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METHOD OF ETCHING FERROUS ALLOY AND COMPOSITION

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This invention relates to the shaping of metal parts and more particularly to the method of shaping metal parts by chemical dissolution techniques.

In recent years it has increasingly become more apparent that conventional methods of machining parts, particularly aircraft parts, have become inadequate for obtaining present day needs. Various methods of fabricating aircraft parts, for example, have been employed in the past to obtain high strength, exceedingly light weight articles. However, conventional methods still do not permit the manufacture of parts having the most desirable strength to weight ratios. This limitation in conventional manufacturing techniques is particularly important where a conventional, relatively heavy material must be used in aircraft or rocket parts. When making turbine or compressor wheels of a jet engine, for example, the web portion of the wheel can be quite thin. Conventional manufacturing methods cannot be used under commercial production conditions to satisfactorily form the webbing to the most desirable thinness.

Moreover, in the manufacture of metal parts, frequently the parts must be machined after being formed by casting, forging or the like. When the part is machined a burr ordinarily results at the edge of the surface which is machined. The presence of a burr on a finished part is ordinarily objectionable and must be removed. Conventionally burr removal is accomplished by an abrasive blast, tumbling, shot peening, etc. However, conventional methods are quite costly and time consuming.

By utilizing chemical dissolution techniques parts made of titanium or aluminum have been manufactured so as to have optimum strength to weight ratios. These techniques, used in conjunction with conventional machining operations, permit the formation of satisfactory, exceedingly thin formed metal sections economically under production conditions. Moreover, the use of chemical dissolution techniques further provides an economical means whereby burrs on machined parts can be removed.

It is universally recognized that the surface finish of a part which is subjected to physical and thermal stresses should be exceptionally smooth. It is accepted that extremely smooth surface finishes are not only desirable but, in most instances, necessary to obtain the optimum resistance to fatigue and corrosion. Heretofore chemical dissolution techniques have only been applied to aluminum and titanium metals. Satisfactory methods were not known which would chemically dissolve other alloys to produce the desired surface finish. A solution may be available which will dissolve a given metal but in so doing will not produce the smooth surface finish required. In making a part utilizing chemical dissolution techniques the primary problem is not to merely obtain metal removal but to obtain it in a controlled manner. Moreover, in some instances, it is even a problem to obtain a solution which will dissolve a given metal at a satisfactory rate.

The satisfactory dissolving of a given alloy requires a highly specific solution which will dissolve the metal and simultaneously either give rise to a smoother surface finish, or at least maintain the existing surface finish of the part. It has been found that, in general, solutions which will dissolve an alloy will simultaneously produce a

rough etched or pitted surface. The solutioning of a given metal must, therefore, be done under controlled conditions, in a specific manner, with a particular type of solution to obtain the surface finish which is desired. By means of this invention a high temperature ferrous base alloy, which is of extreme importance in the manufacture of jet engines, can be satisfactorily machined by chemical dissolution techniques.

It has now been found that a ferrous base alloy consisting essentially, by weight, of about 11.5% to 13.5% chromium and about 86.5% to 88.5% iron can be satisfactorily machined by dissolution in a bath containing ammonium bifluoride, nitric acid and water.

For example, the results obtained with the corrosion-resistant alloy, commonly referred to as AMS 5613, are especially satisfactory when treated in accordance with our invention. The alloy AMS 5613 has a general composition which is as follows:

Carbon	maximum percent	0.15
Manganese	do	1.25
Nickel	do	0.5
Sulfur	do	0.03
Silicon	do	1.0
Phosphorus	do	0.04
Copper	do	0.5
Molybdenum	do	0.6
Chromium	percent	11.5 to 13.5
Iron		Balance

By means of this invention parts made of corrosion-resistant ferrous base alloys, such as AMS 5613, can be chemically readily machined to exceptionally thin sections having an exceptionally smooth surface finish. This invention further provides the method of chemically deburring parts formed of such alloys in a satisfactory economical manner. Now corrosion-resistant ferrous base metals can satisfactorily be machined by chemical dissolution techniques.

In order to form a metal part by means of chemical dissolution techniques, the part is initially cast or premachined to desired measurements prior to the chemical dissolution treatment. It is generally desirable to form the part slightly oversize when no masking is employed so that in the chemical dissolution treatment the part is reduced to finish dimensions. It is preferred to form the part to as close to final desired specifications as is practical by conventional techniques since metal removal by chemical dissolution is somewhat more time consuming. The preformed part can then be placed on a suitable support means where it is cleaned.

Although various methods of cleaning may be employed, highly satisfactory results have been found to be obtainable when the part is initially degreased in a trichloroethylene vapor at a temperature of approximately 180° F. In some instances, one of the many commercially available di-phase cleaners, which is a stable emulsion of an organic cleaner and an alkali cleaner, can be used.

After degreasing, the part is dried and then subsequently immersed in an alkaline solution and electrically cleaned. A solution containing soda ash 35%, trisodium phosphate 55% and caustic soda 10%, all proportions by weight, can be used. In general, it is desirable to include a wetting agent, such as sodium resinate, in the bath in quantities up to 5%, by weight.

The part is subjected to an anodic potential of about six volts for approximately one minute and subsequently rinsed with water. The duration of the anodic cleaning is variable, depending upon the size, configuration, etc. of the part and upon the freshness of the cleaner. The effectiveness of the cleaner decreases in use so that more extended periods of anodic cleaning may be required for

a part in a cleaning solution that has been used a number of times.

After rinsing the part free of any of the cleaning solution that may adhere to its surface, it is dried. The part is then ready to be chemically machined. The part is preferably positioned in the machining solution in such a manner as to avoid non-uniform dissolution of the surfaces. Gas generated during the dissolution of the metal part can accumulate in recesses or horizontal areas of the part so as to interfere with uniform chemical dissolution of the entire surface. When chemical machining an article having a planar configuration, such as a panel, it is desirable to support the panel in the machining solution in a vertical attitude.

On the other hand, articles of a more complicated configuration containing complex contours and recesses may not be suitably maintained in any position which will entirely inhibit collection of the generated gases and formation of gas pockets. For these and other types of articles it may be desirable to chemically machine the parts in a plurality of steps in which portions of the part are masked from the solution. For example, the top of such an article can be chemically machined while its lower surface is masked with a suitable stop-off material. When sufficient metal removal of the upper surface is obtained, the part is removed from the solution, rinsed, and the stop-off removed to expose the protected surface. The machined surface is then masked and the part reimmersed for completion of the chemical machining of the part. Of course, to complete the machining, the part is inverted so that the masked surface is on the bottom of the part.

We have found that exceptionally uniform metal removal can be obtained from the surface of a part made from a corrosion-resistant ferrous base alloy consisting essentially, by weight, of about 11.5% to 13.5% chromium and 86.5% to 88.5% iron when the part is immersed in a solution of the following approximate composition, all proportions by weight:

	Percent
NH_4FHF	10 to 25
HNO_3 (specific gravity 1.42)	15 to 50
H_2O	25 to 75

More specifically we have found that a highly satisfactory surface leveling effect is produced when a part composed of the subject type alloy is immersed in a solution of the following approximate composition, all proportions by weight:

	Percent
NH_4FHF	15
HNO_3 (specific gravity 1.42)	30
H_2O	55

Although optimum results with the above solutions are obtained when the metal removal is accomplished at a bath temperature of approximately 175° F., it has been found that highly satisfactory results are obtained employing bath temperatures of approximately 160° F. to 200° F. At these bath temperatures not only is original surface smoothness retained but a highly desirable surface leveling is additionally effected. In general metal removal rates of approximately 0.001 inch to 0.005 inch per minute are obtained.

If stopping-off of the part to be machined is required, generally any maskant can be used which is insoluble in the bath solutions described above. However, stop-off materials such as a phenolic base lacquer or a polyvinyl base lacquer can be used. Of course, when employing phenolic base lacquers the masked part is subjected to a temperature of approximately 350° F. for several minutes to bake the lacquer. The usual time for air drying of polyvinyl base lacquers can be reduced by heating for several minutes at temperatures up to approximately 250° F.

After the stop-off has been applied, the part is again cleaned to remove any fingerprints or any adhesive from some of the stop-off materials which might have been used. Generally, fingerprints can be removed by wiping the surface of the part with a suitable solvent. One such solvent which can be used with a phenolic base lacquer is methyl ethyl ketone. When using a polyvinyl base lacquer, however, a more satisfactory solvent would be methyl alcohol or some other solvent which does not dissolve the base lacquer as does methyl ethyl ketone. In some instances it may be additionally desirable to wipe the surface with a second solvent which is more particularly suited to the removal of the adhesive which is used in applying the maskant. After cleaning, the part is then ready for immersion in the chemical machining solution.

In the manufacture of high strength, corrosion-resistant parts, especially those employed as aircraft components, it is recognized that surface smoothness is exceedingly important in forming an improved part. It is believed that, with increases in surface smoothness, the fatigue life of a part is not only increased but that its corrosion resistance is also materially increased. Our invention provides a means whereby such surface smoothness can be readily obtained on an alloy of a specific composition. We have found that immersing a part composed of the subject type alloy in any solution which will dissolve it generally does not uniformly dissolve the metal. The rate of chemical dissolution between the grains, grain boundaries, inclusions, etc. are not generally equal. A highly specified solution used under specific conditions must be employed in order to obtain a uniform rate of dissolution of the various phases of the metal composition. Although heretofore chemical machining methods have only been applied to materials, such as aluminum and titanium, it is now possible to also produce a ferrous base alloy part by means of chemical dissolution techniques.

Although this invention has been described in connection with certain specific examples thereof, no limitation is intended thereby except as defined in the appended claims.

We claim:

1. The method of chemically machining a stainless steel alloy part which comprises immersing the stainless steel alloy part in an aqueous solution which is at a temperature of approximately 160° F. to 200° F. so as to uniformly remove metal from said surface at a rate of at least 0.001 inch per minute to form a predetermined configuration, said solution consisting essentially of, by weight, approximately 10% to 25% ammonium bifluoride, 15% to 50% nitric acid and 25% to 75% water.

2. The method of chemically machining a metal part formed of a stainless steel alloy containing 11.5% to 13.5%, by weight, chromium, said method comprising immersing said part in an aqueous solution at a temperature of approximately 160° F. to 200° F. so as to uniformly remove metal from a surface of said part at a rate of at least approximately 0.001 inch per minute to form a predetermined configuration while at least substantially maintaining surface smoothness, said solution consisting essentially of, by weight, about 10% to 25% ammonium bifluoride, 15% to 50% nitric acid and 25% to 75% water.

3. The method of chemically machining a metal part formed of a stainless steel alloy containing 11.5% to 13.5%, by weight, chromium, said method comprising immersing said part in an aqueous solution at a temperature of approximately 160° F. to 200° F. so as to uniformly remove metal from a surface of said part at a rate of at least approximately 0.001 inch per minute to form a predetermined configuration while at least substantially maintaining surface smoothness, said solution consisting essentially of, by weight, about 15% ammonium bifluoride, 30% nitric acid and 55% water.

4. The method of chemically machining a metal part which comprises immersing a part made of a ferrous base alloy consisting essentially of approximately 11.5% to

13.5% by weight, chromium and 86.5% to 88.5% iron in an aqueous solution which is at a temperature of approximately 160° F. to 200° F. so as to uniformly remove metal from a surface of said part to form a predetermined configuration, said solution consisting essentially of, by weight, approximately 10% to 25% ammonium bifluoride, 15% to 50% nitric acid, and 25% to 75% water.

5. The method of chemically machining a metal part which comprises immersing a metal part made of a ferrous base alloy containing maximums of about 0.15% carbon, 1.25% manganese, 0.5% nickel, 0.03% sulfur, 1.0% silicon, 0.04% phosphorus, 0.5% copper and 0.6% molybdenum, about 11.5% to 13.5% chromium and 86.5% to 88.5% iron, all proportions by weight, in an aqueous solution which is at a temperature of approximately 160° F. to 200° F. so as to uniformly remove metal from a surface of said part to form a predetermined configuration, said solution consisting essentially of, by weight, approximately 10% to 25% ammonium bifluoride, 15% to 50% nitric acid, and 25% to 75% water.

6. The method of chemically machining a metal part which comprises degreasing a metal part made of a ferrous base alloy consisting essentially of about 11.5% to 13.5%, by weight, chromium and 86.5% to 88.5% iron, electrolytically cleaning said part in an alkaline electrolyte cleaning solution, masking a surface of said part, immersing said part in an aqueous solution which is at a temperature of approximately 160° F. to 200° F. so as to uniformly remove metal from an unmasked surface of said part to form a predetermined configuration, said solution consisting essentially of, by weight, approximately 10% to 25% ammonium bifluoride, 15% to 50% nitric acid, and 25% to 75% water.

7. The method of chemically machining a metal part which comprises cleaning the surface of a metal part made of an alloy containing, by weight, 11.5% to 13.5% chromium and 86.5% to 88.5% iron, masking a surface of said part and immersing said part in an aqueous solution so as to uniformly remove metal from an exposed surface of said part to form a predetermined contour which improves the strength to weight ratio of said part, said solution containing, by weight, approximately 10% to 25% ammonium bifluoride, 15% to 50% nitric acid, and 25% to 75% water.

8. A chemical machining bath for use in connection with stainless steel alloys wherein the machining is carried out at a temperature of about 160° F. to 200° F., said bath consisting essentially of, by weight, about 10% to 25% ammonium bifluoride, 15% to 50% nitric acid and 25% to 75% water.

9. A chemical machining bath for use in connection with stainless steel alloys containing about 11.5% to 13.5%, by weight, chromium, wherein the machining is carried out at a temperature of about 160° F. to 200° F., said bath consisting essentially of about 15% ammonium bifluoride, 30% nitric acid and 55% water.

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