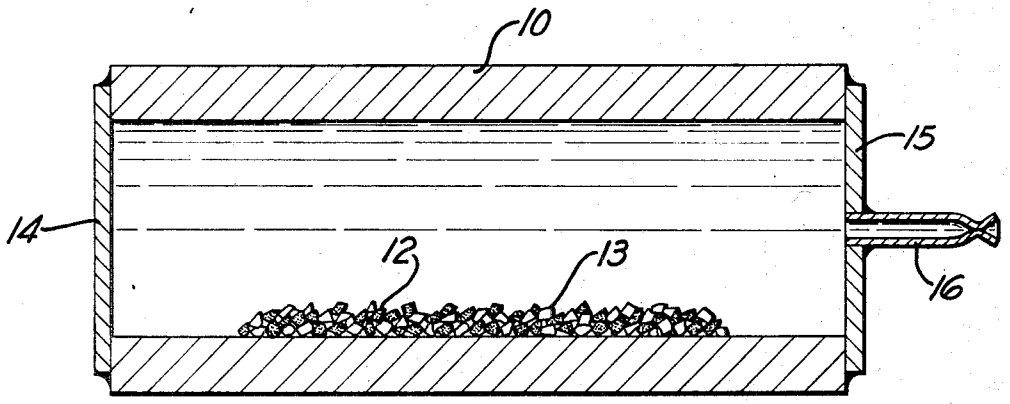
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METHOD OF LINING CYLINDERS

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METHOD OF LINING CYLINDERS

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ABSTRACT OF THE DISCLOSURE

Improvement over known lining method in which pieces of lining material are placed in a metal cylinder, cylinder is heated to melt material and rotated to distribute it by centrifugal force. Improvement is to use pieces of iron-carbon eutectic alloy as solvent in lining material and dissolve high-melting materials, such as chromium, in the eutectic. Enables a cylinder to be lined centrifugally with iron-base materials having components of higher melting point than the metal of the cylinder without using separate melting facilities.

This invention relates to an improved centrifugal method of lining a metal cylinder with an iron-base hard material.

Conventional practice in lining a metal cylinder centrifugally with a low-melting alloy is to place small pieces of the lining material in the cylinder, heat the cylinder to melt the lining material, and rotate the cylinder rapidly to distribute the molten material by centrifugal force. Each piece is of the same composition as the ultimate lining. Brown Pat. No. 1,923,075 describes a typical lining method which operates in this fashion. Such methods commonly are used for applying a hard facing material to the inside of a steel cylinder which is subject to wear, for example the barrel of a reciprocating pump. Mild steel of which the cylinder usually is formed melts at about 2750 F., but the cylinder cannot be heated beyond about 2500° F. without distorting it. Hence this method has been used only for lining cylinders with alloys which melt below this temperature. To the best of my knowledge, it has not been used successfully with iron-base alloys of such metals as chromium, molybdenum or vanadium. Chromium alloys in particular form a desirable lining material for pump barrels because of their resistance to corrosion. I recognize that the Brown patent describes the use of a cobalt-chromium alloy. My own experience leads me to doubt this can be done, but in any event such an alloy is far more costly than an iron-base alloy.

One practice in lining cylinders with higher-melting iron-base alloys has been to melt the lining material separately, pour it into a heated cylinder, and cast the lining in place centrifugally. This practice necessitates the use of separate melting facilities, and does not assure a metallurgical bond between cylinder and lining. It also results in an unfavorable stress pattern in the lining alloy, and the lining may crack in service. An alternative has been to form the liner as a separate piece which is shrink-fitted within the cylinder. This necessitates an unduly heavy liner and of course produces no bond at all.

An object of my invention is to provide an improved centrifugal lining method which broadens the choice of lining materials to include iron-base alloys of high-melting components, yet allows the lining material to be melted within the cylinder.

A further object is to provide an improved lining method which affords a favorable stress balance with high-melting components in an iron-base lining material, that is, the lining material is in compression.

A more specific object is to provide an improved lining method in which a relatively low-melting iron-carbon eutectic alloy is used as a solvent, and higher-melting materials, such as chromium, molybdenum or vanadium, are dissolved in the eutectic after it melts.

In the drawing:

The single figure is a diagrammatic vertical section of a cylinder prepared for lining in accordance with my method.

The drawing shows a cylinder **10** of a metal such as mild steel. I place within the cylinder a charge which consists of small pieces **12** of iron-carbon alloy of a composition approaching the eutectic (about 4.3% carbon) and small pieces **13** of higher-melting alloys. The proportions may vary from about 25 to 75 percent by weight of iron-carbon alloy and the remainder the high-melting alloys. These may include ferrochrome, ferro-molybdenum, ferrovanadium, etc. or various combinations in proportions calculated to produce a lining of the desired composition. I cover the ends of the cylinder with plugs **14** and **15**, preferably welded thereto. Plug **15** has a vent opening in which I mount a short-length tube **16**. I evacuate the cylinder through this tube and seal the tube to produce nonoxidizing conditions within the cylinder. Optionally, I may charge an inert gas to the cylinder before sealing it, particularly if the cylinder is of large diameter.

Next I heat the cylinder to melt first the iron-carbon alloy pieces **12**, which melt at about 2085 F. The molten iron-carbon alloy dissolves the pieces **13** of higher-melting alloys. I continue to heat the cylinder as the melting point of the solution rises as more and more of high-melting alloy dissolves. The melting point of the solution reaches a maximum below about 2400 F. when all the alloy has dissolved. I may use any appropriate means for heating the cylinder, such as high-frequency induction furnace or a conventionally fired fuel furnace. I rotate the cylinder slowly while heating it so that the charge wets the full inside surface of the cylinder as it melts. This assures a true metallurgical bond between the lining and cylinder.

Next I place the cylinder containing the molten charge in a lathe or equivalent device and spin it on its axis. Centrifugal force distributes the lining material over the inside surface, where it solidifies. I cool the cylinder slowly, for example in ground mica or in a cooling furnace, to leave the solidified lining soft enough to be machined. I remove plugs **14** and **15** and machine the lining to its final dimension, after which I reheat the cylinder to about 1900 F. and air-cool it. The resulting lining not only is hard and corrosion-resistant, but is metallurgically bonded to the cylinder and has a favorable stress pattern.

Specific examples of my invention are as follows:

EXAMPLE I

I place within a mild steel cylinder 25 inches in length and 6 inches diameter 25 pounds of a charge made up of small pieces of a composition as follows:

	Pounds
Iron-carbon eutectic alloy	12.55
Alloy consisting of 4.5% C, 67.0% Cr, remainder Fe and incidental impurities	4.50
Alloy consisting of 0.05% C, 70.50% Cr, remainder Fe and incidental impurities	7.10
Alloy consisting of 60% Mo, remainder Fe and incidental impurities	0.85

I plugged the ends of the cylinder and evacuated it. I heated the cylinder in an induction furnace to a temperature of about 2400 F., while slowly rotating it. I spun the cylinder in a lathe, cooled it slowly in ground mica, removed the plugs, machined the lining, reheated the cylinder to 1900 F., and air-cooled it. The resulting lining had a thickness of 1/16 inch and was metallurgically bonded

to the cylinder and was in compression. The lining had a composition 2.7% C, 27.6% Cr, 1.8% Mo, and the remainder iron and incidental impurities.

EXAMPLE II

I repeated the foregoing procedure with similar materials except that I substituted for the molybdenum alloy an alloy consisting of 55% V and the remainder iron and incidental impurities. The results were similar. The composition of the final lining was 2.7% C, 27.6% Cr, 2.0% V, and the remainder iron and incidental impurities.

From the foregoing description it is seen that my invention affords an effective and simple method of lining cylinders with higher-melting iron-base alloys. There is no need to use as a charge material a relatively expensive alloy made up of the final composition of the alloy, but instead the charge can consist largely of low-cost iron-carbon eutectic. To the best of my knowledge, the only way described in the prior art of producing a lining high in chromium by melting in the cylinder and spinning is to use the extremely high-cost cobalt-chromium alloy as in the Brown patent. I believe it is an unexpected result that I attain a favorable stress pattern as opposed to a dual-cast cylinder in which molten lining material is poured into the cylinder.

While I have described only certain preferred ways of practicing my invention, it is apparent further modifications may arise. Therefore I do not wish to be limited by the disclosure set forth, but only by the scope of the appended claims.

I claim:

1. A method of lining a steel cylinder with an iron-base hard facing material comprising:

placing within the cylinder a charge which consists of small pieces of iron-carbon alloy of a composition approaching the eutectic and small pieces of at least one higher-melting alloy of the group consisting of ferrochrome, ferromolybdenum, ferrovanadium and combinations thereof;

the proportions being 25 to 75 percent iron-carbon alloy and the remainder high-melting alloys;

sealing the ends of said cylinder and evacuating it;

heating the cylinder to a temperature about 2085 F. to melt first the iron carbon alloy;

continuing to heat the cylinder as the molten iron-carbon alloy acts as a solvent for the higher-melting alloys, while the melting point of the solution rises but reaches a maximum below about 2400 F. when all the higher-melting alloys have dissolved;

spinning the cylinder containing the molten charge to distribute the charge by centrifugal force; and

cooling the cylinder to solidify the resulting lining.

2. A method as defined in claim 1 in which the cylinder is slowly rotated as it is heated to enable the molten charge to wet the inner surface and assure a metallurgical bond between the lining and cylinder.

3. A method as defined in claim 1 in which the cylinder is cooled slowly to leave the lining soft enough to be machined and subsequently is reheated to about 1900 F. and air-cooled.

4. A method as defined in claim 1 in which the lining is in compression to afford a favorable stress pattern.

5. A method as defined in claim 1 in which an inert gas is charged to the evacuated cylinder before it is sealed.

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