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3,237,441

TUBE ROLLING MILL PLUGS

Filed May 1, 1963

FIG. 1

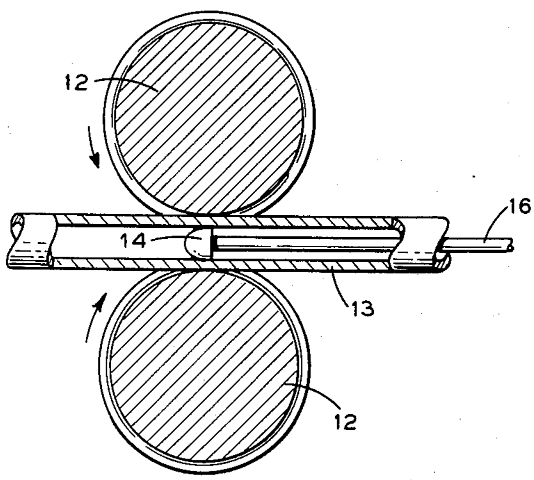
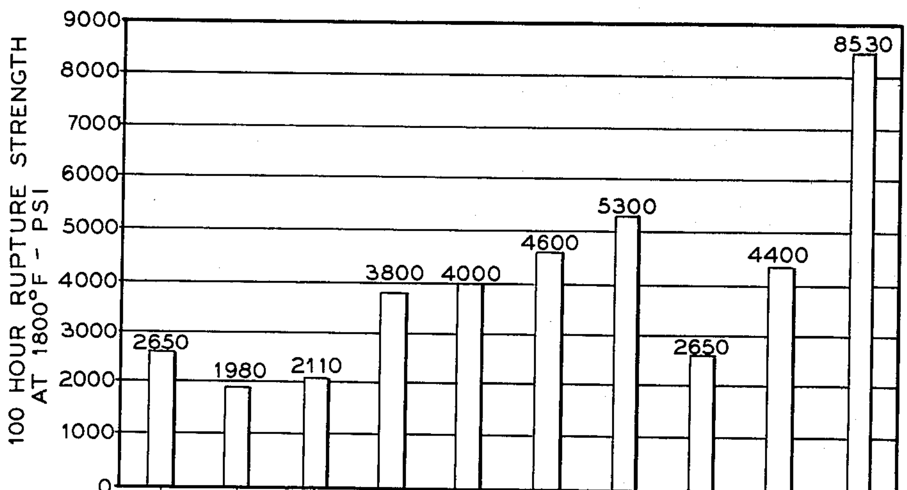


FIG. 2



CARBON	0	0	0	0.25	0.25	0.25	0.25	0	0.25	0.30
IRON	0	0	10	0	0	0	0	0	0	0
CHROME	20	30	30	20	20	20	20	20	20	27
COBALT	80	70	55	74	70	74	74	74	78	62
NICKEL	-	-	5	-	-	-	-	-	-	2.5
CARBIDE FORMER	-	-	-	6Ti	6Cb	6W	6Mo	6Mo	2Mo	5.5Mo

PER CENT OF CONSTITUENTS

INVENTOR.
Fritz T. Eberle

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ATTORNEY

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TUBE ROLLING MILL PLUGS

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The present invention relates to rolling mill plugs for use in the manufacture of seamless metallic tubing, and more particularly to the construction of such plugs of a metallic alloy providing a substantially longer use life for such plugs.

The commercial production of seamless metallic tubing utilizes a rotary piercing process whereby a hot cylindrical billet is peripherally rolled over a substantially conical mandrel or piercing point by driven rolls which are set at an angle to the horizontal plane passing through the center line of the piercing mill. The pierced shell is usually reheated after the piercing operations to approximately 2200–2300° F. With the pierced shell arranged to pass between a pair of grooved rolls, a plug is attached to the end of a bar, the bar holding the plug at the correct position in the roll groove. In order to start the shell over the plug and permit the rolls to secure a good bite upon it, the shell is shoved into the pass with considerable force by a compressed-air-operated ram. Once started, the force of friction due to the pressure exerted by the revolving rolls is sufficient to draw the shell rapidly over the plug, slightly reducing its diameter and wall thickness and increasing its length. As soon as the shell has passed through the roll groove, the plug is removed from the bar. Another plug is then placed on the bar, and the tube is rotated through an angle of 90 degrees. As soon as the tube has passed through the groove for the second working pass, it is returned again to the entering side of the mill, from which it is again rolled or is discharged for further fabrication. In this way the wall of the tube, supported by the plug on the inside and subjected to the action of the rolls on the outside, is reduced in thickness to the gage desired. The pierced shell is proportionately lengthened and slightly reduced in outside diameter. The wall reduction normally made in the plug mill is approximately ⅛ inch to ¼ inch. After plug rolling, the tube has a wall of the desired thickness but is slightly out of round or oval shaped, not perfectly straight, and still at a bright-red heat. After plug rolling, the tube is usually delivered to a reeling machine, the function of which is to round up and to burnish the inside and outside of the tube.

In the rolling process, the plug is subjected to high thermal, compressive, and shear stresses as well as to mechanical and thermal shock and to severe friction forces. As a result, the plugs deteriorate rapidly and have had a notoriously short service life. While this method of making seamless metallic tubes has been used for over fifty years, and much experimentation has been done in an attempt to discover a material for use in the manufacture of such rolling mill plugs, the best alloy for such use has been of the stainless steel type. Representative of the best rolling mill plug material is a cast iron-chrome-nickel alloy containing 1.5 to 1.6% carbon, 0.5 to 0.8% manganese, 18 to 20% chromium, and 6 to 7% nickel, which alloy, from experience, was found to heretofore provide the longest service life. However, plugs formed of this alloy still fail after relatively short use life by

cracking and spalling and wear because of the extreme thermal and mechanical stresses characteristic of this class of service. Furthermore, the progressive deterioration of these plugs tended to produce imperfections in the tube surfaces which frequently resulted in costly product rejections or necessitated surface refinishing operations.

While cobalt-chromium base alloys have been known for many years to possess high temperature strength and fatigue resistance, they have not heretofore been used as rolling mill plugs. Despite these advantageous characteristics the relatively low melting point of these alloys and their relatively low high temperature wear resistance in comparison with the iron-chrome-nickel alloys in use may have discouraged others from attempting their use for the manufacture of rolling mill plugs. This was apparently true also in regard to cobalt-chromium-nickel alloys, such as "Haynes Stellite 21." It was opportune that in the present attempt to discover an improved rolling mill plug material an alloy of substantially similar composition was proposed for investigation. As a result of actual experimental use of this alloy it was discovered that the apparent limitations of this alloy were not detrimental to its use in rolling mill plugs. In actual use, this cobalt-chromium-nickel base alloy develops a strongly adherent oxide scale which prevents the metal from wearing under the operating conditions of a hot rolling mill plug.

According to the present invention it has been found that a rolling mill plug fabricated from a cobalt-chromium-nickel base alloy has a life expectancy at least four times that previously attained without any deterioration in the quality of tubing produced.

The present invention is, accordingly, directed to the use of rolling mill plugs manufactured of a cobalt-chromium-nickel base alloy whose attributes are characterized by a high degree of resistance to thermal fatigue, high temperature strength and the capability of forming a strongly adherent hard surface scale in operation on ferrous tubes.

The invention alloy which meets these requirements has the following base composition:

	Percent
Carbon	0.2–1.5
Silicon, maximum	2
Manganese, maximum	2
Chromium	20 to 35
Nickel	1 to 6
Iron, maximum	3
A carbide former selected from the group consisting of columbium, molybdenum, titanium, tungsten, and zirconium, singly or in combination	2.0–7.0
Cobalt	Balance

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

Of the drawings:

FIG. 1 is a diagrammatic illustration of a rolling mill in which the present invention is utilized; and

FIG. 2 is a graphical representation of rupture strength of various cobalt-base alloys.

A diagrammatic illustration of a rolling mill, to which the present invention is applicable, is shown in FIG. 1. The illustration shows a rolling mill in which the rough tube shell is advanced by a pair of diametrically opposite grooved rolls **12**, to cause the tube **13** to pass over and about a conical plug **14** mounted on a bar **16**. The rolling mill plug is held against longitudinal movement but is free to rotate with the tube being rolled. In this process, the outer surface of the tube is reduced by the action of the rolls while the inner surface is being formed by the plug.

It has been found that by fabricating the rolling mill plug from a cobalt base alloy consisting essentially of the foregoing composition, usually by sand casting the metal in the form of the plug, a use life at least four times that obtainable with the alloy material previously used is possible. The invention alloy, with the addition of a very small amount of boron, is known as "Haynes Stellite 21," and while it has been known and used for a number of years in various other applications, it was thought to be unsatisfactory for the use contemplated by the present invention. One reason for this has been a misunderstanding or misconception of the physical characteristics of the component metal composition necessary to withstand the operating conditions of the plug rolling operation. Failure to try "Haynes Stellite" for such applications may be attributed to two distinctive characteristics of the material, viz its relatively low melting point and its relatively low resistance to high temperature abrasion in comparison with the previously used alloys, both of which would appear to be necessary to long service life under the described operating conditions. It is deemed particularly significant that in the course of the experimentation incident to the discovery set forth in the present invention, it was found that an oxide scale which formed on the exterior surface of the plug during early usage is strongly adherent and forms a protective coating thereon, thus reducing the abrasive wear caused by passage of the tube over and around the plug.

It has been found that the carbide formers, having a combined percentage of 2 to 7 percent, selected from the group consisting of columbium, molybdenum, titanium, tungsten and zirconium are valuable in increasing the high temperature strength of the plug material. It should be recognized that any of these carbide formers may be used singly or in combination with others of the group, so long as the combined percentages fall within the above range.

Furthermore, as can be seen from the comparison illustrated in FIG. 2, not all cobalt-base alloys exhibit the high rupture strength characteristics of the alloy of the present invention under comparable conditions. This rupture strength is believed to be indicative of the durability of a material under the operating conditions characteristic of rolling mill plug use.

While it has been found that rolling mill plugs having a range of constituents as listed above produce the use life desired, it has been determined that the preferred composition, falling within the ranges previously given, is as follows:

	Percent
Carbon	0.25
Manganese	0.6
Silicon	0.6
Chromium	27.0
Nickel	3.0
Iron	1.0
Molybdenum	5.0
Cobalt	62.55

A striking example of the superior service life of the plugs manufactured from an alloy within the range of the present invention over those manufactured from the alloy material found previously to be the best, as noted above, is shown and illustrated in Table I.

Table I

Tube Material	Tubing Produced—Ft. at the Rolling Mill	
	Plug Alloy Prior Art	Plug of Inventive Alloy
ASTM A213 grade T5	1,824	1,848
ASTM A334 grade T61	2,140	2,180
AISI 1015	24,338	23,738
AISI 1026	4,885	4,310
AISI 4068	2,608	2,610
AISI 4130	18,294	18,217
AISI 5048	35,655	35,480
AISI 8620	----	440
AISI 8630	6,588	7,586
Total Feet Produced	96,332	96,309
Total No. Rolling Mill Plugs Used	97	19
Average Feet of Tubing Rolled per Plug	993	5,070

It may be seen in the production of the tubing tabulated in Table I that the plugs fabricated from the alloy of the present invention had a service life over five times that of the plugs utilizing the alloy previously thought to be best suited for the purpose when rolling substantially the same quantity of the same product mix.

While in accordance with the provisions of the statutes there is illustrated and described herein a specific embodiment of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

What is claimed is:

1. In a metal deforming apparatus, the combination of at least two cooperating rolls and a conical plug between said rolls, said plug being composed of an alloy consisting essentially as follows:

	Percent
Carbon	0.2–1.5
Silicon, maximum	2.0
Manganese, maximum	2.0
Chromium	20.0–35.0
Nickel	1.0–6.0
Iron, maximum	3.0
A carbide former selected from the group consisting of columbium, molybdenum, titanium, tungsten and zirconium, total	2.0–7.0
Cobalt	Balance

2. In a metal deforming apparatus, the combination of at least two cooperating rolls and a conical plug between said rolls, said plug being composed of an alloy consisting essentially as follows:

	Percent
Carbon	0.25
Silicon	0.6
Manganese	0.6
Chromium	27.0
Nickel	3.0
Iron	1.0
Molybdenum	5.0
Cobalt	62.55

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MARCUS U. LYONS, *Primary Examiner.*