

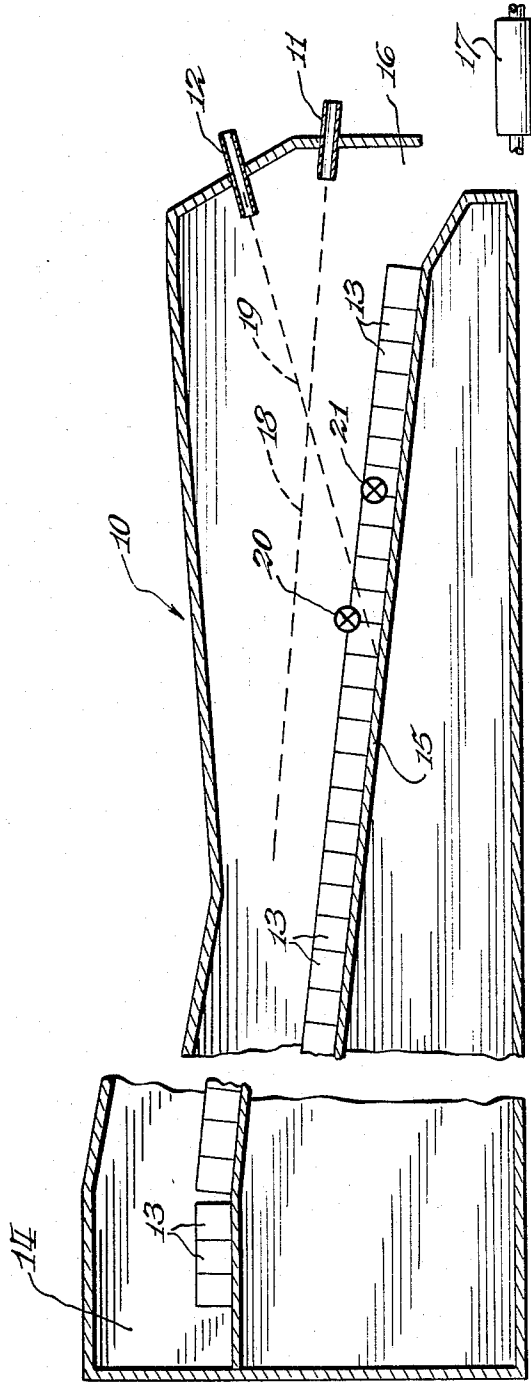
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METHOD FOR HEATING STEEL BILLETS

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METHOD FOR HEATING STEEL BILLETS

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The present invention relates generally to methods for heating steel billets prior to hot rolling, and more particularly to a method for heating billets of steel containing tellurium, in a manner which avoids surface checking of the billets during hot rolling.

Steels containing tellurium have machinability characteristics superior to those of steels containing the same other ingredients but not containing tellurium. Steel billets usually have a square or rectangular polygonal cross-section (e.g., 5 inches by 5 inches) and are usually several feet in length. Surface checking is manifest by small cracks in the billets during hot rolling, typically at the corners of the billets, and surface checking renders the resulting rolled steel article commercially unsalable. A billet is an unfinished form of the resulting steel article.

Prior to hot rolling of billets into articles such as rounds, hexagons, or other polygonal shapes, the billets are subjected to heating which typically comprises moving the billets through an elongated furnace heated by sets of burners, each burner set typically consisting of several burners. The burners fire flames of combustible fuels such as oil or gas. One set of burners may fire flame along a path parallel to the path along which the billets move as they pass from one end to the furnace to another. Another set of burners typically fires along an angular path toward the path of the billets so that when the burners are fully open the outer end portion of the flame from this latter set of burners (i.e., the flame end portion remote from the burners) impinges the billets as they move through the furnace. The outer end portion of a flame parallel to the billets does not impinge the billets.

Billets of steel not containing tellurium can be heated by a method utilizing flame impingement on the billets without harming the billets from the standpoint of surface checking during hot rolling. However, it has been discovered that billets of steel containing tellurium cannot be hot rolled without surface checking if the steel billets have been preheated by a method utilizing flame impingement or which causes an extremely rapid pick-up in b.t.u.'s by the billets. If preheating with flame impingement is employed, a tellurium-steel billet will undergo surface checking during hot rolling no matter how low or how high the final temperature to which the billet is heated.

From a practical standpoint, the final temperature to which the billet is heated is usually determined by hot rolling considerations. More specifically, if the billet is too cold, difficulties are experienced in rolling. If the billet is too hot, "hot shortness" or brittleness during hot rolling can result. "Hot shortness" is a different type of rolling-manifest defect, not to be confused with surface checking.

Therefore, in order to avoid surface checking of billets composed of steel containing tellurium, the billets must be preheated utilizing a method without flame impingement against the billets or which avoids a very rapid pick-up in b.t.u.'s. One method by which this may be accomplished is by employing only furnace burners firing along paths parallel to the path of movement of the billets as they move through the furnace; or, if furnace burners firing along paths intersecting the path of the moving billets are employed, these burners must be only partially open so that the flame from these burners is relatively

short and does not impinge against the moving billets or cause a rapid pick-up of b.t.u.'s in the moving billets.

Other features and advantages are inherent in the invention claimed and disclosed or will become apparent to those skilled in the art from the following detailed description in conjunction with the accompanying diagrammatic drawing which illustrates, in longitudinal cross-section, a typical embodiment of a furnace utilized in heating billets prior to hot rolling.

Referring to the diagrammatic drawing an embodiment of a method for heating billets of steel containing tellurium, without surface checking during hot rolling, and in accordance with the present invention, may be performed in an elongated furnace 10 including two sets of burners 11, 12, each set consisting of several burners, although only one is shown for purposes of illustration.

Tellurium-containing steel billets 13 are introduced into furnace 10 at one end 14 and are moved along the length of the furnace (from left to right as shown in the drawing) by conventional means, such as a ram (not shown), familiar to those skilled in the art. The billets, as they travel through the furnace 10, move along a path 15 constituting an inclined ramp. When the billets reach the far end of the furnace, designated by the numeral 16, they are discharged onto a rolling mill stand or roller means 17 which transport the billets 13 to the rolling mill rolls (not shown).

As billets 13 move along path 15 they may be heated by the flame from bottom burners 11 and top burners 12, all of which may be fired with oil, gas or other conventional fuel. Bottom burners 11 fire along a path 18 substantially parallel to the path 15 along which the billets move. Top burners 12 fire along an angular path 19 which intersects the path 15 of billets 13 so that the flame from burner 12 will impinge against or cause an extremely rapid b.t.u. pick-up in moving billets 13 if burners 12 are firing at full blast. On the other hand, if burners 12 are cut back so that they are only partially open, the flame from burners 12 will not extend so far that it impinges against billets 13. This is the setting for burners 12 which is necessary in order to avoid surface checking of billets 13 during subsequent hot rolling. If billets 13 are heated in a manner utilizing flame impingement by burners 12, surface checking will result; and, this will happen over a wide range of billet final temperatures.

Heating the billets in a manner which avoids surface checking can be accomplished utilizing only parallel firing burners such as 11, all of which fire along a path parallel to the path of billets 13. In situations where there are sufficient parallel firing burners so that heating of the billets is accomplished rapidly enough to fulfill commercial requirements, utilization of angular firing burners such as 12, which fire flames along paths intersecting the path of billets 13, are not required. However, if parallel firing burners 11 do not provide sufficient rapidity of heating to fulfill commercial requirements, angular firing burners 12 also can be utilized, but only in a partially open condition, to provide additional heat in furnace 10. In a partially open condition, that is, one in which the flames from burners 12 do not extend far enough to impinge against billets 13, surface checking can be avoided to the same extent that it can be avoided if burners 12 are completely shut off.

Tests were run during which billets were heated in a furnace such as that illustrated in the diagrammatic drawing and various adjustments of the top or angular firing burners 12 were made to determine the effect of burner settings upon the billets from the standpoint of surface checking. Two different compositions of steel were used. For purposes of illustration these steels will be referred

to as A and B, and they had the following respective compositions:

Element	A	B
C	0.41-0.42	0.07-0.08
Mn	0.90-0.95	1.10-1.22
P	0.013	0.07-0.08
S	0.018-0.024	0.30-0.33
Si	0.30-0.31	0.01
Cr	0.91-0.99	
Mo	0.20	
Pb		0.15-0.30
Te	0.056-0.060	0.027-0.043

The following table summarizes the test conditions and test results. Under some conditions both steels, A+B, were processed while under other conditions, only one steel was processed. In the furnace, first and second thermocouples (20 and 21 in the drawing) were installed to measure the furnace temperature at the former's respective locations. After the billets were discharged from the furnace, their temperature was measured with an optical pyrometer at a location corresponding approximately to 17 in the drawing.

With reference to the following table, it should be noted that there was no substantial flame impingement on the billets unless the top burner was set above about one-half. As the top burner was increased beyond the one-half setting the danger of flame impingement increases proportionately and, accordingly, surface checking also increased proportionately. A top burner setting expressed as "soft" means no flame impingement on the billet.

the flame without cutting down the extent to which the burners are open.

For optimum rolling conditions and to avoid "hot shortness" the billets should be heated to a hot rolling temperature in the range between about 1950° F. and 2050° F.

Thus, a tellurium-containing, as rolled steel article produced in accordance with the present invention has a relatively smooth surface (i.e., an unchecked surface free of surface cracks) especially along the corners of the article when the latter has a polygonal cross-section.

It should be noted that the invention is not restricted to heating the specific compositions set forth under the headings A and B listed above. The method of the present invention is useful for preventing surface checking in virtually all tellurium-containing steels, and as used in this application the term "tellurium-containing steels" refers to a steel having the following typical range of elements:

Element	Weight percent
C	0.05-1.0.
Mn	0.60 minimum.
S	0.02-0.50.
P	0.01-1.
Te	.02-.50.
Fe plus usual impurities	Balance.

In addition to the above elements, 0.02-0.50 wt. percent lead is oftentimes used in conjunction with tellurium to further increase machinability of the steel. As used here in the term "tellurium-containing steels" refers to steels

	Burner Setting		Steel composition	Furnace Temp. at 1st thermocouple ° F.	Furnace Temp. at 2d thermocouple ° F.	Temp. of heated billet at first rolling mill stand, ° F.	Surface condition after hot rolling
	Top	Bottom					
1	Full	Full	A	2,260 avg. 2,280 high	2,220 avg. 2,240 high	1,940	Surface got poorer as furnace temp. increased.
	do	do	B	2,235 avg. 2,250 high	2,210 avg. 2,220 high	1,850	
	do	do	B	2,180 avg. 2,400 high	2,210 avg. 2,250 high	1,930	
2	Soft flame	Cut back slightly	A+B	<2,200	<2,200	1,815 avg. 1,790-1,850	Clear.
	do	do	B	2,225 avg. 2,275 high	2,215		Very light checking.
3	do	Full	B	2,540 high	2,510 high	1,930 avg. 1,890-1,960	Clear.
4	Off	do	B	2,500 high	2,475 high	1,945 avg. 1,920-1,980	Do.
5	½ flame	¾ full	A+B	2,380 high	2,360 high	1,980 avg. 1,960-2,020	Do.
6	¾ for 24% of time, remainder was soft flame.	Full	B	2,440 high	2,420 high	1,960 avg. 1,930-2,070	18 of 75 billets = medium to heavy checking.
7	¼	do	B	2,220	2,210	1,960 avg. 1,900-2,050	11 = clear.
8	¼ (increased above ¼ for very short time).	do	A+B	2,100 avg. 2,180 high	2,080 avg. 2,200 high	1,900 avg. 1,850-1,980	1 = very light. 14 = clear. 1 = very light.
9		Primarily	B	2,040 avg. 2,060 high	2,020 avg. 2,040 high	1,870 avg. 1,830-1,910	Clear.
10	¼ increased to full off and on in spurts.	Full	B	2,240 avg.	2,190 avg.	1,880-2,020	49 = clear. 19 = very light. 10 = light. 2 = medium. 6 = medium hvy. 9 = heavy. Clear.
11	¼	do	B	2,060 avg.	2,040 avg.	1,930 avg. 1,890-2,010	Clear.
12	Full	do	B	Billets lime coated		1,940 avg. 2,050 high	5 = clear. 1 = very light.
13	do	do	B	Billets uncoated		2,000	2 = clear. 1 = light. 1 = medium. 1 = medium hvy. Clear.
14	Off ½	do	B			1,930 avg. 1,900-1,950	Clear.
15	¼	do	B			1,910 avg. 1,890-1,930	Do.

With reference to tests 12 and 13, it should be noted that surface checking can be avoided, even if the top angularly firing burner is fully open and the flame blasting against the billets, if the billets are coated with lime. The effect of the lime or like protective material is to protect the surface of the billets from impingement of

70 containing tellurium or tellurium and lead or tellurium and other similar machinability increasing elements such as selenium.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications

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will be obvious to those skilled in the art. For example, the method of the present invention is not limited to employment in billet-heating furnaces such as those illustrated diagrammatically in the drawing. The method may be employed in other billet-heating furnaces of the type illustrated on pages 407-9 of *The Making, Shaping and Treating of Steel*, 7th edition, 1957, United States Steel Corporation, Pittsburgh, Pa., the important considerations being the heating of the moving billets while avoiding flame impingement thereagainst.

What is claimed is:

1. A method for deterring surface checking on a hot-worked article composed of tellurium-containing steel, said method comprising the steps of:
 - moving said article, in an unfinished form, on a pre-determined path extending within and along the length of an elongated furnace;
 - providing a source of heat comprising a plurality of flames fired into said furnace along the length thereof; heating said article to a hot-working temperature as the article moves on said path through said furnace; said heating of the article being performed in its entirety without impingement of the outer end portion of any of said flames on the surface of said article; and then hot working said article.
2. A method as recited in claim 1 wherein:
 - at least one of said flames is fired parallel to said path.
3. A method as recited in claim 1 wherein:
 - at least one of said flames is fired along a path intersecting said path of the article;
 - and the length of said one flame is restricted to prevent the outer end portion of the flame from impinging against the surface of said article.
4. A method as recited in claim 1 wherein:
 - at least one of said flames is fired along a path intersecting said path of the article;
 - the length of said one flame being restricted to prevent the outer end portion of the flame from impinging against the surface of said article;
 - and another of said flames is fired parallel to the path of the article.
5. A method as recited in claim 1 wherein:
 - said article is removed from said furnace when the

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temperature of the article is between 1950° F. and 2050° F.

6. A method as recited in claim 1 and comprising: coating said article, in its unfinished form and before said heating step, with a material which protects the surface of the article against impingement of flame.
7. A method as recited in claim 1 wherein:
 - each of said flames is fired along a path selected from the group consisting of a path parallel to the path of said article and a path intersecting the path of said article;
 - each of said flames being fired in a manner which avoids impingement of the outer end portion of the flame on the surface of the article.

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