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PICKLING SOLUTION

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This invention relates to acid solutions useful for the removal of foreign metallic objects embedded in stainless steel. In particular, it relates to a solution of mineral acids adapted to vigorously attack high-speed alloys while having no corrosive effect upon stainless steel.

Stainless steel commonly used in various types of construction is an alloy containing iron, chromium, nickel and carbon. The so-called high-speed alloys are tungsten and molybdenum alloys containing various combinations of metals such as cobalt, chromium, manganese and vanadium; or steels in which one or more of these metals is incorporated. High-speed alloys are capable of retaining a cutting edge although subjected to high temperatures and friction, and are customarily used in drills, taps, reamers, lathes and other cutting tools employed for working metals, steels, and in particular, stainless steel.

Heretofore, various methods were used to remove embedded tools such as broken bits and taps or other embedded metallic objects from stainless steel. One such method consisted of drilling out the embedded tool, welding the steel again into a continuous piece and redrilling the desired hole or bore. Another method consisted of pickling the entire stainless steel piece in boiling nitric acid (67%) for a period of from about 3 to about 8 hours. Due to the necessity of immersing the entire piece in the nitric acid, this method can be used only with small objects. In using this technique, the entire surface area of the piece is exposed to the corrosive effect of the nitric acid which not only attacks the alloy of the tool but also the steel itself, which is highly undesirable in most instances.

Still another method was to immerse the article containing the broken tool in a dilute solution of nitric acid containing hydrofluoric acid in quantities not in excess of about 2% by volume of 100% HF. While superior to using boiling nitric acid, these solutions required extended periods of time to dissolve the foreign material.

I have discovered a new pickling solution which permits rapid and convenient removal of embedded metal objects from stainless steel without substantial damage to the stainless steel itself.

In accordance with the present invention, a solution comprising hydrofluoric acid (100%) in amounts of from about 30% to about 50% by volume and nitric acid (100%) in amounts of about 10% to about 35% by volume, the balance of the composition being water, is employed as the pickling agent.

These solutions attack high speed alloys at room temperature more rapidly than any of the known pickling agents used for this purpose. Furthermore, they are far less corrosive towards stainless steel than boiling nitric acid or the dilute solutions of nitric acid containing less than 2% hydrofluoric acid.

The solutions provided by this invention are prepared by merely mixing the nitric acid and hydrofluoric acid in appropriate proportions. If desired, water may be added provided the concentration of the acids is maintained within the ranges set forth above. The alloys presented in Table I below are representative of the high speed alloys which are attacked by the pickling solution of this invention.

TABLE I

Alloy A		Alloy B	
Metal	Wt. Percent	Metal	Wt. Percent
Cobalt	30.0	Vanadium	01.0
Iron	52.0	Iron	76.3
Tungsten	14.0	Tungsten	18.0
Chromium	04.0	Chromium	04.0
		Carbon	00.7
	100.0		100.0

For the purpose of comparison, a series of tests were conducted to illustrate the effect of the solutions provided by this invention and the effect of solutions previously known in the art upon high speed alloys and stainless steel. The results of these tests are presented in Table II below.

TABLE II

Relative corrosiveness of pickling solution for drill removal from stainless steel at ambient temperature

Pickle Solution, By volume	Time required to dissolve one gram of drill, Minutes	Weight of drill dissolved/minute, 10^{-3} grams	Parent Metal Weight Loss, 10^{-3} grams/cm.^{2}/gram of drill dissolved
48% HF(100%)	105	9.5	3.4
13% HNO_3(100%)	80	12.5	3.0
39% Water			
45% HF(100%)	107	9.3	2.4
17% HNO_3(100%)	115	8.6	2.3
39% Water			
40% HF(100%)	89	11.2	3.7
22% HNO_3(100%)			
38% Water			
30% HF(100%)	297	3.4	5.1
34% HNO_3(100%)			
36% Water			
2% HF(100%)	1,370	0.74	15.0
17% HNO_3(100%)	1,660	0.60	21.0
81% Water			
67% HNO_3(100%) boiling	3,120	0.32	100.0
33% Water boiling	3,120	0.32	62.0

The above tests were performed by immersing in the various pickling solutions, weighed samples of a high speed drill made from an alloy containing chromium, tungsten, vanadium, carbon and iron and embedded in a weighed sample of stainless steel.

As is shown by the above data the embedded drill was dissolved as much as 35 times faster by the solutions of this invention than by boiling nitric acid and as much as about 7 times faster than by previously known hydrofluoric-nitric acid pickling solutions. In addition, the loss of stainless steel due to the corrosive action of the solutions of this invention are on the order of about 40 times less than losses due to the use of nitric acid, and as much as about 9 times less than losses from the use of previously known hydrofluoric-nitric acid pickling solutions. It is evident from the data shown above that employing the solutions of this invention will effect a great saving in time and damage in such procedures.

In addition to the obvious advantages realized from the selective action of these solutions, the rate of their reaction and the temperature at which they react permit them to be used in several different manners.

The stainless steel piece containing the foreign object can be immersed in the solution and the embedded object thus allowed to dissolve while the stainless steel piece remains relatively unaffected.

Another method of applying the solution which has various advantages heretofore unknown in the art consists of pouring or dropping the solution directly onto the object to be removed. It is usually preferable to pour or drop small quantities of the solution onto the object and allow the vigorous reaction which ensues to subside before replenishing the solution. By applying the solution in this manner, damage to the finished part of the steel is minimized as only the area immediately adjacent to the foreign object is affected. Furthermore, this method of application is not limited by the size or the shape of either the foreign object or the stainless steel piece.

The solutions provided by this invention can be used to remove foreign objects of any size from stainless steel parts having any shape or size by merely applying the solution to said embedded object. Due to its ease of application and the rapidity with which they react with tooling alloys, these solutions have many valuable uses such as removing cutting tools from stationary stainless steel pieces or pieces too large to immerse, or pieces upon which it is desirable to preserve the surface, or pieces which would be difficult to redrill, or pieces not easily accessible, etc.

I claim:

1. A pickling solution consisting essentially of an aqueous solution of hydrofluoric acid in an amount of from about 30% to about 50% by volume of the total volume of the solution and from about 10% to about 35% nitric acid by volume of the total volume of the solution.

2. A pickling solution consisting essentially of an aqueous solution of hydrofluoric acid in an amount of about 48% by volume of the total volume of the solution and about 13% nitric acid by volume of the total volume of the solution.

3. A pickling solution consisting essentially of an aqueous solution of hydrofluoric acid in an amount of about 45% by volume of the total volume of the solution and about 17% nitric acid by volume of the total volume of the solution.

4. A pickling solution consisting essentially of an aqueous solution of hydrofluoric acid in an amount of about 40% by volume of the total volume of the solution and about 22% nitric acid by volume of the total volume of the solution.

5. A pickling solution consisting essentially of an aqueous solution of hydrofluoric acid in an amount of about 30% by volume of the total volume of the solution and about 34% nitric acid by volume of the total volume of the solution.

6. The method of removing embedded high speed metal alloy objects from stainless steel which comprises dissolving said embedded object with an aqueous pickling solution consisting essentially of from about 30% to about 50% by volume hydrofluoric acid and from about 10% to about 35% nitric acid.

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