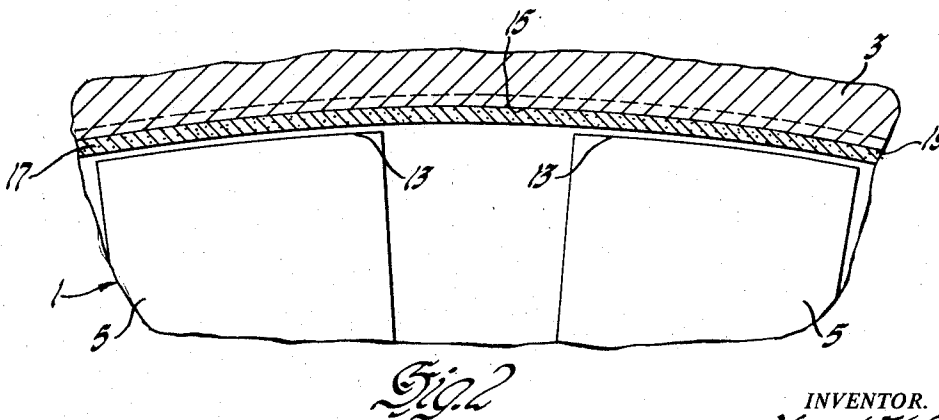
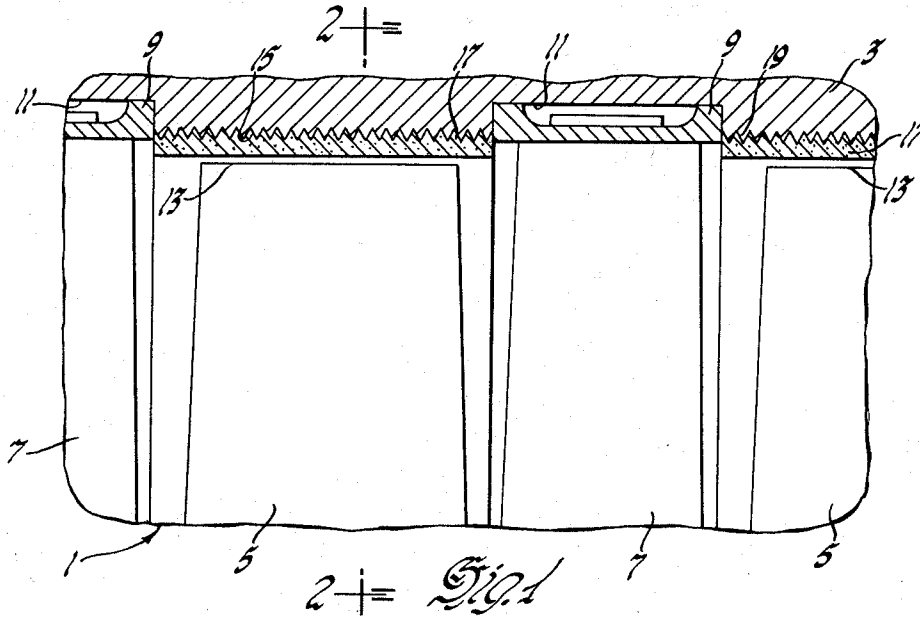
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ABRADABLE PROTECTIVE COATING FOR COMPRESSOR CASINGS

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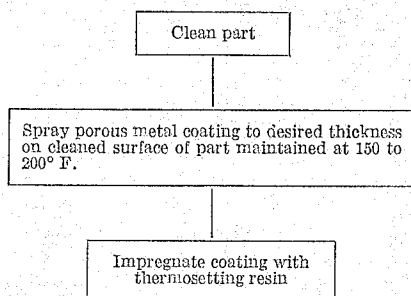
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This invention relates to improvements in compressors and more particularly to improvements in the efficiency of axial-flow compressors by application of a suitable resin impregnated metal coating to the inner wall surface of the compressor housing.

A simplified flow diagram of the method is as follows:



Typical axial-flow compressors, such as those used in modern turbine engines, include a rotor which carries rows of outwardly extending rotor blades or vanes and a compressor housing which carries corresponding rows of stator vanes. The body of the rotor may be formed of a suitable high strength forgeable material such as an alloy of titanium, aluminum, and/or steel while the rotor vanes, generally dovetailed into the rotor, may be of stainless steel or the like.

The compressor housing or casing, which may be cast from stainless steel, aluminum, magnesium, or the like, and various alloys thereof, generally is a two-piece assembly split on a plane through the compressor axis. Secured to the inner circumference of the housing are longitudinally spaced rows of stator vanes of stainless steel or the like which project inwardly between the corresponding rows of rotor vanes.

Up to the present time, one of the primary difficulties with axial-flow compressors has been the excessive energy loss due to the leakage of air past the rotor blade tips. The amount of air leakage depends to a large degree upon the clearance between the tips of the rotor blades and the compressor housing. This clearance in turn depends on the rigidity and dimensional stability of the compressor. In addition to the warpage and elastic deformation encountered in operation, the differential expansion of the compressor parts over the wide range of temperatures encountered in use, makes it highly impractical to manufacture a compressor having a minimum clearance for optimum efficiency. Not only would more costly finishing and inspection operations be required in manufacture, but in many cases the dimensional instability of the closely fitting parts would result in damage to the compressor by scoring or gouging of the housing or breakage of the rotor vanes.

Accordingly, the principal object of this invention is to provide effective methods for minimizing the clearance between the rotor blade tips and the compressor housing and for minimizing corrosion of the housing. A further object is to provide a method for applying a readily machinable heat-resistant coating to the interior of the compressor housing to reduce the clearance between the blade tips and the housing. Other objects and advantages will more fully appear from the description which follows.

I have discovered that the clearance between the blade tips and the compressor housing in an axial-flow compressor can be effectively reduced to a minimum by providing the interior of the compressor housing with a coating of a relatively soft metal which is adapted to be cut away by the tips of the moving blades to provide a minimum clearance for optimum operating efficiency, the method of application of said material to said housing being to apply a machinable porous metal coating and a resinous plastic coating to fill the pores to produce a tightly adherent, non-porous, substantially warp and crack resistant coating which is readily machinable and protects the housing from corrosion.

The invention will be best understood in connection with the accompanying drawing, in which:

FIG. 1 is a fragmentary view, partially in section, of a multistage axial-flow air compressor incorporating the invention; and

FIG. 2 is a fragmentary view, partially in section, of one stage of an air compressor taken on line 2—2 of FIG. 1.

Referring now to the drawing in detail, a turbo-compressor indicated generally at 1, is shown in a housing 3, only so much of the compressor being shown as is necessary to illustrate the invention. The rotor is fabricated to carry a plurality of rows of rotor blades 5, the blades being supported on the rotor shaft in any manner well known in the art and not shown. Extending inwardly from the housing 3 between the rows of rotor blades 5 are the rows of stator vanes 7. The stator vane rows are supported by rings 9 which are suitably secured in annular grooves 11 in the housing 3.

The present invention is directed to methods for reducing the clearance between the tips 13 of the rotor blades 5 and the inner circumferential surface 15 of the compressor housing. In accordance with this invention the portions of the housing adjacent the paths described by the tips 13 of the moving blades 5 are provided with a porous coating 17 of a relatively soft metal such as aluminum, bronze or zinc which is adapted to be readily machined by the blade tips to establish a minimum operating clearance between the blade tips and the rotor housing. As indicated in the fragmentary end view in FIG. 2, the coating 17 extends around the entire circumferential portion of the housing adjacent the moving rotor blade tips. Also, as is described more fully hereinafter, the surface of the housing 3 which is coated is roughened as by cutting shallow threads 19 therein as shown in FIG. 1.

I have found that by impregnating the porous coating 17 with a heat-resistant resinous plastic not only are the pores sealed thus precluding corrosion of the housing, but that the machinability of the resultant coating is very greatly improved as is also the surface smoothness and uniformity. Extended development and tests demonstrated that a metal coating having the desired properties noted above and which is adherent to the base metal and possesses a uniform surface free from blisters, chips or other objectionable defects may be obtained by the hereinafter described methods.

It is essential that the surface to be coated be properly cleaned and conditioned prior to application of the metal coating. The surface should be thoroughly cleaned to remove dirt, grit, and oils by solvent cleaning as by vapor degreasing in trichloroethylene or by dip-washing in a petroleum solvent. The surface is then conditioned to enable a tightly adherent coating by machining a shallow thread in the surface and/or grit blasting or shotting to provide a roughened surface. The resultant aluminum, magnesium or steel surface should have a rather fine texture and should be substantially uniform in quality.

The porous metal coating is then applied to the desired thickness in any suitable manner as by spray coating with

a metallizing spray gun. I have found it necessary to pre-heat the surface to be coated to a temperature of from about 175°-200° F. During the spraying operation I have found it necessary to maintain the temperature of the part between 150°-200° F. Parts deviating from these temperatures are apt to have an inferior bond between the coating metal and the base metal. The desired temperature control may be conveniently achieved by applying a hot air blast to the opposite side of the part being treated.

In applying a porous bronze coating to a magnesium compressor housing surface, I found that a coating thickness of from 0.003 to 0.005 inch without any intermediate bonding layer was sufficient to produce the desired characteristics. In applying a porous aluminum coating to a steel compressor housing surface it was found that an intermediate bonding layer of stainless steel produced the best results. My preferred method is to spray coat a layer of stainless steel of from about 0.002 to 0.005 inch thickness followed by the application of a porous aluminum coat of from about 0.030 to 0.035 inch thickness. It should be noted that other intermediate layer materials may be utilized, i.e., bronze, zinc, copper.

While the porous metal coating is machinable, I have found that the impregnation thereof greatly improves the machinability while at the same time producing a uniformly smooth surface and precluding corrosion of the base metal. Impregnation is accomplished by using a high temperature resistant thermosetting resin such as any of the well known epoxy or silicone resins in sufficient solvent or thinner to produce a solution of the desired viscosity. About equal parts by volume of epoxy resin and thinner has been found to be suitable. Similarly, a mixture of about 18.0-22.0 parts by weight silicone resin solids and about 78.0-82.0 parts solvent is satisfactory. I have found that a minimum of two coats of impregnant should be applied in any suitable manner, as by brushing, spraying, dipping or rolling. Complete impregnation is accomplished when resin is still on the surface after about 20 minutes of air drying after application, this dry period being used after each coat.

After complete impregnation, the part is subjected to baking at elevated temperatures in progressive steps in order to thoroughly dry and cure the materials. I have found it to be satisfactory if the impregnated coating is first baked at about 150° F. for at least one-half hour followed by a bake at about 450° F. for one hour. Where the porous metal coating is relatively thick, as in the case of aluminum, a final bake is desirable at about 625° F. for a period of about 3 hours. Upon cooling to room temperature, sanding with steel wool or other finishing may be used to obtain a smoother finish, if desired.

While I have described my invention in terms of applying the coating directly to the housing of the compressor, it should be understood that it may be applied to parts positioned on the housing. Other embodiments may be apparent to those skilled in the art and such embodiments are within the scope of my invention as defined by the claims which follow.

I claim:

1. The method for forming a machinable metal coating on a metal part adapted to form that portion of an axial flow compressor housing adjacent the path of the rotor blade tips comprising the steps of cleaning the surface of the part to be coated, spraying a porous metal coating on said surface to the desired thickness, controlling the temperature of said surface during coating to maintain a temperature of between 150° and 200° F. and thus preclude inferior bonding between said coating and said surface, and impregnating said coating with a high temperature thermosetting resin to fill the pores thereof.

2. A method as set forth in claim 1 including the steps of roughening the surface to be coated and preheating the part to a temperature of about 175°-200° F. prior to coating.

3. A method as set forth in claim 2 including the steps of subjecting the coated and impregnated part to baking at successive elevated temperatures not to exceed about 625° F.

4. A method for forming a machinable porous bronze coating on that portion of a magnesium housing of an axial flow compressor adjacent the path of the rotor blade tips comprising the steps of cleaning the surface to be coated, roughening said surface to promote formation of a tightly adherent coating, preheating said surface to a temperature of about 175°-200° F., spraying a porous bronze coating on the surface to the desired thickness, controlling the temperature of said surface during coating to maintain a temperature of between 150° and 200° F. to thus preclude inferior bonding between said coating and said surface, and impregnating said porous coating with a high temperature thermosetting resin.

5. A method as set forth in claim 4 including the steps of baking the impregnated coating at a temperature of about 150° F. for a period of at least ½ hour followed by baking at a temperature of about 450° F. for a period of about one hour.

6. A method as set forth in claim 5 wherein the thickness of said coating is from about 0.003 to 0.005 inch and said impregnating resin is an epoxy resin.

7. A method for forming a machinable porous aluminum coating on that portion of a steel housing of an axial flow compressor adjacent the path of the rotor blade tips comprising the steps of cleaning the surface to be coated, roughening said surface, preheating said surface to a temperature of about 175°-200° F., spraying an intermediate bonding layer of stainless steel, spraying a porous aluminum layer on said bonding layer to the desired thickness, controlling the temperature of said surface during coating to maintain a temperature of between 150° and 200° F. to thus preclude inferior bonding between said coating and said surface, and impregnating said coating with a high temperature thermosetting plastic.

8. A method as set forth in claim 7 including the steps of baking the impregnated coating at a temperature of about 150° F. for a period of at least ½ hour followed by baking at a temperature of about 450° F. for a period of about one hour and at a temperature of about 625° F. for a period of about three hours.

9. A method as set forth in claim 8 wherein the thickness of the bonding layer is from about 0.002 to 0.005 inch, the thickness of the aluminum is from about 0.030 to 0.035 inch, and the impregnating resin a silicone resin.

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