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[54] **HARDFACING MATERIAL AND DEPOSITS CONTAINING TUNGSTEN TITANIUM CARBIDE SOLID SOLUTION**

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[63] Continuation-in-part of Ser. No. 20,151, March 16, 1970, abandoned.

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[58] **Field of Search** .... 75/208 R; 29/182.7, 182.8, 29/182.3; 51/309

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[57] **ABSTRACT**

The specification discloses a hardfacing material having as the principal hard ingredient solid solution tungsten titanium carbide.

5 Claims, No Drawings

HARDFACING MATERIAL AND DEPOSITS CONTAINING TUNGSTEN TITANIUM CARBIDE SOLID SOLUTION

This application is a continuation-in-part of Ser. No. 20,151, filed Mar. 16, 1970, now abandoned, entitled "Hardfacing Material and Deposits Formed Thereby."

The present invention relates to hardfacing compositions, especially in the form of powder-filled rods and wires or solid rods and to hardfacing deposits applied with the compositions and also to a method of forming such deposits.

Hardfacing is a procedure which is well known and consists, essentially, of the application to a substrate of base metal of a layer of metal which is substantially harder than the base metal. The purpose of the application of hardfacing is to improve the wear or abrasion resistance or hardness of the base metal. Hardfacing is practiced as an economy in connection with machine wear parts such as crushing members and the teeth of digging members and the like and enables a substantial economy to be realized over replacement of such members when they become worn.

There are certain instances in which wearing members can be made wear or corrosion resistant or hard by forming them of a material such as cemented tungsten carbide, or by applying cemented tungsten carbide wear plates to the member. However, cemented tungsten carbide is comparatively expensive and it is also comparatively brittle and must be brazed or cemented in place on the member to be hardfaced, or cannot be adapted to the part to the hardfaced and, for these reasons, is not an economical material to employ for the hardfacing of many classes of work members.

When work members such as crushing rolls and plates or digging teeth, such as are found on buckets, or the like are to be hardfaced, the hardfacing is usually applied by depositing hard wear-resistant and corrosion-resistant materials on the base metal by electric-arc deposition or by gas-torch deposition of the material from powder-filled rod or wire form to the base metal. In most cases, electric-arc deposition is used because it is much more economical to use than gas deposition.

Heretofore, particulate tungsten carbide has been a preferred material, deposited together with an alloy such as an iron-base alloy which forms the matrix in which the hard wear and corrosion resistant material is distributed.

In electric-arc applications, especially, which produce high deposition temperatures, the carbides of tungsten tend to be converted to binary or double carbides of tungsten and iron of which one form is Fe_3W_3C, and referred to herein as double carbide. This double carbide compound is hard and wear-resistant but it is also quite brittle and deposits containing it tend to crack and also tend to be somewhat porous. The material, furthermore, is somewhat dendritic and tends to form large interlocking patterns, or chains of crystals, and is thus in a form which is relatively easily broken.

Still further, the specific gravity of such tungsten carbide grains as survive without conversion to double carbide is such that they tend to sink in the matrix metal while the matrix metal is molten so that, after the deposit solidifies, the hard material is not uniformly distributed therein but tends to concentrate toward the bottom of the deposit.

The present invention has a primary objective the provision of hardfacing compositions, and deposits laid down thereby, and methods of applying the deposits, which avoid the deficiencies referred to above. A particular object is the provision of a deposit of the nature referred to which is nonpourous, substantially free of cracking and which is not brittle so that superior wear characteristics are obtained.

Another object of the present invention is the selection of a hard material for inclusion in hardfacing compositions which resists conversion to double carbides when applied by electric-arc methods, and which distributes uniformly in the matrix metal when a deposit is laid down and which will tend to disperse other hard materials contained in the composition, such as the carbides of tungsten referred to above, thereby to prevent the formation in the deposit of large fragile crystals, or chains of connected crystals.

BRIEF SUMMARY OF THE INVENTION

The present invention is concerned with hardfacing material having as an essential ingredient particulate solid solution of tungsten monocarbide in titanium carbide. The remainder of the hardfacing material is made up of other metals which upon deposition form a hard alloy matrix for the solution of tungsten monocarbide in titanium carbide, such metals including, for example, iron, manganese, nickel, cobalt, molybdenum, chromium, tungsten, silicon and carbon. It is essential that said matrix alloys must, in addition to possessing good strength and resistance to wear, firmly bond and adhere to the particles of tungsten titanium carbide dispersed in the deposit.

A solution of tungsten monocarbide in titanium carbide may vary in the proportion of tungsten carbide present and ordinarily it is preferred, but not essential, for the titanium carbide to be substantially saturated with tungsten carbide.

The solid solution carbide referred to can be produced by reaction of tungsten and titanium carbides, or of tungsten oxide and titanium oxide reacted with carbon in solid state form, or by the liquid-metal menstruum method. The latter method is preferred because the material produced thereby is dense, pore free, has comparatively low specific surface, good flow properties, and compositional homogeneity.

Tunsten titanium carbide may, for the purpose of this invention, contain in solid solution up to 10 per cent of tantalum carbide (TaC) or niobium carbide (NbC), or both, without detrimental effect. It is contemplated that these carbides in the concentration range indicated would improve the thermal toughness of the essential hardfacing material disclosed.

When tungsten carbide is applied by electric-arc deposition, as in the form of powder-filled iron tubes or wire or a sintered solid rod, there is found a substantial conversion of tungsten carbide to binary carbides of tungsten and iron. These binary carbides are quite hard but are extremely brittle and thermal cracks tend to develop in the deposition upon cooling and upon reheating and cooling of the deposit.

The particulate tungsten titanium carbide solid solution referred to, however, survives the high temperature of electric-arc deposition and forms a stable hard carbide dispersion which does not form brittle or thermally unstable carbides and the deposit does not tend to become brittle or crack. This material can be applied in the form of powder-filled tubes or tubewire composed essentially of iron, nickel or cobalt or alloys thereof, or as sintered solid rod contained in a sheath of one of the above mentioned metals.

It has been found that electric-arc deposits containing tungsten titanium carbide solid solution possess a microstructure in which fine, discrete, isolated crystals or crystal fragments of tungsten titanium carbide are imbedded in an evenly dispersed fashion in the iron alloy matrices. Interconnected or semicontinuous carbide micro-structures of the type that are formed by the binary carbides of tungsten and iron, and which reduce physical and thermal toughness of the deposit are absent.

While particle size ranges of the crystals of the tungsten titanium carbide which provides good flow properties are preferred to facilitate the fabrication of powder-filled tubes and tubewire, it has been found that the tungsten titanium carbide crystals apparently undergo some physical separation during the deposition of the hardfacing material so that finer carbide depositions than would normally be expected are developed without clustering or carbide intergrowth.

In particular, the dispersion of the solid solution throughout the matrix metal in finely divided physically separated form occurs when the material is deposited by an electric arc. The temperature under arc deposition is higher than during sintering and this higher temperature appears to produce the dispersion of the fine crystals referred to.

A characteristic of tungsten titanium carbide which has proved to be of benefit in connection with the hardfacing material is the specific gravity range thereof, which is within the range of about 9.5 to 10 for the saturated compound, and about 6.0 to 6.5 for an undersaturated solid solution of tungsten titanium carbide containing about 30 per cent by weight of dissolved tungsten carbide. Specific gravities falling between 6.5 and 9.5 can be obtained by varying the proportions of the two parts of the solution.

In contrast thereto, tungsten carbide has a specific gravity of about 15 to 17, depending on the method of manufacture, and tungsten carbide crystals thus have a pronounced tendency to migrate downwardly in the molten matrix alloy during deposition of the material thereby producing a nonuniform dispersion. Titanium carbide, on the other hand, has a specific gravity of about 4.5 to 4.9, depending on the purity thereof, and tends to rise in the molten matrix metal producing an imbalance in the distribution of the hardface material in a hardfacing deposit.

The hardness of solid solution tungsten titanium carbide is substantially higher than that of tungsten carbide and is close to, or even slightly higher, than that of titanium carbide. In practice, it has been found that titanium carbide, even though harder than tungsten carbide, is inferior thereto as a component for hardfacing material because it results in lower fusability and a higher deposit porosity than is desirable. By the use of the solid solution tungsten titanium carbide, the several benefits of higher fusability, lower porosity, good hardness, and a high degree of dispersion of the carbide crystals are realized.

As examples of hardfacing applications practicing the present invention, the following examples are given. In the following examples, all of the compositions are expressed in calculated weight per cent of the hardfacing deposit, all depositions were effected with direct current, reverse polarity, and the tungsten titanium carbide solid solution component of the compositions was a saturated solution of tungsten carbide in titanium carbide having an initial particle size range of minus 40 mesh plus 200 mesh (A.S.T.M.).

EXAMPLE 1

Application	—	Roll crusher crushing glacial alluvium to minus 3/8" product. Severe abrasion and high impact.		
Test product	—	7/64" tubewire		
Deposit by	—	Open Arc. Wire feeder, semi-automatic and automatic.		
Composition	—	Tungsten titanium carbide	—	15.0%
		Mn	—	14.5
		Ni	—	2.5
		Mo	—	2.5
		Si	—	0.5
		Free C	—	0.75
		Fe	—	Balance
Result	—	Exceeded by more than 2 times the service life of manganese stainless hardfacing alloy. Exceeded abrasion resistance of a high chromium hardfacing wire. No spalling.		

EXAMPLE 2

Application	—	Build up roller flanges on tractor rolls. Tractor weight approximately 65,000 lbs. Ripping, dozing and pushing in strip mine.		
Test product	—	1/8" tubewire		
Deposit by	—	Submerged arc, automatic		
Composition	—	Tungsten titanium carbide	—	7.5%
		Mn	—	1.25
		Mo	—	2.40
		Ni	—	2.50
		Si	—	0.3
		Free C	—	0.12
		Fe	—	Balance
Result	—	Low wear, no chipping or spalling.		

EXAMPLE 3

Application	—	Overlay pulsing valve in cement pump conveying dry cement powder.		
Test product	—	1/8" filled tube		
Deposit by	—	Manual, heliarc torch		
Composition	—	Tungsten titanium carbide	—	16.0%
		Cr	—	10.0
		Mn	—	1.5
		Si	—	0.75
		Free C	—	0.70
		Fe	—	Balance
Result	—	Efficient service life of valve was prolonged substantially in comparison with a cobalt-chromium base hardfacing alloy.		

EXAMPLE 4

Application	—	Overlay crusher rolls crushing highly abrasive rock. Maintenance of close roll tolerance required.		
Test product	—	7/64" tubewire		
Deposit by	—	Open arc, semi-automatic		
Composition	—	Tungsten titanium carbide	—	15.0%
		Cr	—	15.3

-Continued

EXAMPLE 4				
		Mn	—	1.6
		Si	—	0.7
		Free C	—	3.5
		Fe	—	Balance
Result	—	Extended wear-spall life to 4 times that of a high chromium-manganese-carbon iron-base hardfacing alloy.		

EXAMPLE 5				
Application	—	Deposits on steel test bars.		
Test product	—	Solid sintered core in iron sheath, 5/32" rod.		
Deposit by	—	Open arc, manual.		
Composition	—	Tungsten titanium carbide	—	51%
		Ni	—	11%
		Fe	—	Balance
Results	—	Microstructure of deposit contained uniform dispersion of 2 to 5-micron tungsten titanium solid solution crystals. Very low porosity. Rockwell C scale hardness 55 to 56. No depositional cracks. No double carbides formed.		

EXAMPLE 6				
Application	—	Cement pump valve		
Test product	—	1/8" filled cobalt tube		
Deposit by	—	Manual, tungsten inert gas		
Composition	—	Tungsten titanium carbide	—	15.0%
		Cr	—	28.0
		W	—	4.5
		Si	—	1.8
		Ni	—	2.0
		Fe	—	3.5
		C	—	1.25
		Co	—	Balance
Result	—	Finish grinding of hardfaced valve areas required approximately 6 times as long as when same areas were hardfaced with a cobalt-chromium-tungsten hardfacing material, demonstrating resistance of deposit to mechanical attrition.		

EXAMPLE 7				
Application	—	Ripper teeth for crawler tractor ripping highly abrasive soil.		
Test product	—	7/64" semi-automatic wire		
Deposited by	—	Open arc, semi-automatic		
Composition	—	Tungsten titanium carbide	—	7.5%
		Cr	—	15.0
		Mn	—	1.3
		C	—	3.5
		Fe	—	Balance
Result	—	High resistance to abrasive action.		

A characteristic of the deposits formed in accordance with the present invention is the distribution of the hard material substantially uniformly throughout the deposit because the carbide does not tend to migrate in a vertical direction in the molten matrix metal while, furthermore, the tendency of the carbide crystals to subdivide according to the present invention tends to cause complete dispersion of the crystals as opposed to the tendency of other carbides to form long chains of crystals or to clump together.

Still further, due to the comparatively high stability of the tungsten titanium carbide, it does not form other carbide compositions with metals of the matrix alloy, such as the iron, which are inferior for hardfacing applications.

The solid solution of tungsten titanium carbide can be in the form of crystals, grains, or fine powder and can vary in composition from a saturated solution consisting of about 25 per cent titanium carbide and 75 per cent tungsten monocarbide by weight to an unsaturated solution containing preferably not less than about 30 per cent by weight of tungsten carbide and the remainder titanium carbide. The specific gravity of the solid solution can thus be varied substantially. The best range for the specific gravity has been found to fall within about 6.0 to 10.0.

It is contemplated that the hardfacing material can be in the form of metal tubes or hollow wires filled with a powder in which the solid solution tungsten titanium carbide is a component part of the main constituent. In such case the material of the hollow tube or wire goes into the melt and forms a part of the matrix metal in which the hard carbide phase is distributed.

It is also contemplated forming the rod by sintering the carbide together with a matrix powder consisting, for example, of iron, nickel, or cobalt, or an alloy thereof. Such a sintered solid rod can be contained in a metal sheath placed about the rod as, for example, by inserting the rod into the sheath.

It will be understood that an external coating of flux of types commonly applied to achieve tractable depositional characteristics may be applied to the hardfacing rod materials disclosed.

In any case, the resulting hardfacing deposit having the superior chracteristics referred to above consists of a hard phase of solid solution tungsten titanium carbide finely and uniformly dispersed in a metal or metal alloy binder or matrix metal.

It will be understood that modifications of the percentage of tungsten titanium carbide component of the deposit or of the matrix alloy composition in which the hard carbide phase is dispersed can be made in the present invention falling within the scope of the appended claims.

What is claimed is:

1. A hardfacing deposit comprising; about 15 per cent tungsten titanium carbide solid solution having a specific gravity in the range from about 6.0 to 10.0; about 14.5 per cent Mn; about 2.5 per cent Ni; about 2.5 per cent Mo; about 0.5 per cent Si; about 0.75 per cent free carbon; Fe—Balance; in which the percentages are per cent by weight of the deposit.

2. A hardfacing deposit comprising; about 7.5 per cent tungsten titanium carbide solid solution having a specific gravity in the range of from about 6.0 to 10.0; about 1.25 per cent Mn; about 2.40 per cent Mo; about 2.50 per cent Ni; about 0.3 per cent Si; about 0.12 per cent free carbon; Fe—Balance; in which the percentages are per cent by weight of the deposit.

3. A hardfacing deposit comprising; about 16.0 per cent tungsten titanium carbide solid solution having a specific gravity in the range from about 6.0 to 10.0; about 10.0 per cent Cr; about 1.5 per cent Mn; about 0.75 per cent Si; about 0.70 per cent free carbon; Fe—-

Balance; in which the percentages are per cent by weight of the deposit.

4. A hardfacing deposit comprising; about 15.0 per cent tungsten titanium carbide solid solution having a specific gravity in the range of from about 6.0 to 10.0; about 15.3 per cent Cr; about 1.6 per cent Mn; about 0.7 per cent Si; about 3.5 per cent free carbon; Fe—-Balance; in which the percentages are per cent by weight of the deposit.

5. A hardfacing deposit comprising; about 51 per cent tungsten titanium carbide solid solution having a specific gravity in the range of from about 6.0 to 10.0; about 11 per cent Ni; Fe—Balance; in which the percentages are per cent by weight of the deposit.

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