

United States Patent

Tarmann et al.

[15] 3,680,623

[45] Aug. 1, 1972

[54] **IMPROVEMENTS IN OR RELATING TO PROCESSES OF MANUFACTURING ROLLED STOCK FROM PRODUCTS OF CONTINUOUS CASTING PROCESSES**

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[22] Filed: **July 29, 1969**

[21] Appl. No.: **847,816**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 605,464, Dec. 28, 1966, abandoned.

[30] **Foreign Application Priority Data**

Dec. 15, 1966 Austria.....11106/66

[52] U.S. Cl.....164/76, 164/82

[51] Int. Cl.....B22d 11/00

[58] Field of Search.....164/4, 76, 82, 154, 270, 282, 164/283

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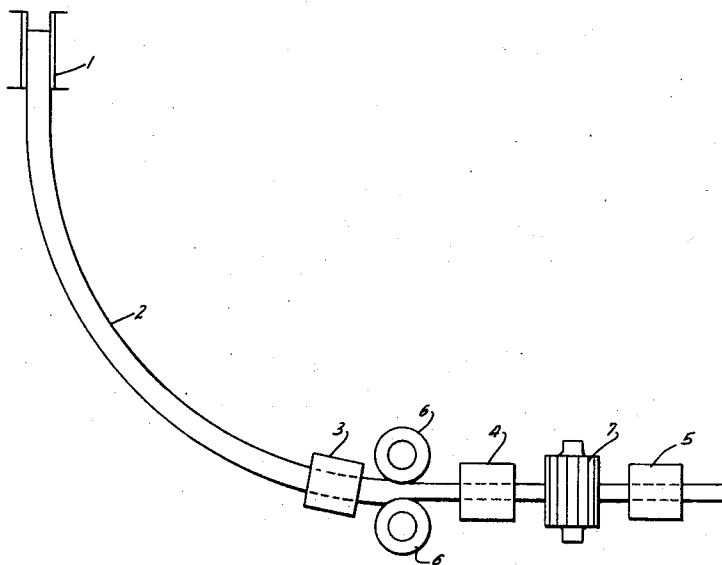
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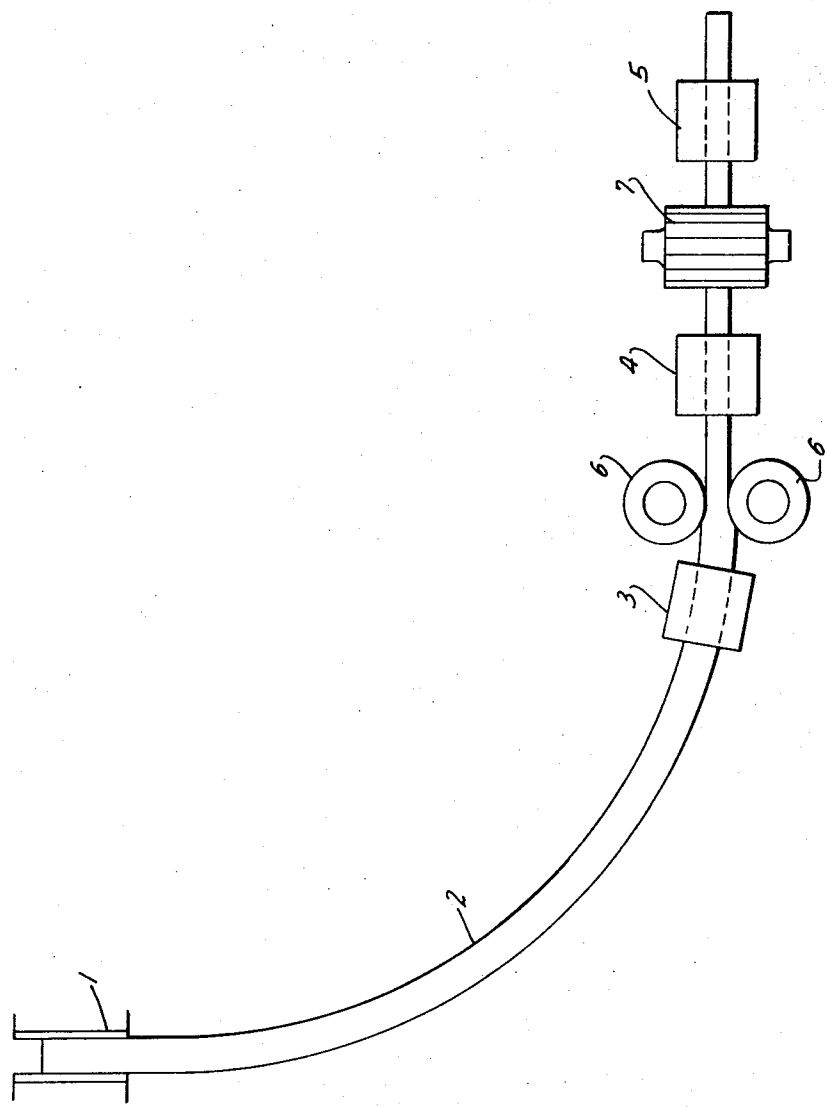
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[57] **ABSTRACT**

A process for making rolled stock directly from strands of continuously cast steel products in a working and forming installation, comprising two pairs of rolls which are respectively mounted in spaced relationship to each other along the path through which the strand travels. The distance between the rolls of each pair of rolls being adjusted so that the mass flow rate of said strand immediately upstream from the first pair of rolls being at least 0.5 percent larger than the mass flow rate of said strand immediately downstream from said first pair of rolls, while the mass flow rate immediately upstream and downstream from the second pair of rolls is substantially the same. The second pair of rolls squeezing the strand to such an extent that it effects a reduction in cross-sectional area in the strand of at least 10 percent.

10 Claims, 1 Drawing Figure





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IMPROVEMENTS IN OR RELATING TO PROCESSES OF MANUFACTURING ROLLED STOCK FROM PRODUCTS OF CONTINUOUS CASTING PROCESSES

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation-in-part application of our earlier copending application, Ser. No. 605,464, filed on Dec. 28, 1966 and now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to a process of manufacturing rolled stock. A continuous casting is subjected to two successive rolling operations which are controlled so that the mass flow rate of the casting immediately before the first rolling operation is at least 0.5 percent higher than immediately after said first rolling operation, the mass flow rate of said casting is the same before and after the second rolling operation, and the second rolling operation reduces the cross-sectional area of the casting by at least 10 percent. The process may be carried out immediately after a continuous casting operation so that the casting contains a molten core immediately before the first rolling operation. The process may be applied to the manufacture of billets, slabs and sheet bars made from various types of steels, such as plain carbon and alloy structural and tool steels, spring steels, stainless and acid-resisting steels.

The mass flow rate referred to hereinabove is equal to the product of the cross-sectional area of the strand and the linear velocity of the strand.

A number of proposals have already been made for rolling products of continuous casting processes. According to these proposals, the products can be rolled while they still contain a molten core or when the casting has been completely solidified. The known processes result generally in the desired reduction in cross-section and in an improvement of the surface of the casting. On the other hand, the disturbing and sometimes inevitable internal flaws which often occur in products of continuous casting processes have not been removed or have not been sufficiently removed by these known processes. During a shaping of the casting when it still contains a molten core, cracks due to squeezing may occur and such cracks may not be closed during the subsequent processing so that defective products result.

The present invention is based on the observation that continuous castings can be shaped with the aid of two pairs of rolls, which pairs are spaced in the axial direction of the casting, to produce rolled stock which is particularly free of internal flaws and which has desirable properties in other respects too. In carrying out the rolling process according to the invention, the product of the cross-sectional area of the casting and the velocity of the casting before the first pair of rolls must be at least 0.5 percent larger than behind this first pair of rolls and this product must be equal before and behind the second pair of rolls, which effect a reduction in cross-section by at least 10 percent.

Hence, the invention relates to a process of making rolled stock directly from products of continuous casting processes with the aid of two pairs of rolls, and the invention resides in that the two pairs of rolls which are spaced apart in the direction of the axis of the product

are set so that the product of the cross-sectional area of the material and the velocity of the material immediately before the first pair of rolls is at least 0.5 percent larger than immediately behind said first pair, and said product is the same before and behind the second pair of rolls, which effects a reduction in cross-section by at least 10 percent.

The fact that the products of the cross-sectional area of the material and the velocity of the material is larger before the first pair of rolls than behind the same may be due to various reasons. This difference may be due to core imperfections, secondary pipes, blowholes and the like. Experiments have shown that the continuous casting at room temperature may have a void volume amounting to 1 percent. In carrying out the process according to the invention it is essential in this case that the voids are entirely eliminated by the shaping effected by the first pair of rolls. This is essential for meeting the second requirement that the product of the cross-sectional area of the material and the velocity of the material before and after the second pair of rolls should be the same whereas the cross-sectional area is reduced by at least 10 percent by the second pair of rolls.

In contrast to a usual rolling of the continuous casting in a rolling mill after a soaking of the casting to the rolling temperature, the process according to the invention is preferably carried out at a time when the temperature in the interior of the casting is still close to the solidus temperature whereas the surface of the continuous casting has already reached the usual rolling temperature. In the shaping process according to the invention, this temperature distribution promotes a reliable welding and elimination of the internal flaws.

The solidus temperature in the interior of the cast strand can, of course, not be exactly measured during a casting operation. Thus, by the expression "close to the solidus temperature" is meant that the interior of the cast strand has a temperature range the upper limit of which is defined by the liquidus temperature and the lower limit of which is defined by a temperature not more than 100° C. under the solidus temperature of the steel of the cast strand. The aforescribed two temperature limits are completely defined for all types of steel and will be easily ascertainable to a man skilled in the art. The temperatures of the surface of the cast strand can, of course, be exactly measured and these temperatures, in the process of this invention, should be as follows: for the edges of the cast strand (assuming, of course, that a strand having edges is being cast) should be in the range of about between 1,050° - 1,250° C. The temperature on the even surfaces of the cast strand should be about 30° - 50° C. higher.

When billets are made of continuous castings by the process according to the invention, particularly good results will be obtained if the product of the cross-section of the material and the velocity of the material before the first pair of rolls, i.e. the mass flow rate, is 1 - 5 percent larger before the first pair of rolls than behind the same. This has been found by means of experiments mainly in processing plain carbon and alloy structural and tool steels, spring steels and stainless and acid-resisting steels.

Examples of such steels are given in the following table:

	C	Si	Mn	Cr	Ni	Mo	W	V	Nb
a	0.16	0.2	0.4						
b	0.22	0.25	0.5						
c	0.35	0.25	0.6						
d	0.45	0.25	0.6						
e	1.10	0.2	0.2						
f	0.13	0.3	0.4	0.8	3.5				
g	0.16	0.3	1.2	1.0					
h	0.34	0.3	0.5	1.5	1.50.2				
i	0.60	1.4	1.1						
j	0.95	0.2	1.07	0.5			0.55	0.1	
k	0.45	0.3	0.4	13.5	max.0.3				
l max.	0.06 0.6		0.8	18.5	10.0				
m max.	0.08	0.6	0.8	18.5	10.5				0.8

In making slabs or sheet bars for use in the manufacture of sheet, the product of the cross-sectional area of the material and the velocity of the material before the first pair of rolls, i.e. the mass flow rate, is preferably 5 – 25 percent larger than behind the first pair of rolls.

These recommendations are particularly applicable to the processing of plain carbon and alloy tool steels and of special steels. Examples of such steels are listed in the following table:

	C	Si	Mn	Cr	V	W	Ni	Ti
a	0.850.2	0.25						
b	0.850.2	0.4	0.5	0.2				
c	1.000.3	0.3	1.5					
d	1.050.2	0.9	1.1		1.5			
e	0.950.2	1.07	0.5	0.1	0.55			
f max.	0.060.6	0.8	18.5				10.0	
g max.	0.060.6	0.8	18.5				10.5	0.35
h max.	0.100.4	0.4	17.0				max. 0.3	
i	0.100.4	0.4	13.0				max. 0.3	

The cross-sectional area of the material and the velocity of the material before and behind each of the two pairs of rolls may be determined by mechanical or optical methods of measurement known per se. The velocity of the material must not be measured by sensing the speed of the rolls as the peripheral velocity of the rolls is not the same as the velocity of the material.

The two pairs of rolls which are set according to the invention may obviously be succeeded by additional pairs of rolls for a further reduction in cross-section.

BRIEF DESCRIPTION OF THE DRAWING

The invention is illustrated by way of example in the sole FIGURE of the accompanying drawing which forms part of this application and in which there is illustrated diagrammatically an apparatus which is suitable for carrying out the process of this invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

From a ladle, not shown, molten steel is supplied to the top end of a mold 1, which is, for example, square. When the casting 2 has partly solidified in the mold 1, it is withdrawn from the mold along a curved path by means of the pair of rolls 6. The guide rollers, means for a direct cooling of the casting and means for controlling the surface temperature of the casting are arranged along this path. These means are known per se and are not shown on the drawing. Behind these various means, the casting moves in succession past the sensing unit 3, the pair of rolls 6, the sensing unit 4, the

pair of vertical rolls 7 and finally the sensing unit 5. The sensing units 3, 4, and 5 serve for a rapid sensing of the cross-sectional area and velocity of the casting at their respective locations. The sensing units 3, 4, and 5 are preferably provided with computers, not shown, for computing the product of the cross-sectional area and velocity of the casting at the respective location, and with means for indicating said product.

The respective diameters of the pair of rolls 6 and 7 should be 2 – 4 times, and preferably 2 ½ times, as large as the thickness, respectively diameter, of the cast strand. The types of rolls used in the process of this invention are not of the usual "caliber" rolls, but rolls having a relatively smooth surface. The distance between the pairs of rolls 6 and 7 should be at least 6 times and not more than 12 times the thickness, i.e. diameter, of the strand.

As soon as the starter bar, which has been used in known manner for initiating the casting operation, has left the pairs of rolls 6 and 7, these pairs of rolls are screwed down so that the reduction in cross-section by the pair of rolls 7 is at least 10 percent and the reduction in cross-section by the pair of rolls 6 is about 5 percent. At the same time, the above mentioned products of the cross-sectional area and the velocity of the casting at the locations of the several sensing units are computed and compared. If said product, that is the mass flow rate, at the location of the sensing unit 4 is larger than at the location of the sensing unit 5, the amount of deformation effected by the pair of rolls 6 is not sufficient to eliminate all internal voids in the casting. For this reason, the pair of rolls 6 are screwed down further so that the clearance between the two rolls is further reduced, and the pair of rolls 7 are sufficiently readjusted to ensure a reduction in cross-section by at least 10 percent by this pair of rolls. The abovementioned products at the locations of the several sensing units are compared once more. This sequence of operations is repeated until the abovementioned products at the locations of the sensing units 4 and 5 are the same and are smaller by at least 0.5 percent than the corresponding product at the location of the sensing unit 3.

When this state has been reached, the shaping operation effected by the pair of rolls 6 can be relied upon to eliminate all voids and to squeeze out any residual molten metal so that the reduction in cross-section of the casting by at least 10 percent to which the casting is subjected when passing between the rolls 7 will not result in a further compaction of the casting.

Thus, the process according to the invention enables a simple and quick adjustment of the conditions under which continuous castings can be directly rolled, depending on the properties of the continuous casting, so as to obtain rolled stock having a satisfactory, dense structure.

What is claimed is:

1. A process for making rolled stock directly from a product of a continuous casting process, comprising the steps of subjecting said product to successive first and second rolling operation by means of a first and a second pair of rolls; said first rolling operation taking place at a point where the interior of the casting is still close to the solidus temperature while the surface of the casting has already reached the usual rolling temperature;

adjustable controlling said rolling operations by adjusting the respective clearances between the rolls of said first and second pair of rolls so that the mass flow rate of said product immediately before said first pair of rolls is at least 0.5 percent higher than immediately after said pair of rolls, whereas the mass flow rate of said product remains substantially unchanged before and after said second pair of rolls, said second pair of rolls reducing the cross-sectional area of the product passing therebetween by at least 10 percent.

2. A process as set forth in claim 1, in which said product is in an as-cast state immediately before said first rolling operation.

3. A process as set forth in claim 1, for making billets, in which said first rolling operation is controlled so that the mass flow rate of said product before said first rolling operation is 1 - 5 percent higher than after said first rolling operation.

4. A process as set forth in claim 3, as applied to the manufacture of billets having a round cross-section.

5. A process as set forth in claim 3, as applied to the manufacture of billets having a rectangular cross-section.

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6. A process as set forth in claim 1, for making slabs, in which the mass flow rate of said product before said first rolling operation is 5 - 25 percent higher than after said first rolling operation.

7. A process as set forth in claim 1, for making sheet bars, in which the mass flow rate of said product before said first rolling operation is 5 - 25 percent higher than after said first rolling operation.

8. A process as set forth in claim 1, in which the distance between said first pair of rolls and said second pair of rolls is at least 6 times as large and no more than 12 times as large as the thickness of the product passing therebetween.

9. A process as set forth in claim 1, wherein the diameters of the rolls of said first and second pair of rolls is 2 to 4 times as large as the thickness of the product passing therebetween.

10. A process as set forth in claim 9, wherein the diameters of said first and second pair of rolls are about 2 1/2 as large as the thickness of the product passing therebetween.

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