Oct. 19, 1971 SHOJIRO TAKIMURA ET AL 3,613,319

METAL ROLLING WORK ROLL AND METHOD OF MAKING SAME

Filed March 2, 1970 2 Sheets-Sheet 1

Fig. 1

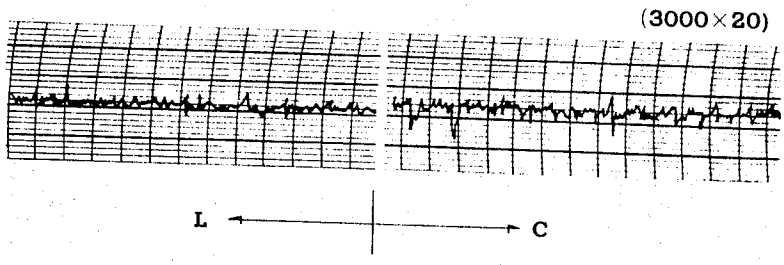


Fig. 2

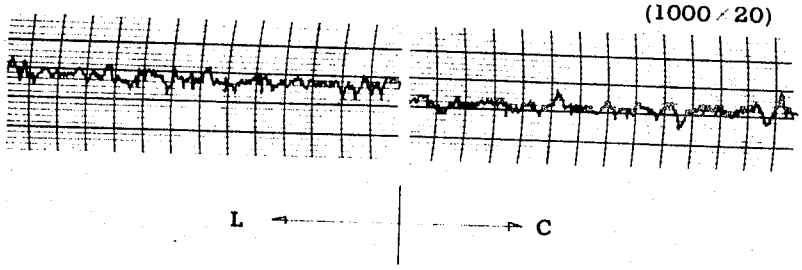
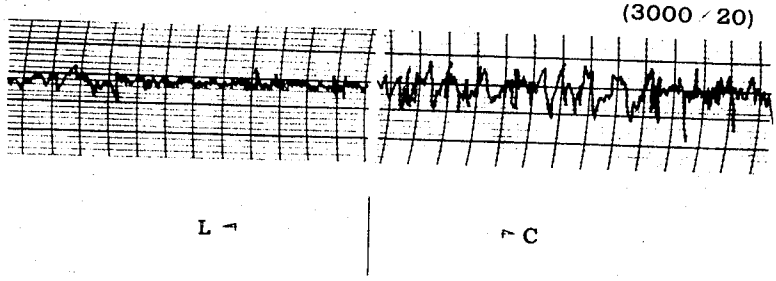


Fig. 3



Shojiro Takemura
Tomeji Doi
Hiroshi Kuwamoto
INVENTOR.

BY Robert D. Flynn
Attorney for applicants

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Filed March 2, 1970 2 Sheets-Sheet 2

FIG. 4

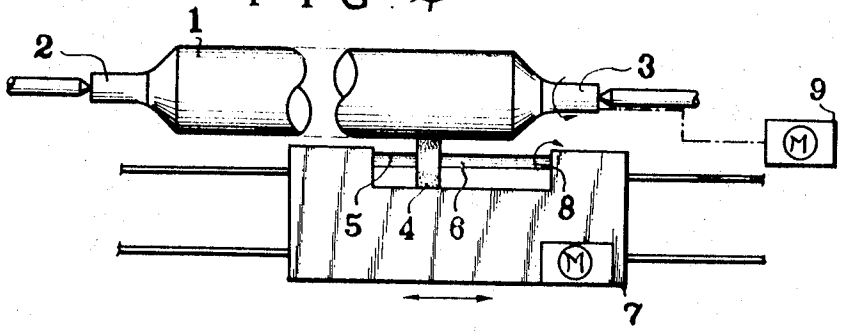


FIG. 5

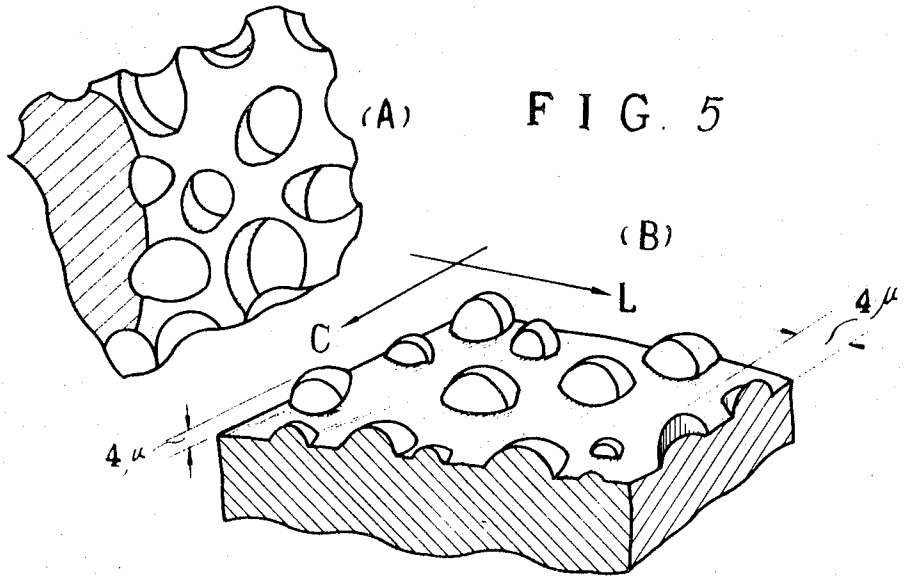
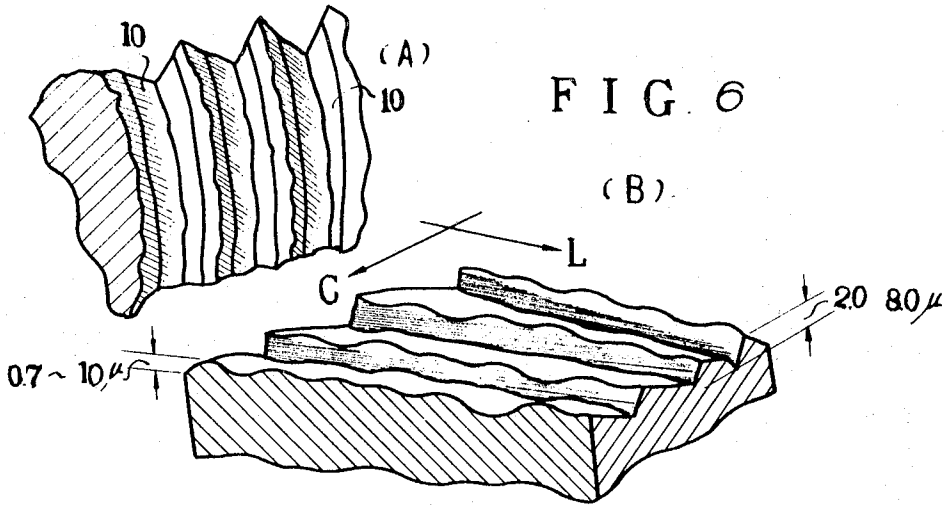


FIG. 6



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3,613,319

METAL ROLLING WORK ROLL AND METHOD OF MAKING SAME

Shojiro Takimura, Tomeji Doi, and Hiroshi Kuawamoto, all % Nippon Kokan Kabushiki Kaisha Mizue Iron Works, 5-1 Mizue-cho, Kawasaki-shi, Kanagawa-ken, Japan

Continuation-in-part of application Ser. No. 678,603, Oct. 27, 1967. This application Mar. 2, 1970, Ser. No. 15,444

Int. Cl. B21b 27/02

U.S. Cl. 51—289 R 9 Claims

ABSTRACT OF THE DISCLOSURE

A work roll for rolling low carbon steel or the like has a surface which is dull finished by grinding with a #40 or less roll grinder to form circumferentially oriented impressions on the surface of the work roll. These work rolls impart surface roughnesses and qualities to the rolled steel strip whereby the roughness of the surface in the direction transverse to rolling is greater than the roughness in the direction of strip rolling, to thereby reduce sticking tendencies, improve the surface luster, and improve manufacturing economies.

This is a continuation-in-part of application Ser. No. 678,603, filed Oct. 27, 1967, now abandoned.

This invention relates to work rolls for use in rolling low carbon steel sheet or strip and, more particularly, a work roll having a dull finish surface and a method of making same. The surface properties of the steel sheet or strip rolled by the dull finish work rolls of the present invention are superior to those rolled by known conventional work rolls.

It is generally well known in industry that suitable control over the surface roughness of steel sheet or strip improves its deep drawability and ductility. A prior art method of dull finishing steel sheet or strip utilizes a temper rolling step in which a working roll is placed into a shotblast machine, wherein the roll is blasted with grit or shot and thereby dull-surface finished. Subsequently, the dull-finished roll is mounted in a temper mill in which a light rolling is effected of the steel sheet or strip. Somewhat more recently, as other uses for the dull finished roll could be employed in the final step or pass of a tandem or reversing mill in which the effect or results are to some extent different from the temper rolling method. In essence, the more recently developed methods were aimed at preventing the sticking or adhesion between the center layers of rolled or superimposed steel sheet or strip coils, inasmuch as any such sticking between coil layers resulted in the rejection of the steel sheet or strip as scrap. Although the aforementioned dull finishing method alleviated the problems to some extent, many drawbacks and disadvantages were still encountered. In order to emphasize the advantages of the work rolls of the present invention, the disadvantages of dull finished rolling methods as presently employed in the prior art will now be reviewed.

When temper rolling with presently known dull finished rolls, extreme variations are encountered in the surface luster of the steel sheet or strip after temper rolling. Although, as indicated previously, a dull finished strip has an improved press-formability and also superior coating properties, a satisfactory and uniformly controlled surface luster of the steel is also of considerable importance. It is generally widely known that a steel strip having the optimum press-formability, deep-drawability and coating properties has an H max., surface roughness value, of 3μ to 8μ; however, it is also apparent and unavoidable

that the surface luster of the steel sheet or strip decreases gradually as H max., exceeds 6.

Further, when subjecting the steel strip to a process or step of press forming, some powdered iron is produced and deposited upon the surface of the steel strip and remains behind during the press forming. The powdered iron is a result of the formation of the finished roll surface roughness by shot-blasting, whereby the roughness pattern is similar in the cross-wise direction, as well as in the longitudinal direction of the roll and, moreover, is intermittent across the roller surface. Such production of powdered iron on the steel strip surface causes the rolling resistance to be greatly increased by the intermittent roll surface unevenness whereby the steel strip surface is chipped off and damaged. It is also apparent that such excess iron powder on the surface of the steel strip may have other serious effects on the press forming process. Thus, the iron powder is agglomerated due to static electricity generated on the die punch head during press forming, which not only slows down the press forming process but also adversely affects the life of the press die or punch. Additionally, as a result of an increase in the frictional resistance, using the aforementioned conventional dull finished roll the electric power consumption for the cold rolling mill is greatly increased, while the manufacture of the dull finished roll necessitates an additional expenditure. These disadvantages and drawbacks greatly increase the cost of the prior art methods, rendering them frequently economically undesirable.

Although the aforementioned drawbacks of prior art dull finished rolls are discussed in connection with cold reversing mill practice, it is apparent that similar disadvantages are encountered in other cold rolling mill practices, such as in temper mills or cold tandem mills. In the prior art cold reversing mill practice, particularly with regard to rolling into steel sheet size, rolling the strip or sheet begins with conventional bright or smooth finished rolls and then, after an exchange of these rolls for a dull finished roll, the last pass is completed. Unfortunately, however, the above process serves merely as a remedy for the elimination of sticking or adhesion between the center layers of the steel coil and other drawbacks, such as, a deterioration in the surface luster, an increase of detrimental iron powder and an increased power consumption during rolling, and increases in the production costs because of the additional requirement for changing the working rolls, remain in evidence. However, in presently employed rolling methods, the prior art dull finished rolls must be used, notwithstanding the inherent disadvantages, in order to obviate sticking of the steel coils at the annealing stage and with a resultant improvement of the press formability of the steel strip.

Experimentation has clearly indicated that the above-mentioned disadvantages are the result of two basic phenomena due to rolling with an ordinary dull finished roll; in effect, impressions on the steel strip surface are discontinuous in the L- or longitudinal rolling direction, and further, the configurations of the impressions in the C- or cross-sectional rolling, or transverse direction, are equal to those in the L-direction of strip rolling.

On the basis of above-mentioned experiments, conducted by the applicants, a primary requirement of the present invention is that the cold rolling of the steel sheet or strip enables impressions on the strip surface to be continuous in the L-direction, or direction of strip travel or rolling. A second requirement is that the cold rolling method causes the dimensions of the impressions in the transverse, or cross-sectional, C-direction to be larger than those in the L-direction. In order to accomplish the above-mentioned strip surface requirements, in accordance with the present invention, the surface of the work roll should be ground with a conventional grinder using a comparatively

coarse grinding stone with, for example, a surface finish of #40 or less. Using the grinder as indicated above, it becomes readily practicable to manufacture a work roll by means of a conventional roll grinder without the need for a further manufacturing sequence, such as shot-blasting; with a consequently sizable reduction in processing costs.

It is accordingly a primary object of the present invention to provide an improved dull finished work roll for rolling steel sheet, strip, or the like.

Another object of the present invention is to reduce the manufacturing steps in a cold rolling process for steel strip or sheet so as to reduce the manufacturing costs.

SUMMARY OF THE INVENTION

According to the present invention, the surface of a work roll has a plurality of circumferentially oriented impressions therein to provide a surface roughness in the direction of the width of the roll of about three times that of in the circumferential direction of the roll.

Further, in accordance with the present invention, the work roll is formed by grinding the work roll with a #40 or less roll grinder to provide the plurality of circumferentially oriented impressions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a wave form of surface roughness of steel strip in the transverse (C) and longitudinal (L) rolling directions, which is rolled with a conventional bright finished work-roll;

FIG. 2 illustrates a wave form of surface roughness of steel strip in the transverse (C) and longitudinal (L) rolling directions, which is rolled with a conventional dull finished work-roll which has been surface finished by a prior art shot-blasting process;

FIG. 3 illustrates a wave form of surface roughness of steel strip in the transverse (C) and longitudinal (L) rolling directions, which is rolled with the work rolls of the present invention which are dull finished with a #40 or less grinder;

FIG. 4 illustrates a method of producing work rolls of the present invention;

FIGS. 5A and 5B illustrate the surface characteristics of the prior art work rolls and of the strips rolled thereby, respectively; and

FIGS. 6A and 6B illustrate the surface characteristics of the work rolls of the present invention and of the strips rolled thereby, respectively.

In the present application, the description of the prior art surface finish wave forms, which are illustrated in FIGS. 1 and 2 of the drawing, is to provide for an understanding of the inventive process in comparison with the prior art processes and methods of steel strip or sheet rolling.

Generally, a work roll for bright finishing steel strip rolling is ground with a #120 surface grindstone, which results in a steel sheet or strip surface as shown in FIG. 1. The wave is measured by a standard needle contact method and is increased to 3,000 times magnification in the vertical direction of the drawing and to 20 times magnification in the horizontal direction. Usually, the wave form is measured by means of the needle contact method from the second steel coil rolled by new work-rolls. The roughness value H max. obtained by this method is generally about 0.8μ in both the C-direction and L-direction of steel strip rolling. Although the cold rolling strip having an H max. as stated above has a beautiful surface luster, a major disadvantage of this bright finished steel strip is that a center layer of the strip or coil is subject to sticking or adhesion during the subsequent annealing process, because of its extremely large and smooth contact area. Such sticking or surface adhesion may, particularly occur in so-called sheet size strip (about 1.6 mm.–0.6 mm. thickness) and frequently affects up to about 30% of the steel coils annealed. Consequently, in order to prevent the coil sticking in the prior art, a dull finishing roll which is surface finished by a shot blast machine is employed in lieu of the bright finished roll. An example of surface wave forms on steel strip surface rolled with this dull-finished roll is shown in FIG. 2 of the drawing. The wave is measured by the same method in FIG. 1 and is magnified 1,000 times in the vertical direction of the drawing and 20 times in the horizontal direction. The roughness value H max. is about 4.0μ in both the C-direction and L-direction of strip rolling, and are generally of the same size in both of these surface directions. Based on precise and careful observations, it has been found that the surface impressions formed by a roll which is surface finished by shot blasting are independent of each other and therefore are intermittent or discontinuous. As previously indicated, steel strip coil which has surface finish wave forms provides the advantages of reduced coil sticking during annealing and of good pres formability, while subject to the drawbacks of producing excessive surface iron powder and requiring great increases in electrical rolling power.

This present invention provides an improved work roll for manufacturing steel sheet or strip by a dull finishing method in which the advantages in the prior art are completely removed. An example of a steel strip surface roughness wave rolled by the roll of the present invention is shown in FIG. 3 of the drawing. The wave is measured by the same method as in FIGS. 1 and 2, and is magnified about 3,000 times in the vertical direction of the drawing and about 20 times in the horizontal direction. The strip surface roughness value H max. is measured at approximately 0.9μ in the L-direction and 2.7μ in the C-direction of strip rolling movement. Comparing the wave form of FIG. 3 with those of FIG. 1, considerable and essential differences may be determined. Primarily, there are greatly different strip surface roughness values observed in the L- and C-direction of strip rolling; that is, the value in the C-direction (transverse) is approximately three times as large as the value of H max. in the L-direction of strip rolling (longitudinal). This is fundamentally and considerably different from the roughness values shown in FIGS. 1 and 2 of the drawing. In comparison with such values or waves, it is further noteworthy that the roughness H max. in the L-direction in FIG. 3 is quite similar to that in FIG. 1, notwithstanding that the wave form in FIG. 3 is obtained with a dull finished roll ground with a #36 coarse grindstone, as compared with a #120 find grindstone for the work roll used in FIG. 1. This indicates that the top and bottom of the surface impressions in the strip in the C-direction are continuous, and with a degree of said impressions extending into the L-direction. According to extensive experimentation it has been found that this degree of impressions in the L-direction is scarcely affected within the range of H max. 3μ to 8μ. This H max. is the roughness in the C-direction of the strip, and forms the most suitable surface roughness conditions for press forming. Such properties of surface roughness as indicated above are the most desirable features of this invention and provide the following results:

(a) The improved H max. in the C-direction of the steel strip prevents sticking of the coil center layers;

(b) The lubricating functions of rolling oil films are enhanced since the oil is distributed over the strip surface in view of the continuous impressions in the L-direction of the strip; this will considerably decrease frictional resistance during rolling, and in consequence, almost no powdered iron is produced, thereby reducing the requirements for electrical rolling power;

(c) According to observations after temper rolling, it is found that the luster of the steel surface is as attractive as that of a bright finished steel sheet; and

(d) There is no need to add a further production step, such as a shot blasting process for the work roll; accordingly, in a cold reversing mill, this eliminates the

need to exchange the bright finished work roll for a dull finished roll for the last pass.

Further, according to experimentation, in a case where a roughness value H max. in the C-direction of the strip is less than 2.0μ, as shown in FIG. 3, such strip coils could have a strong tendency to stick in the center layers of a coil during annealing, and also if H max. should be in excess of 7.0μ, the luster on such strip surface may diminish. It is, therefore, recommended that the surface roughness value H max. on the work-roll should be within the range of 4.0μ to 6.0μ. Such range may be easily obtained through a grinding process, wherein a grading of grindstone is selected to be within, for example, #30 to #40, the revolutions per minute (r.p.m.) of the grinder wheel are adjusted to a suitable r.p.m., and a grinding resistance for the roll is adjustably determined as the occasion may demand.

In FIG. 4 there is shown a method of making the work roll of the present invention. The roll **1** is rotatably supported at its ends **2** and **3** along its longitudinal axis by means not shown. The roll grinder **4** is rotatably supported at its ends **5** and **6** along its longitudinal direction by means not shown. A motor **7** is provided to impart rotation to the grinder **4** in the direction shown by the arrow **8**. The roll **1** and grinder **4** are pressed against each other also by means not shown in order to cause the grinder **4** to create the required impressions (i.e., streaks or scratches) on the surface of the roll **1**. Rotation may also be imparted to roll **1** by means of a motor **9** in a direction opposite to that of the grinding roll. If desired, the roll **1** and grinder **4** may both be driven by the same motor with an appropriate transmission means being provided to impart the appropriate rotations to the roll and grinder. It should be clear that the particular arrangement for making the roll shown in FIG. 4 is given merely by way of example and that many modifications and alterations may be made thereto.

FIG. 5A illustrates the surface characteristics of a work roll which is dull finished by conventional methods, such as by shot-blasting. FIG. 5B shows the surface characteristics of a strip which is formed by rolling with the shot-blasted roll of FIG. 5A. It is seen that independent impressions are formed on the strip which are randomly located. Further, it is seen that the surface roughness in the L- and C-directions are approximately equal.

FIG. 6A illustrates the surface characteristics of a work roll formed according to the present invention by grinding with a #40 or less roll grinder. FIG. 6B illustrates the surface characteristics of a strip which is formed by rolling with the roll of the present invention. From FIG. 6A it is seen that the roll has continuous impressions **10** (i.e., streaks or scratches) which are circumferentially oriented with respect to the surface of the roll and which are irregular in the circumferential direction of the roll. By virtue of these impressions **10**, substantially longitudinal, irregular impressions are formed in the surface of the strip.

The surface roughness in the L-direction of the strip, when the roll has been ground by a #36 grinder, is typically 2.0μ to 8.0μ and the surface roughness in the C-direction is typically 0.7μ to 1.0μ.

An advantage of the roll of the present invention is that lubrication is efficiently carried by the circumferential impressions formed on the roll, thereby enabling power consumption to be substantially decreased, when using the prior art rolls, as exemplified by the roll illustrated in FIG. 5A, the lubricating oil remained stuck in the random impressions on the roll and in the impressions on the strip which were formed during the rolling process. Thus, lubrication is lost and not efficiently utilized. The lubrication of the lubricant is thereby decreased and power consumption required to operate the prior art rolls is increased by approximately 20%.

Referring to the following actual examples utilizing the work roll of the present invention: the steel employed

is a capped steel for deep drawing, and the rolling mill employed is a cold reversing mill in which usual drawbacks of the prior art are developed, that is, defects based on a work roll finished by a shot blast machine.

Coil conditions

Initial size (hot strip)—2.8 mm.×1,403 mm.
Final size (cold strip)—0.8 mm.×1,403 mm.
Weight (all coil)—about 13 t.

Chemical analysis

All materials are within following range.

C	0.04–0.06
P	0.015–0.020
Mn	0.28–0.33
S	0.016–0.020

Rolling oil

Mineral soluble oil—5% solution

Work-roll conditions

Roll A: bright finished roll; surface finished by #120 grinding roll.
Roll B: dull finished roll; surface finished by #80 shot blast machine.
Roll C: dull finished roll; surface finished by #36 grinding roll.

Numbers of test coils

	Coils
With roll A	11
With roll B (exchange roll A for B at the last pass step)	14
With roll C	15

TABLE 1.—PASS SCHEDULE AND POWER PER TON

	1st pass	2d pass	3d pass	4th pass
Roll A:				
Thickness, mm	2.10	1.51	1.05	0.80
Integrated power, kw.-hr	7.2	15.9	30.1	50.2
Roll B:				
Thickness, mm	1.88	1.27	0.89	0.80
Integrated power, kw.-hr	11.1	24.7	50.4	60.9
Roll C:				
Thickness, mm	2.10	1.51	1.05	0.80
Integrated power, kw.-hr	8.0	16.5	31.9	51.8

NOTES:
1. "Thickness and integrated power" are the values determined after the respective pass.
2. "Roll B" is the value when Roll A was used from the 1st to the 2d and then, in place of Roll A, Roll B was put into the stand at the las pass step.
3. "Roll C" is the value when Roll C was used from the 1st pass to the last.

Independent of the above-mentioned example, another test in which Roll B had been put in said stand from the first pass step was carried out. As a result, it was found that the rolling schedule required about 11 pass steps in which the upward tendency of said integrated power consumption increased to 78.1 kwh. per ton. Additionally, excessive quantities of iron powders were produced on the strip surface. The poor test results were sufficient to warrant stopping the test roll at only one coil. As shown above, it became obvious that a process in which Roll B is used from the first pass step is of no practical use in the industry.

To the contrary, the process using Roll B at the last pass step, indicates, as shown in Table 1, an improved value in comparison with the above prior art process. However, the power consumption value at "Roll B Column" is still greater than the value at "Roll C Column." At the same time, quantities of the iron powders produced were still excessive. Further, the "Roll B Column" process requires the additional manufacturing sequence of preparing the work roll with a shot blasting step, and also requires a roll exchanging step. These defects and drawbacks cannot be disregarded and consequently, the "Roll B Column" Process in Table 1 is not entirely satisfactory.

Subsequently, the coil being rolled under the schedules in Table 1 was transferred to an annealing line.

Annealing conditions

Annealing furnace: conventional tight coil furnace
Soaking temperature: 730° C., 15 hrs.

TABLE 2.—ANNEALED RESULTS

	Total	Satisfactory	Sticking coils
Coils by—			
Roll A	11	8	3
Roll B	14	14	0
Roll C	15	15	0

NOTE.—The numerical value for each column shows the number of treated coils.

According to Table 2, it is clearly shown that there is no sticking of the coils using Roll C. These coils made by Roll C have, as stated previously, comparatively low surface roughness values, i.e., C-direction H max., 2.7μ, and L-direction, 0.9μ. In spite of such low roughness, the fact that sticking practically never occurs shows the superiority of the Roll C process, which is the present inventive process. Accordingly, except possibly for special cases, it may be understood that there is no necessity for using the conventional Roll A process.

According to close observations during the exemplary rolling practice, it was found that the surface roughness obtained by the Roll C process is to some extent worn away during a cold reversing rolling. It was ascertained that the first H max., 5.3μ (in C-direction), was reduced to the last H max., 2.6μ (after rolled weight, 202.5 t.). Therefore, if the roll grinding conditions are set so that the first H max. becomes 6.0μ, the desired surface finish or roughness may be easily obtained.

In a temper mill or cold tandem mill, generally no problems arise. However, in the event that H max. (in the C-direction) is less than 2.5μ, there is a possibility of some sticking between the coil center layers during the annealing stage. Accordingly, each cold rolling schedule must be decided on its own merits and physical surface roughness requirements.

We claim:

1. A method of manufacturing a work roll for use in rolling steel or the like, comprising grinding said work roll with a #40 or less roll grinder to provide a plurality of circumferentially oriented impressions in the surface of said roll such that the surface roughness in the direction of the width of the work roll is approximately three times that of in the circumferential direction of the work roll.

2. The method of claim 1, wherein said circumferentially oriented impressions are continuous.

3. The method of claim 1, wherein said work roll is ground with a #30–#40 roll grinder.

4. A work roll for use in rolling steel or the like having a plurality of circumferentially oriented impressions in the surface thereof and having a surface roughness in the direction of the width of the work roll approximately three times that of in the circumferential direction of the work roll.

5. The work roll according to claim 4, wherein said circumferentially oriented impressions are continuous.

6. The work roll of claim 4, wherein the surface roughness, H max., in the direction of the width of the work roll is in the range of 2.0μ–8.0μ.

7. The work roll of claim 4 for use in a cold reversing rolling apparatus and having a surface roughness, H max., in the direction of the width of the work roll of about 50μ–70μ.

8. The work roll of claim 4 for use in a cold tandem rolling apparatus and having a surface roughness, H max., in the direction of the width of the work roll of about 20μ–80μ.

9. The work roll of claim 4 for use in a temper rolling apparatus and having a surface roughness, H max., in the direction of the width of the work roll of about 20μ–80μ.

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LOWELL A. LARSON, Primary Examiner

U.S. Cl. X.R.

29—121 R, 148.4 R; 72—199, 366