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Description

This invention relates to a hot rolling method for avoiding edge build-up and edge drop of rolled strips or plates and is concerned with such a method involving preventing local wear of the work rolls of rolling mills, such as four or six high mills, whilst simultaneously controlling the profiles of the steel strips or plates.

Recently, it has been required to improve the accuracy in thickness of steel strips or plates rolled by rolling mills in order to improve the yield rate of the steel. To meet this requirement, various profile controlling methods have been proposed. Among them, a taper end roll rolling method is effective to prevent edge drops with the aid of work rolls of particular geometrical shapes, for example, as disclosed in JP-A-54 024 256. In accordance with this document both ends of each of the work rolls include tapered portions in order to prevent the edges of the strips becoming thinner.

In this case, the effect of profile controlling tends to decrease with change in the width of the steel strips or plates. To avoid this, a work roll shift method is effective for profile controlling as disclosed in JP-A-55 077 903. In accordance with this document a pair of work rolls is used wherein each has a tapered portion and the rolls are arranged one above the other with the tapered portions on opposite sides of the rolling path. The work rolls are shifted in the axial direction, before rolling, in accordance with the width of the strips to be rolled.

Referring to Figures 1 and 2 of the accompanying drawings, as the number of rolled strips having the same width increases during hot finish rolling, the work rolls 1 progressively wear to form tracks or traces 2 for the strips whose edge portions 2b usually wear deeper than the centre portions 2a as shown in Fig.1. As a result, the rolled strip 3 has a sectional profile including at its edges irregular protrusions or ridges p and p' which are referred to as "edge build-up" as shown in Fig.2. It is clearly evident that such an edge build-up causes the greatest difficulty for profile controlling of the strips and for roll-change-free rolling which is rolling with a pair of work rolls over a wide range of sizes of strips or plates to be rolled without changing the rolls. The same holds true when using taper end rolls.

It is an object of the invention to provide an improved hot rolling method capable of preventing edge build-up caused by uneven wear of the work rolls forming tracks for the strips or plates and making it possible to effect profile controlling so as to enable roll-change free rolling to be carried out.

It is a further object of the invention to provide a hot rolling method with work rolls being displaced in a roll shift pattern determined in consideration of the thermal expansion of the rolls in addition to the equalisation or mitigation of roll wear to reduce crown formation on the rolled strips and to stabilise the profiles of the rolled strips.

According to the present invention, there is provided a hot rolling method using a hot finishing mill including a pair of axially adjustable work rolls each having a tapered portion at one end of its barrel and arranged one above the other with the tapered portions being on opposite sides of the rolling path and being so axially adjusted as to locate each edge of strip material to be rolled in a roll gap zone determined by the respective tapered portion of one of the work rolls characterised in that, during the course of rolling a sequence of discrete lengths of strip material, each of substantially the same width, in the interval between succeeding lengths said work rolls are cyclically axially displaced relative to each other within a range of displacement such that said edges of the material remain within the roll gap zone delimited by said tapered portions thereby preventing edge build-ups of the material, whereby the upper limit of the cyclical values of the distance from an edge of the material to the transition point between said tapered portion of the work roll nearest to said edge of the material and the central portion of the roll is variably set so as to decrease as the thermal expansion of the work rolls increases.

In carrying out the invention, the amplitude of displacement of the work rolls lies between a maximum where the shapes of the material at the exit side of the work rolls do not exceed a limit value and a minimum where the profile controlling performance of the work rolls for the material is still maintained.

It is another object of the invention to provide a hot rolling method capable of effectively suppressing edge build-ups without causing the formation of crowns on the strips which would tend to occur as a consequence of fine displacement of the work rolls, thereby enabling roll-change-free rolling to be effected by displacing the taper end work rolls.

To achieve this object, according to preferred embodiment of the invention the work rolls are finely displaced and simultaneously a bending action is applied to the work rolls in a manner so as to eliminate the bending action on the work rolls caused by the material being rolled by the work rolls.

It is a still more specific object of the invention to provide a hot rolling method capable of effectively reducing crown formation on rolled strips through-out a rolling cycle by simply setting suitable initial crowns on the work rolls without causing irregularities in the crowns of the rolled strips which would unavoidably be caused by variation in the kind of steel, the period of rolling allowed by one pair of work rolls, and the thermal crowns of the work rolls due to heat.

To this end, according to a still further particular embodiment of the invention stepwise variation in the displacement of the work rolls per unit number of rolled material is effected during the rolling cycle.

Preferably, the stepwise variation is made smaller in the first half of the rolling cycle and is made larger in the latter half of the cycle.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig.1 is a schematic view of work rolls illustrating their wear;

Fig.2 is an explanatory view of a profile of a rolled strip including edge build-ups;

Fig.3a is a sectional view illustrating rolling of a strip by taper end work rolls;

Fig.3b is a graph showing an effective E_L zone;

Fig.4 is an explanatory elevation illustrating a rolling condition with the maximum E_L;

Fig.5 is an explanatory elevation showing a rolling condition with the minimum E_L;

Fig.6 is a partial sectional view of a work roll illustrating deep wear;

Fig.7 is a partial sectional view of a work roll illustrating the equalised or mitigated wear therein;

Fig.8 illustrates profiles of strips rolled in the prior art method;

Fig.9 illustrates profiles of strips rolled according to another method;

Fig.10a is a graph illustrating the uniform crowns of strips rolled with a bending action applied to the work rolls;

Fig.10b is a graph illustrating the variation in crown of strips rolled without a bending action exerted upon the work rolls;

Figs.11a and 11b are schematic views for explaining the application of a bending action to the work rolls;

Fig.12 illustrates profiles of strips rolled with a constant E_L value of 200 mm;

Fig.13 illustrates profiles of strips rolled with variable E_L value with work rolls subjected to fine cyclic shifting;

Fig.14 illustrates profiles of strips rolled according to Fig. 13 but with the application of bending action to the work rolls;

Figs.15a and 15b are elevations of a work roll for explaining thermal expansion;

Fig.16 is a graph for explaining how to determine the E_L value in consideration of the thermal expansion of the work rolls;

Fig.17 is a graph for explaining the shift of the E_L value in consideration of mitigation of wear of the rolls;

Figs.18a and 18b are schematic views illustrating irregular wear in a roll;

Fig.19 is a graph illustrating the reduced crown of rolled strips resulting from E_L values;

Fig.20a is a profile of a strip rolled in consideration of thermal expansion according to the invention;

Fig.20b is a profile of a rolled strip including defective edges caused by irregular wear of the work rolls;

Fig.21 is a schematic view for explaining the displacement distance of the rolls;

Fig.22 illustrates various shift pitch patterns of work rolls for carrying out rolling;

Fig.23 is a graph illustrating the comparison of the difference Δ S in roll diameters with respect to respective shift pitches;

Fig.24 is a graph illustrating the difference Δ S dependent upon the numbers of rolled strips;

Fig.25 is a graph illustrating the relationship between the difference ΔS and the numbers of rolled strips;

Fig.26 is a graph illustrating the effect of variation in shift pitch on the difference ΔS;

Fig.27 is a graph illustrating shift pitch patterns used in actual rolling according to an embodiment of the invention; and

Fig.28 is a graph illustrating the suppression of the difference ΔS resulting from the shift pitch patterns shown in Fig.27.

Referring to Figure 3a, there is shown a pair of work rolls 1' which are so called "taper end rolls" each having a taper ground end 4' at one end of a roll barrel 4. The rolls are arranged one above the other with the taper ground ends on opposite sides of the rolling path so as to locate both edges of strips or plates 3 to be rolled in roll gap zones determined by the respective taper ends 4'. During profile controlling using such work rolls, the inventors found effective E_L values to be determined by limit values depending on the shape of the strips determined by the roll stand, where E_L is the distance from an edge of the strip to the starting point of the taper ground end, while relief E_H of the strip 3 at its edge relative to the taper ground end 4' is constant.

If the amplitude of displacement of the work rolls is such that the work rolls are displaced to an excessive extent beyond the effective E_L value, the shape of the rolled strip at the exit side of the rolls exceeds its limit value making it impossible to carry out the rolling. On the other hand, if the work rolls are displaced to a too small extent beyond the opposite limit of the effective E_L value, the profile controlling performance of the work rolls is incapable of controlling crown formation on the rolled strips.

The inventors further investigated the effective E_L value to achieve a hot rolling method capable of preventing edge build-up of the rolled strips or plates so as to enable profile controlling and roll-change-free rolling to the effected.

One method of rolling using a four high mill will be explained hereinafter. Fig.4 illustrates the most displaced position of the work rolls when the E_L value shown in Fig.3 is increased to its maximum but not exceeding the limit value determined by the shape of the strips at the exit side of the rolls. Fig.5 shows the least displaced position of the work rolls when the E_L value is decreased to its minimum but the rolls still maintain their profile controlling performance. Reference numeral 5 denotes back up rolls.

In the event that the work rolls 1' are cyclically displaced so as to permit E_L to be within the range of the effective E_L values from Fig.4 to Fig.5, local wear 2b'' in the track or trace 2' for the strips can be equalised or mitigated in the axial direction of the work roll even after the number of rolled strips has increased as shown in Fig.7 ,instead of being in the form of a deep local wear 2b' in the case of a constant E_L value as shown in Fig.6.

In order to clarify this further, Figs.8a, 8b and 8c illustrate one example of variation in sectional profile of strips at the exit side having thicknesses of 2.0 mm and widths of 1,040 mm according to Japanese Industrial Standards (JIS) SPHC continuously rolled by a taper end roll rolling method with a constant E_L of 200 mm. As can be seen from these drawings, the profiles were not greatly varied when the tenth strip had been rolled. However, when the twentieth strip had been rolled, remarkable edge build-ups p and p' occurred to maximum heights of as much as 20 μ which made it impossible to continue rolling strips having the same width.

Figs.9a-9d illustrate the variation in sectional profile of strips similar to those of Figs.8a-8c and continuously rolled with the work rolls being cyclically shifted by 20 mm per two strips with EL values of 200-100 mm Even after forty-six strips having the same width had been rolled, no perceptible edge build-ups could be recognised.

As can be seen from the above description, This latter hot rolling method can equalise or mitigate local wear in tracks or traces in the work rolls for strips having the same width. Thus it can effectively maintain sufficient profile controlling effect for preventing edge drops, thereby simultaneously making compatible roll-change-free rolling and profile controlling of the strips.

In carrying out such a method, when the work rolls are finely displaced within a range corresponding to the effective E_L value, the crown of the rolled strips becomes larger as shown in Fig.10b. In other words, the crowns of the strips rolled by the work rolls as they are finely displaced within the range of effective E_L values vary over a fairly wide range.

Another technique can be used to solve this problem. Fig.11a illustrates work rolls 1' positioned at the maximum E_L value but not exceeding the limit value determined by the shape of the strips at the exit side of the work rolls. When the work rolls 1' are being displaced to make the E_L value smaller, according to this technique an increasing bending action is applied to the work rolls as shown by reference numeral 6 in Fig.11b compatible with the reduced value of the E_L value but still maintaining their profile controlling performance, in which position the work rolls are subjected to the maximum bending action.

In this case, the bending action is applied to the work rolls in such a manner as to eliminate or cancel the bending action acting upon the work rolls as a result of the strip being rolled by the work rolls. One preferred method of applying such a bending action to the work rolls is to apply loads to both journals of the work rolls in transverse directions substantially perpendicular to the axes of the work rolls.

As shown in Fig.10a, according to this technique, the crowns are substantially constant for successive rolled strips. In this manner, this technique is very advantageous for effecting profile controlling of strips so as to make the crowns of the strips substantially constant and simultaneously allowing roll-change-free rolling (i.e. rolling of a wide range of widths of strip without changing the work rolls).

Fig.12 illustrates sectional profiles of successive strips (JIS) SPHC having thicknesses of 2.0 mm and widths of 1,040 mm with a constant E_L value of 200 mm according to the prior art. The twentieth strip included remarkable edge build-ups 5' having a height of 20 μ. It was clearly impossible to continue further rolling with the same width strips.

Fig.13 illustrates sectional profiles of strips (JIS) SPHC having thicknesses of 2.0 mm and widths of 1,040 mm rolled with an E_L value of 100-200 mm. The work rolls were finely cyclically displaced so as to reduce the E_L value by 20 mm per two rolled strips without applying any bending action on the work rolls. After fifty strips having the same widths had been rolled, no edge build-up occurred. However, the crowns varied greatly and were larger than those in Fig.12.

Fig.14 illustrates sectional profiles of strips (JIS) SPHC having thicknesses of 2.0 mm and widths of 1,040 mm rolled with an E_L value of 100-200 mm. The work rolls were finely displaced so as to reduce the

E_L value by 20 mm per two rolled strips and were subjected to an increasing bending action of 0 to 200 tons per chock as the E_L value decreased.

In this case, after fifty strips had been rolled, no edge build-up occurred and the crowns of the rolled strips were substantially constant. Thus rolled strips having good sectional profiles throughout the rolling cycle were obtained.

This technique can effectively suppress edge build-up on rolled strips or plates without detrimentally affecting the crowns of the strips so as to eliminate the disadvantages in conventional roll-change-free rolling, whereby hot rolling with high accuracy as to thickness can be accomplished.

A rolling method in accordance with the invention will now be explained hereinafter, which method takes into consideration the thermal expansion of the rolls.

When hot rolling is carried out as shown in Figs.11a and 11b, the work rolls 1' will thermally expand from the configuration shown in Fig.15a to that shown in Fig.15b. If the rolling is continued with a constant E_L value which is set in an initial rolling stage with less thermal expansion, the centre zones of the rolled strips are rolled to an excessive extent in comparison with the edge zones of the strips to form waves therein, which make it difficult to pass through the work rolls. This is caused by the increased influence of the effect which decreases the crown of the rolled strips.

In order to avoid this, according to the invention, the upper limit of the E_L value is determined at a value corresponding to the limit value causing the above mentioned waves in the centre zones of the rolled strips and the E_L value is successively reduced depending upon the thermal expansion of the work rolls to determine an effective variable E_L value as shown in a line ℓ in Fig.16.

The thermal expansion of the work rolls corresponding to the numbers of the rolled strips is preferably measured with actual rolling conditions to previously determine the data of the thermal expansion, on the basis of which the E_L values of the rolls are previously determined. The thermal expansion may be experimentally determined with the aid of theoretical thermodynamic equations.

In this case, moreover, the variable E_L value shown in broken line ℓ is slightly shifted, as shown in curve P in Fig.17 so as to equalise or mitigate the wear of the work rolls to achieve a decrease in the crown and stability of rolled strips.

The upper limit value of the E_L value is determined with the aid of the pattern or curve P shown in Fig.17. In this manner, the profiles of the rolled strips are not detrimentally affected by the thermal expansion of the rolls, and the irregular wear in the rolls is equalised or mitigated as the rolling cycle proceeds. The irregular wear would otherwise occur in tracks in the rolls for the strips as shown in Figs.18a and 18b. This effect is particularly remarkable in the case of rolling in an order from wider strips to narrower strips.

Figs. 19 and 20a and 20b illustrate results of the rolling according to the invention wherein strips of (JIS) SPHC having thicknesses of 2.0-2.6 mm and widths of 750-950 mm were rolled by means of six roll stands of a finishing mill with E_L values of 100-300 mm decreasing depending upon the thermal expansion of the rolls. Three of the stands F3, F4 and F5 included taper end rolls. In these examples, the work rolls were finely displaced by 20 mm per two rolled strips.

Fig.19 shows the E_L values set in the cycle and the crowns μ of the rolled strips. The plotted crowns are thicknesses at the centres of the rolled strips minus the thicknesses at locations 25 mm inwardly spaced from the edges of the strips. As can be seen from Fig.19, the crowns of the rolled strips were reduced to 35 μ on an average. Furthermore, by finely displacing the work rolls, profiles of the rolled strips became stable as shown in Fig.20a to prevent defective profiles due to irregular wear of the rolls as shown in Fig.20b.

As can be seen from the above it is important to take into consideration the so called "thermal crown" of the rolls, or the crown of the rolls due to their thermal expansion, which would detrimentally affect the crowns of the rolled strips. It has been known that the variation in crown of the rolls depends not only upon the periods of rolling allowed by each pair of work rolls, the actual rolling time, the water-cooling conditions, and the like, but also on the kind of steel to be rolled, the size of the strips to be rolled, and the like. Moreover, it is known that the phenomenon of crown increase is different in the first and second halves of the rolling cycle.

As a result of various investigations and experiments on rolling with displaced work rolls by the inventors, it has been found that the distribution of the thermal crown along the roll barrel varies with the pattern of displacement of the work rolls, or the profile of the thermal crowns depends upon the shift pattern of the work rolls.

By utilising these findings, the inventors reduced the crown of rolled strips with the aid of variation in shift pitch in the rolling cycles.

If the shift pattern of work rolls are non-variably determined without considering the kind of steel, the period of rolling allowed by one pair of work rolls, and the first and latter halves of the rolling cycle, irregularities in the crowns of the rolled strips unavoidably occur throughout the rolling cycle due to the differences in the increase of the thermal crown of the rolls in their lengthwise directions. In this case, when the difference ΔS in roll diameter between the centre and the edges of the strips to be rolled in the first half of the rolling is relatively small, the crown of the strips becomes large. On the other hand, in the latter half of the rolling, the difference ΔS becomes larger and reduces the crown of the strips, but there is a tendency for the rolled strips to form waves in their centres resulting in defective strips.

This results from the fact that, although the larger crown of the work rolls is effective to reduce the crown of the rolled strips, the initial crown of the work rolls has to be small in order to avoid defective rolled strips having waves at the centres in the latter half of the rolling with the result that the crown of the rolled strips is too large in the initial half of the rolling and therefore irregularities in the crown of the rolled strips become larger throughout the rolling cycle.

Fig.21 illustrates the displacement of the work rolls 1' relative to the centre O of the path of the strips or plates. The "shifting distance" of the rolls is defined by the distance x from the centre O of the path of the strips to the centres of the barrels of the work rolls on both the drive and the operation side.

The shifting distance x of the rolls is stepwise increased per a predetermined number of rolled strips until the shifting distance x becomes a maximum, for example, 100 mm and thereafter is stepwise decreased per the predetermined number of the strips. A "shift pitch" is defined by the stepwise increase or decrease of the shifting distance of the rolls per unit number of rolled strips or plates in the repetition of the above displacing operations or cyclic roll displacement.

In rolling for obtaining (JIS) SPCC strips having thicknesses of 2.3 mm and widths of 935 mm, the roll displacing operation was simultaneously applied to three roll stands F3, F4 and F5 of a finishing mill having six roll stands with constant shift pitches 20 mm/2 coil, 40 mm/2 coil and 60 mm/2 coil in a cyclic system as shown in Fig.22. Fig.23 illustrates the results of the rolling.

It is clear from Fig.23 that the larger the shift pitch and the shorter the period, the gentler is the profile of the thermal crown and the smaller is the difference ΔS in roll diameter corresponding to the centres and edges of the rolled strips.

Therefore with the kind of strips capable of making the thermal crown relatively small, for example, steel strips to be rolled at relatively lower temperatures, the shift pitch should be set at a small value so as to enlarge the thermal crown in the area corresponding to the width of the strips, thereby mitigating the crown of the rolled strips.

As the number of rolled strips increases, the profile of the thermal crown varies usually as shown in Fig.24. The thermal crown or difference in roll diameter between the centres and edges of the strips depends upon the number of rolled strips or coils. This relationship is shown in Fig.25 wherein the rolling is effected with the constant shift pitch 40 mm/2 coil according to the procedure in connection with Fig.22.

As can be seen from Fig.25, the difference ΔS in roll diameter between the centres and edges varies greatly in the first and latter halves of rolling. In rolling with the work rolls being cyclically displaced, it is effective for mitigating the crown of the rolled strips to control the difference ΔS in the thermal crown in the first and latter halves of the rolling cycle as explained hereinafter.

Namely , the shift pitch is made smaller to enlarge the difference ΔS in the first half of the cycle generally exhibiting small differences ΔS, and the shift pitch is made larger to suppress the difference ΔS to a small value in the latter half of the cycle, thereby stabilising the difference ΔS throughout the rolling cycle.,

Fig.26 illustrates the difference ΔS dependent upon a variable shift pitch shown in a solid line and a constant shift pitch in a broken line. The difference ΔS is stabilised as shown in the solid line in Fig.26. The crowns of the rolled strips can be mitigated and irregularities in the crowns of the rolled strips can be reduced throughout the cycle only by providing work rolls with initial curves.

In order to obtain strips of (JIS) SPCC having thicknesses of 2.3 mm and widths of 935 mm by the use of a finishing mill having six roll stands, work roll displacement rolling was effected with the work rolls of the F3, F4 and F5 stands being cyclically shifted, while the shift pitches were varied in the first and latter halves of the rolling cycle. The results are shown in Fig.27. Fig.28 illustrates the variation of the difference ΔS. Table 1 below shows a comparison of rolled strips produced with a constant shift pitch with those produced in the above manner according to the invention in respect of the values x of the crowns of the rolled strips and the irregularities δ of the crowns.

Table 1

	Crown x of rolled strips	Irregularity δ of Crown
Prior art	48 μ	17.8
Invention	35 μ	8.2

According to this embodiment, as the difference ΔS increases rapidly in the initial half of the rolling cycle, the crown of the rolled strip can be effectively reduced. Particularly, the crown of the rolls becomes larger in an earlier period in the initial half of the rolling so as to reduce the crown of the rolled strips, and becomes constant in the latter half of the rolling so as not to produce defective rolled strips and to reduce the crown of the rolled strips.

Moreover, as the thermal crown is stabilised in the earlier period of the rolling cycle, it is possible to enlarge the convex curves of the initial crowns of the work rolls without any risk of disturbance in configuration of the rolled strips and further it is possible to reduce the crown of the rolled strips. In the prior art, such large curves of initial crowns would cause waves in the rolled strips during the latter rolling of the cycle.

As to the difference in thermal crown and hence in ΔS due to the period of rolling allowed by one pair of work rolls in the prior art, the roll initial curve should be changed every time the period of rolling or the kind of steel is changed. In contrast herewith, according to the invention the difference ΔS can be varied by changing the shift pitch. In this manner, this technique can be applied for compensating for the difference in ΔS. Accordingly, this embodiment has the advantages of enlarging the use of range of the rolls and of improving the grinding efficiency by unifying the initial curves for several kinds of steel.

Claims

1. A hot rolling method using a hot finishing mill including a pair of axially adjustable work rolls (1') each having a tapered portion (4') at one end of its barrel (4) and arranged one above the other with the tapered portions (4') being on opposite sides of the rolling path and being so axially adjustable as to locate each edge of strip material (3) to be rolled in a roll gap zone determined by the respective tapered portion (4') of one of the work rolls characterised in that, during the course of rolling a sequence of discrete lengths of strip material, each of substantially the same width, in the interval between succeeding lengths said work rolls (1') are cyclically axially displaced relative to each other within a range of displacement such that said edges of the material remain within the roll gap zone delimited by said tapered portions thereby preventing edge build-ups of the material, whereby the upper limit of the cyclical values of the distance (E_L) from an edge of the material to the transition point between said tapered portion of the work roll nearest to said edge of the material and the central portion of the roll is variably set so as to decrease as the thermal expansion of the work rolls increases.

2. A hot rolling method as claimed in claim 1 wherein said work rolls (1') are subjected to a fine displacement and simultaneously a bending action is applied to said work rolls to eliminate the bending action, acting upon the work rolls, caused by the material being rolled by said work rolls.

3. A hot rolling method as claimed in claim 2, wherein said bending action applied to said work rolls (1') is progressively increased as the distance (E_L) from an edge of the material to the starting point of said tapered portion nearest to said edge of the material is decreased.

4. A hot rolling method as claimed in any one of claims 1 to 3, wherein the axial displacement of said work rolls (1') per unit number of rolled material is varied stepwise during the rolling cycle.

5. A hot rolling method as claimed in claim 4, wherein said stepwise variation is relatively small in the first half of the rolling cycle and relatively large in the latter half of the rolling cycle.

Revendications

1. Procédé de laminage à chaud utilisant un laminoir de finition à chaud qui comprend deux cylindres de travail (1') réglables dans la direction axiale, dont chacun possède une partie à section décroissante (4') à une extrémité de son corps cylindrique (4) et qui sont disposés l'un au-dessus de l'autre, dans une position telle que les parties (4') à section décroissante se trouvent de chaque côté de l'axe de laminage et soient réglées axialement de manière à placer chaque bord d'une matière en bande (3) qu'il s'agit de laminer dans une zone de l'entrefer de laminage qui est déterminée par la partie à section décroissante (4') respective de l'un des cylindres de travail, caractérisé en ce que, pendant le cours du laminage d'une séquence de longueurs discrètes de matière en bande, dont chacune a sensiblement la même largeur, dans l'intervalle compris entre deux longueurs successives, lesdits cylindres de travail (1') sont cycliquement déplacés axialement l'un par rapport à l'autre dans une plage de déplacement telle que les bords de la matière restent dans la zone de l'entrefer de laminage qui est délimitée par lesdites parties à section décroissante, ce qui évite les accumulations marginales de la matière, la limite supérieure des valeurs cycliques de la distance (E_L) comprise entre un bord de la matière et le point de transition entre ladite partie à section décroissante du cylindre de travail qui est la plus proche dudit bord de la matière et la partie centrale du cylindre, est réglée de façon variable de manière à décroître au fur et à mesure que la dilatation thermique des cylindres de travail s'accroît.

2. Procédé de laminage à chaud selon la revendication 1, dans lequel lesdits cylindres de travail (1') sont soumis à un déplacement fin et que, en même temps, on applique un effet de flexion auxdits cylindres de travail pour éliminer l'effet de flexion agissant sur les cylindres de travail qui est provoqué par la matière en cours de laminage entre lesdits cylindres de travail.

3. Procédé de laminage à chaud selon la revendication 2, dans lequel ledit effet de flexion appliqué auxdits cylindres de travail (1') est progressivement augmenté au fur et à mesure de la diminution de la distance (E_L) comprise entre un bord de la matière et le point de départ de ladite partie à section décroissante qui est la plus proche dudit bord de la matière.

4. Procédé de laminage à chaud selon une quelconque des revendications 1 à 3, dans lequel le déplacement axial desdits cylindres de travail (1') par nombre unitaire de matière laminée est modifié par échelons successifs pendant le cycle de laminage.

5. Procédé de laminage à chaud selon la revendication 4, dans lequel ladite modification par échelons est relativement petite dans la première moitié du cycle de laminage et relativement grande dans la dernière moitié du cycle de laminage.

Patentansprüche

1. Warmwalzverfahren, das ein Warmnachwalzwerk benutzt, welches ein Paar von axial einstellbaren Arbeitswalzen (1') enthält, wovon jede einen konischen Teil (4') an einem Ende ihres Zylinders (4) hat, die eine über der anderen angeordnet sind, wobei sich die konischen Teile (4') auf voneinander abgewandten Seiten des Walzweges befinden, und die derart axial eingestellt sind, daß sie jede Kante eines Streifen-Materials (3), das zu walzen ist, örtlich in einem Walzenspaltbereich festlegen, der durch den betreffenden konischen Teil (4') einer der Arbeitswalzen bestimmt ist, dadurch **gekennzeichnet**, daß während des Verlaufs des Walzens einer Folge von einzelnen Längen des Streifen-Materials, die alle im wesentlichen von gleicher Breite sind, in dem Intervall zwischen aufeinander folgenden Längen die Arbeitswalzen (1') zyklisch innerhalb eines Verlagerungsbereiches relativ zueinander derart axial verlagert werden, daß die Kanten des Materials innerhalb des Walzenspaltbereiches verbleiben, der durch die konischen Teile begrenzt ist, um dadurch Randaufwerfungen des Materials zu verhindern, wodurch die obere Grenze der zyklischen Werte des Abstands (E_L) von einer Kante des Materials zu dem Übergangspunkt zwischen dem konischen Teil der Arbeitswalze, der der Kante des Materials am nächsten liegt, und dem zentralen Teil der Walze veränderbar eingestellt wird, um sich so zu verringern, wenn die Wärmeausdehnung der Arbeitswalzen zunimmt.

2. Warmwalzverfahren nach Anspruch 1, bei dem die Arbeitswalzen (1') einer Feinverschiebung unterzogen werden und gleichzeitig eine Biegekraft auf die Arbeitswalzen ausgeübt wird, um die auf die Arbeitswalzen einwirkende Biegekraft, welche durch das Material verursacht wird, das durch die Arbeitswalzen gewalzt wird, zu eliminieren.

3. Warmwalzverfahren nach Anspruch 2, bei dem die Biegekraft, die auf die Arbeitswalzen (1') ausgeübt wird, progressiv erhöht wird, wenn sich der Abstand (E_L) von einer Kante des Materials zu dem Anfangspunkt des konischen Teils, der der Kante des Materials am nächsten liegt, verringert.

4. Warmwalzverfahren nach einem der Ansprüche 1 bis 3, bei dem die axiale Verlagerung der Arbeitswalzen (1') pro Einheiten-Anzahl des gewalzten Materials schrittweise während des Walzzyklus verändert wird.

5. Warmwalzverfahren nach Anspruch 4, bei dem die schrittweise Veränderung in der ersten Hälfte des Walzzyklus relativ klein und in der letzten Hälfte des Walzzyklus relativ groß ist.

FIG_1

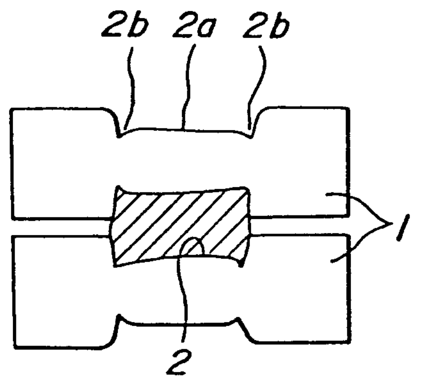


FIG_2

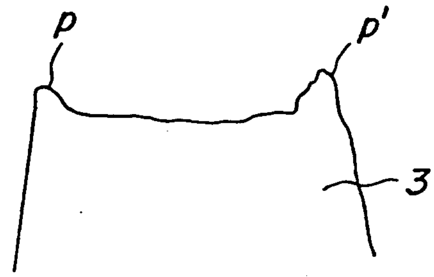


FIG_3a

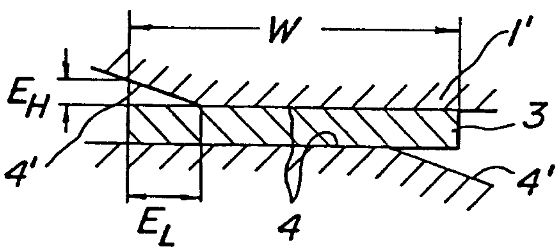


FIG_3b

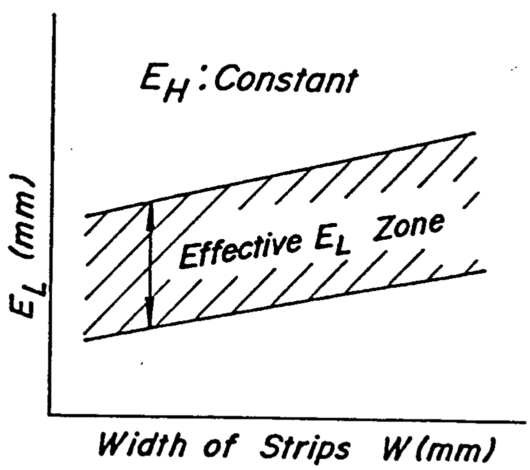


FIG_4

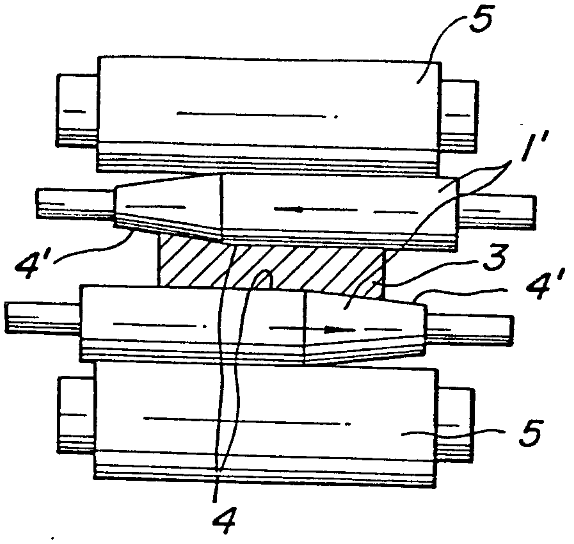


FIG_5

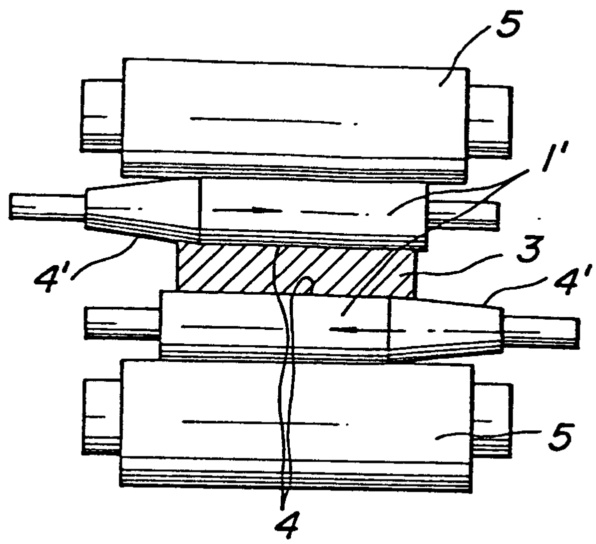


FIG_6

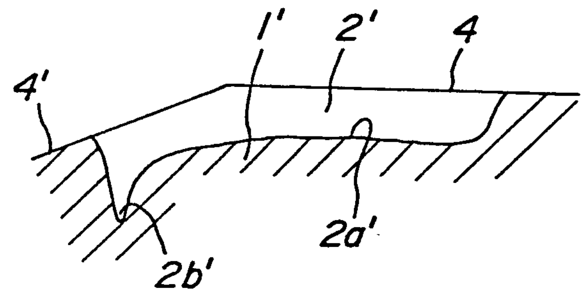


FIG_7

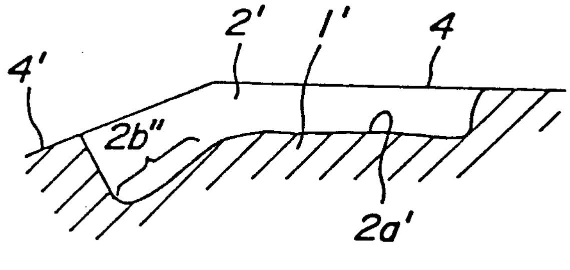


FIG_8a

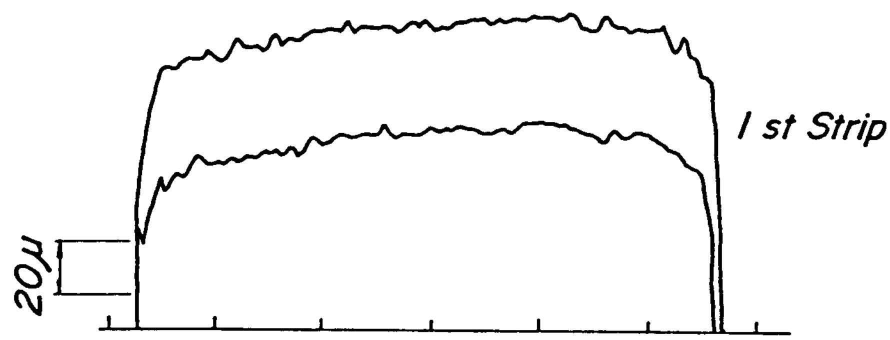


FIG_8b

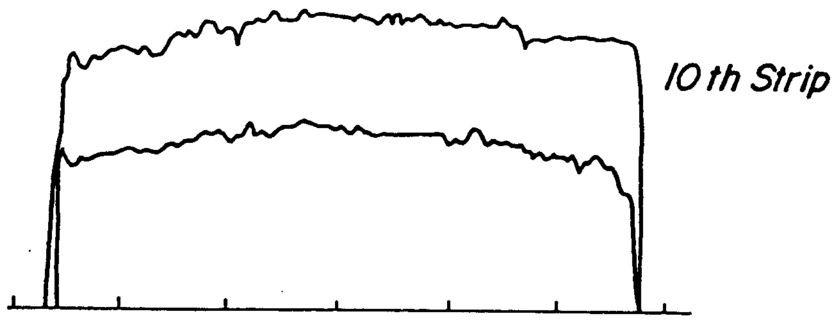


FIG_8c

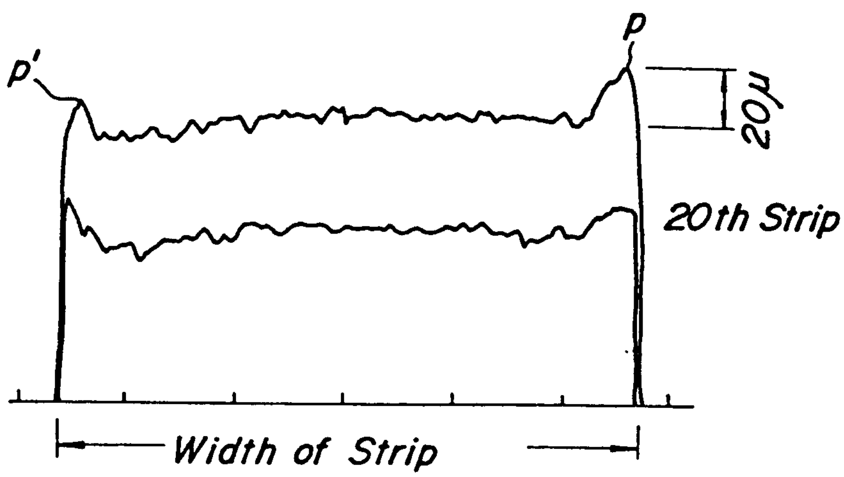


FIG_9a

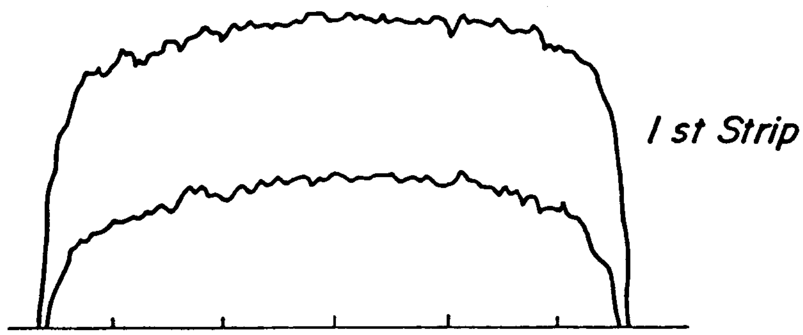


FIG_9b

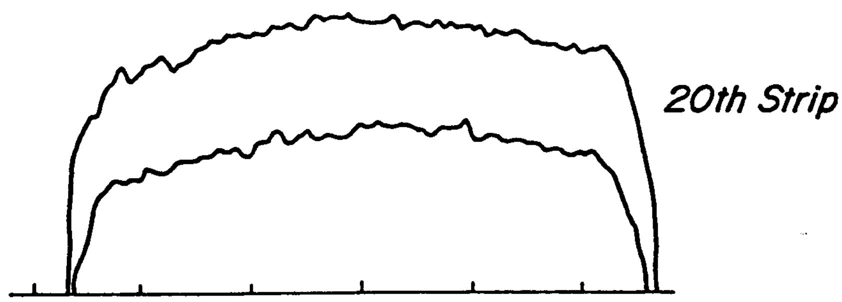


FIG_9c

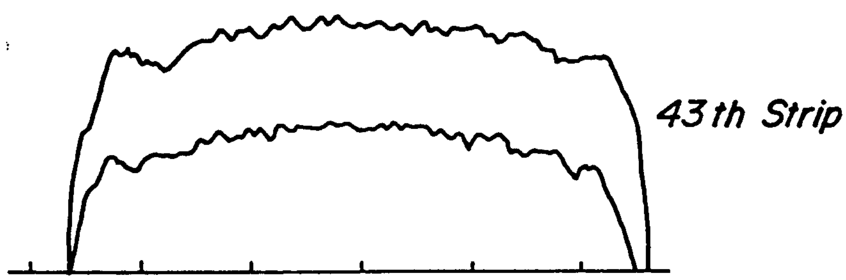


FIG_9d

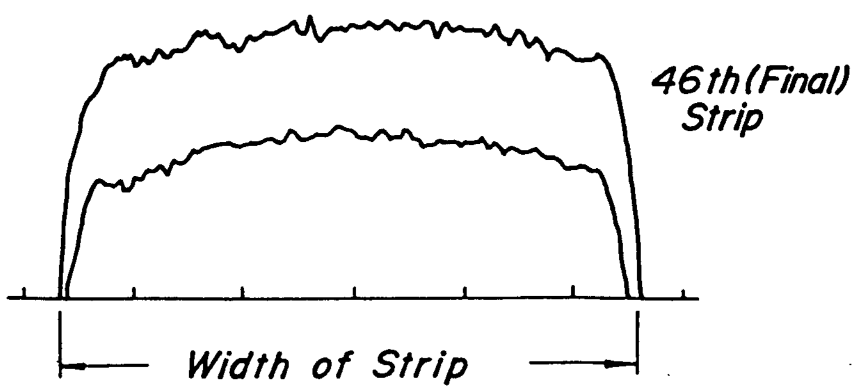


FIG. 10a

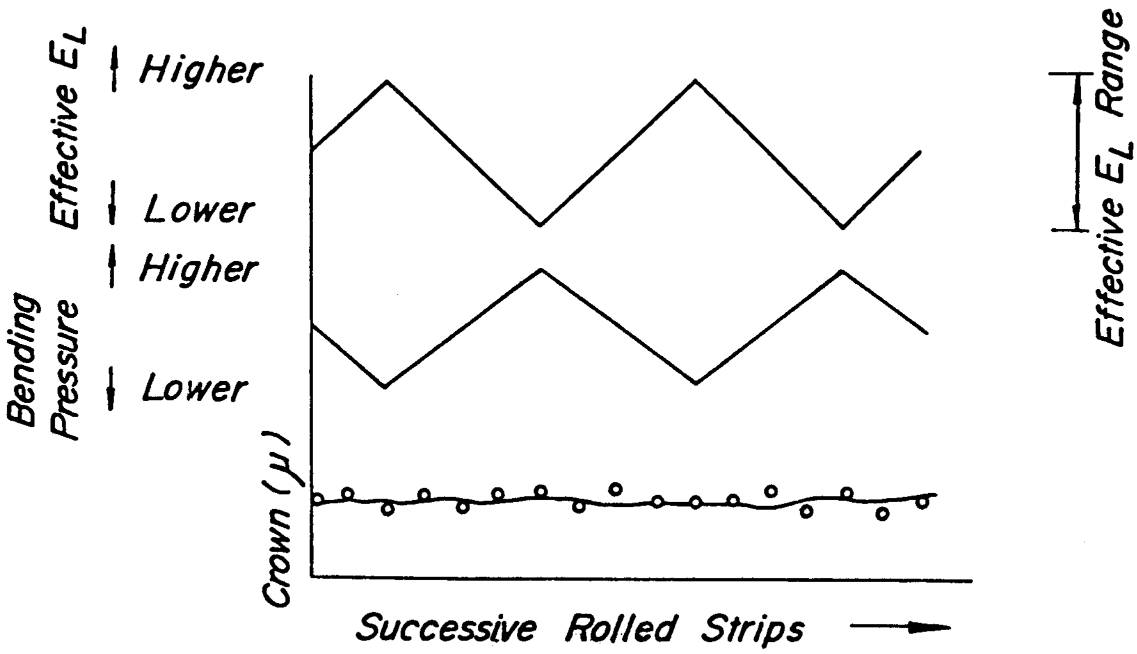


FIG. 10b

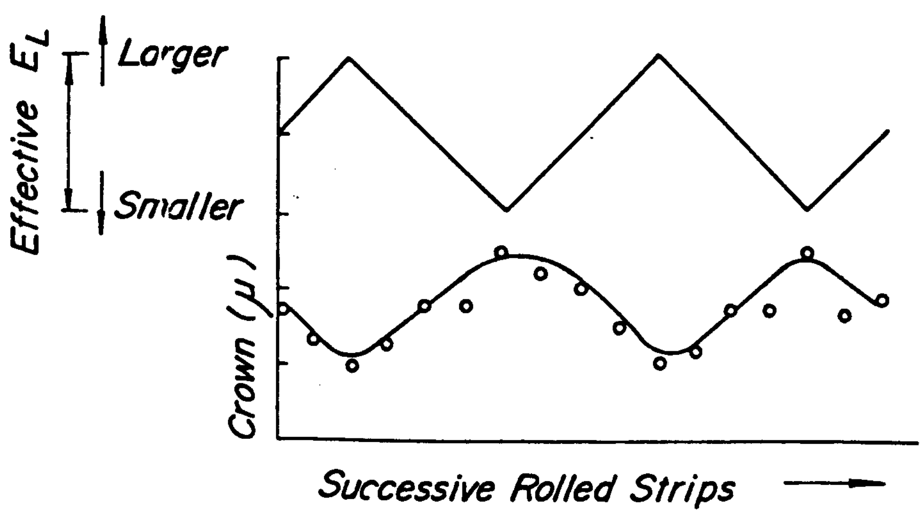


FIG_11a

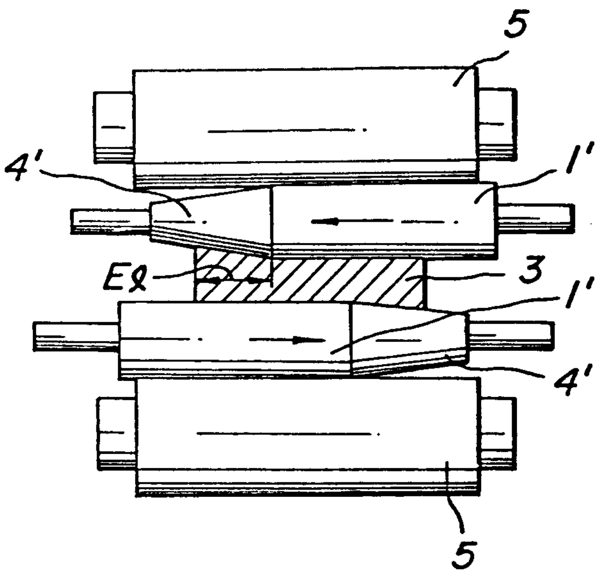


FIG_11b

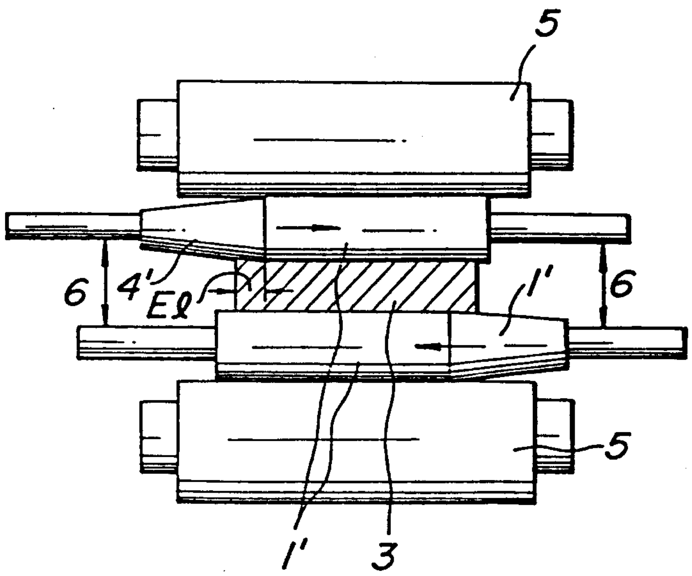


FIG_12

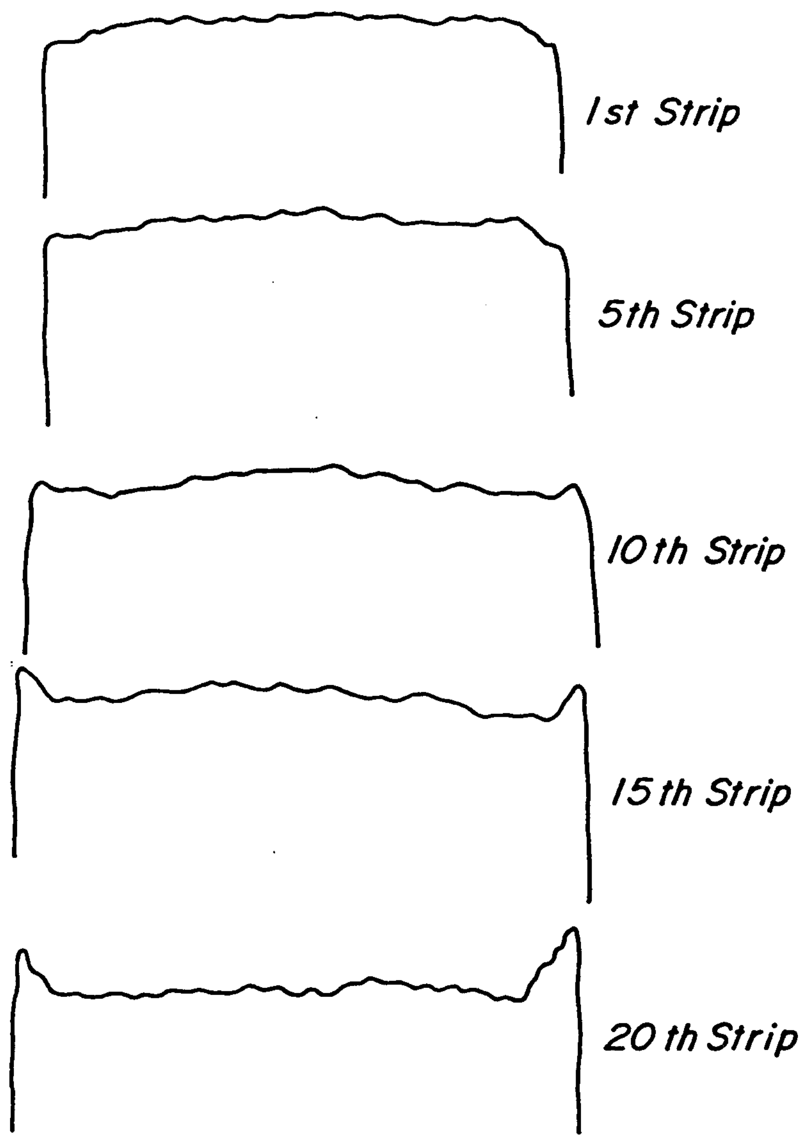


FIG. 13

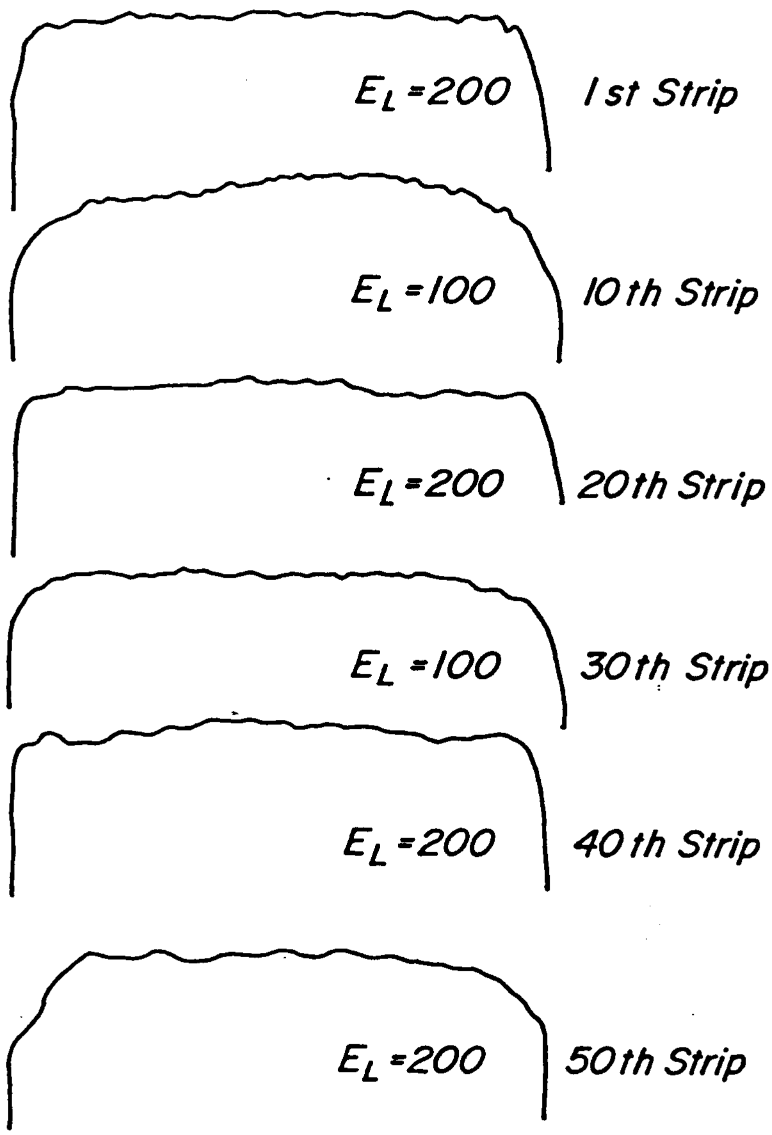

E_L=200
1st Strip
E_L=100
10th Strip
E_L=200
20th Strip
E_L=100
30th Strip
E_L=200
40th Strip
E_L=200
50th Strip

FIG_14

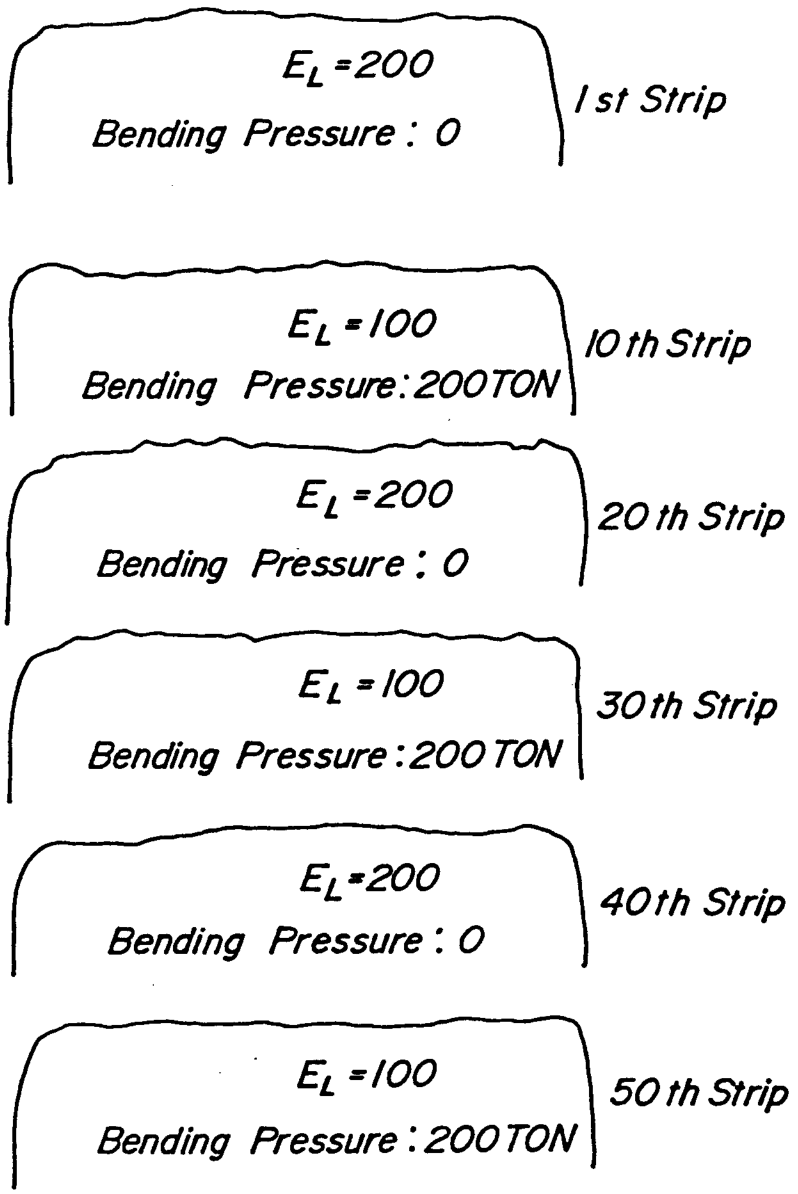
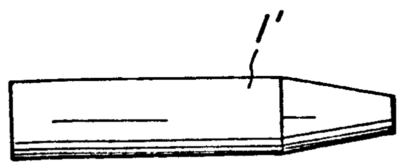
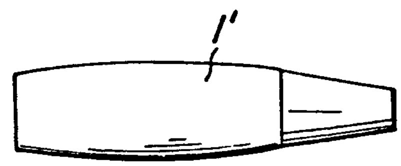

E_L =200
Bending Pressure : 0
1 st Strip
E_L =100
Bending Pressure: 200TON
10 th Strip
E_L =200
Bending Pressure : 0
20 th Strip
E_L =100
Bending Pressure : 200 TON
30 th Strip
E_L =200
Bending Pressure : 0
40 th Strip
E_L =100
Bending Pressure : 200 TON
50 th Strip

FIG_15a



(Before Thermal Expansion)

FIG_15b



(After Thermal Expansion)

FIG_16

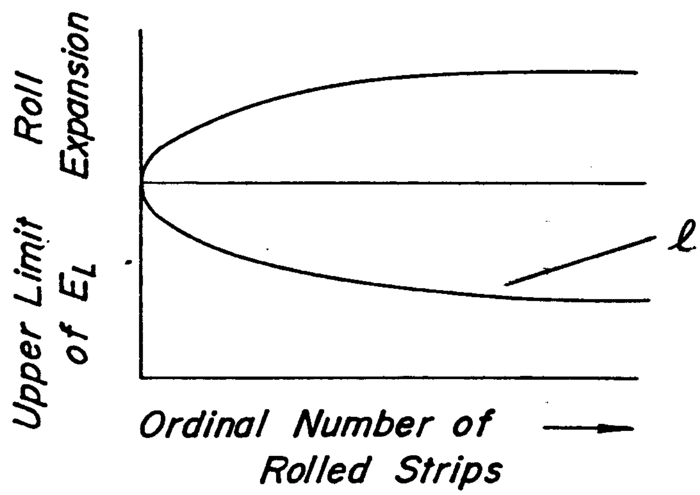


FIG_17

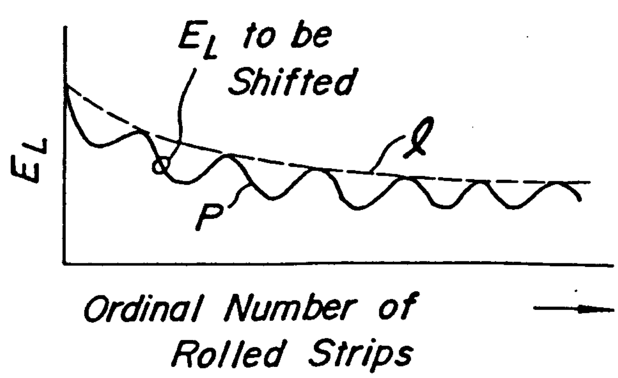


FIG_18a

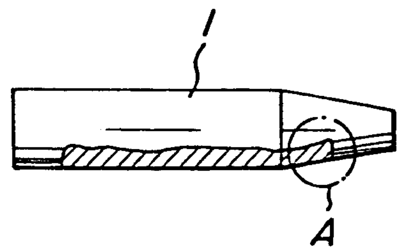


FIG_18b

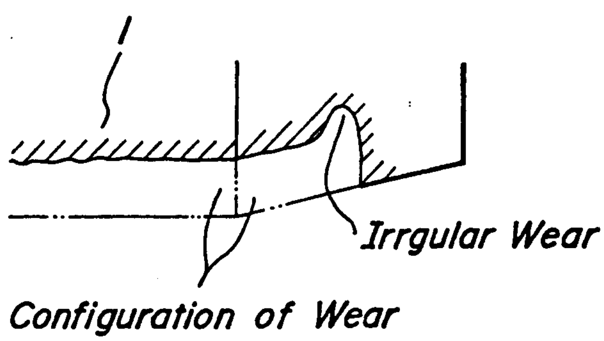
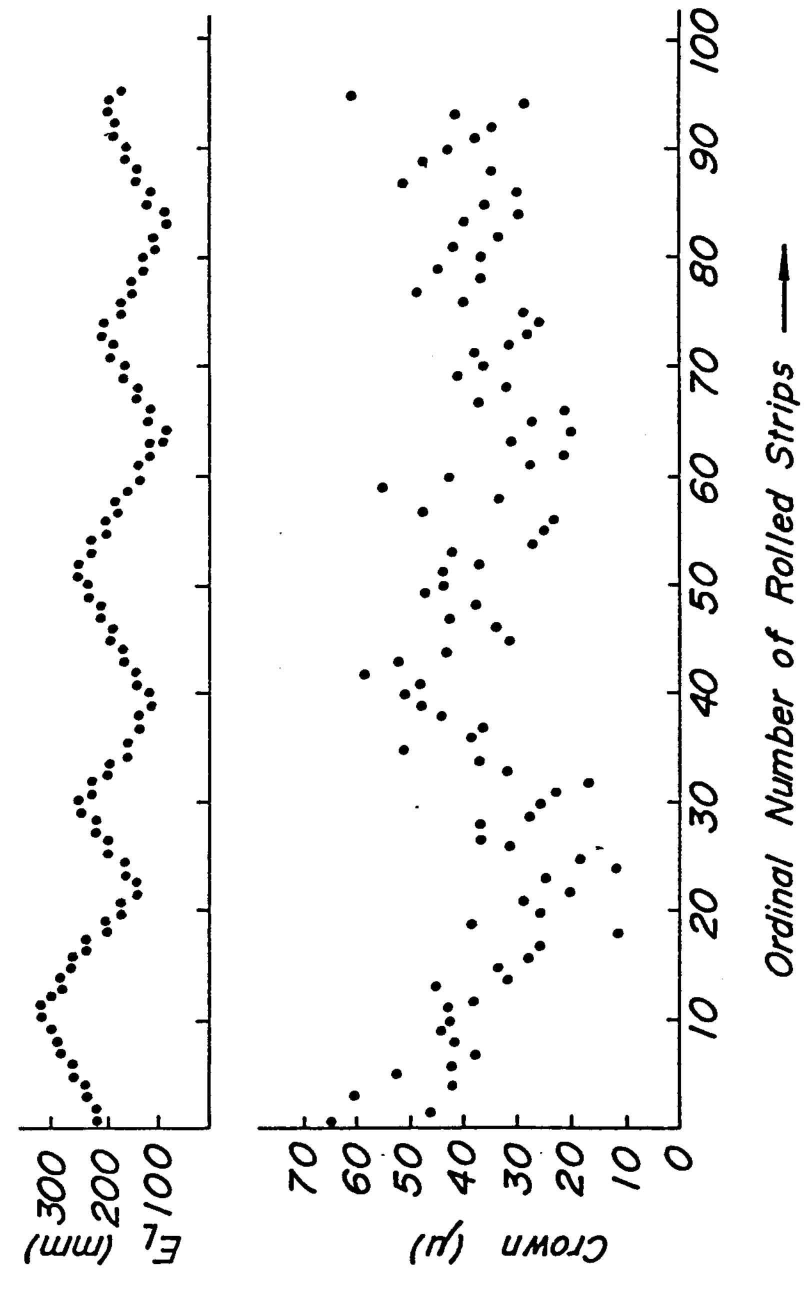


FIG_19



E_L (mm)
300
200
100
Crown (μ)
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
Ordinal Number of Rolled Strips

FIG_20a

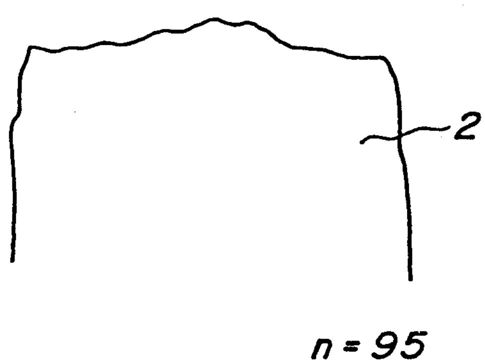


FIG_20b

FIG_21

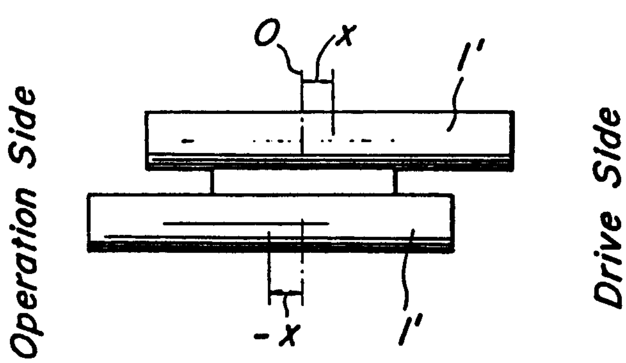


FIG.22

Material: JIS SPPC Thicknees: 2.3mm
Width: 935mm
(Finishing Mill Having Six Roll Stands Among which Three Stands F_3, F_4 and F_5 are Shifted)

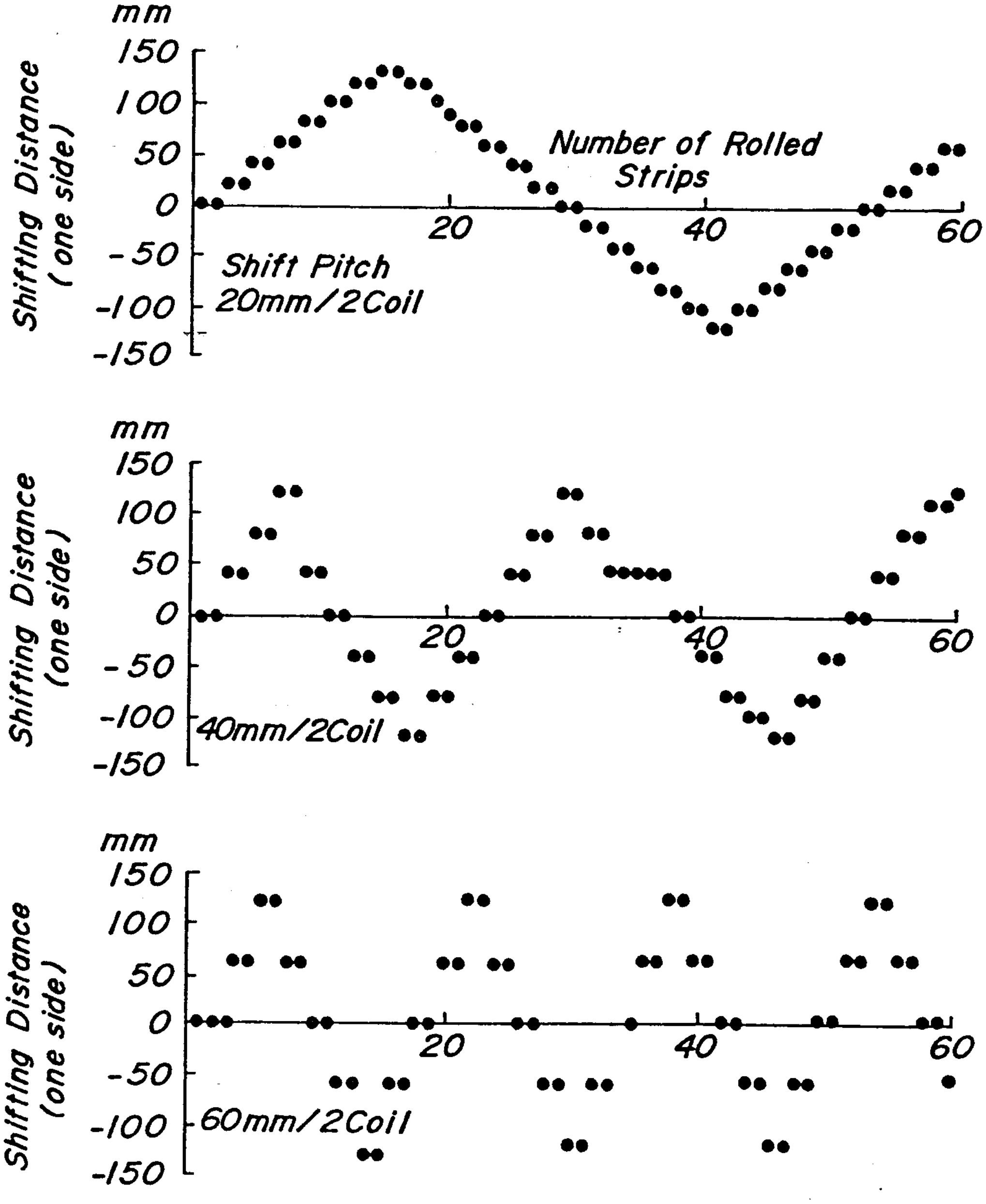


FIG_23

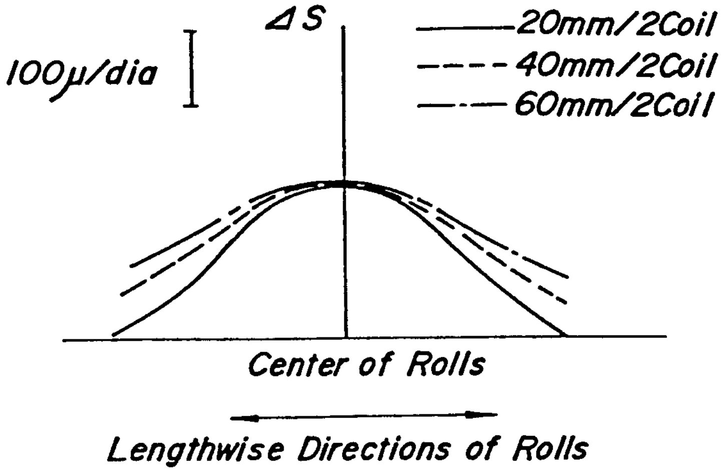


FIG_24

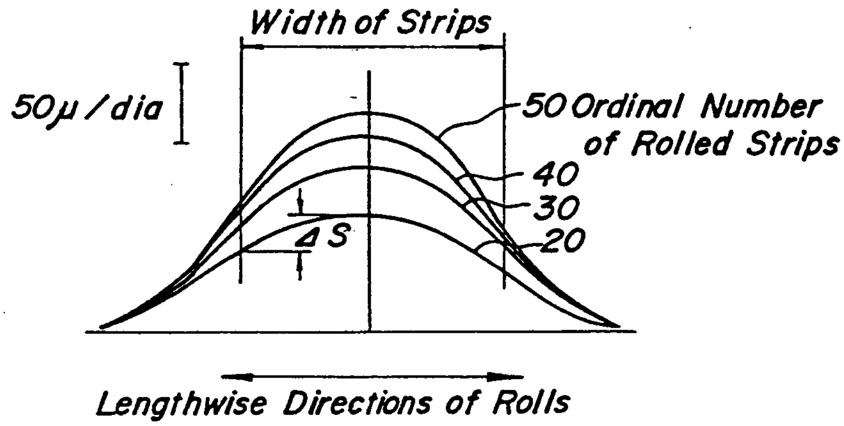


FIG_25

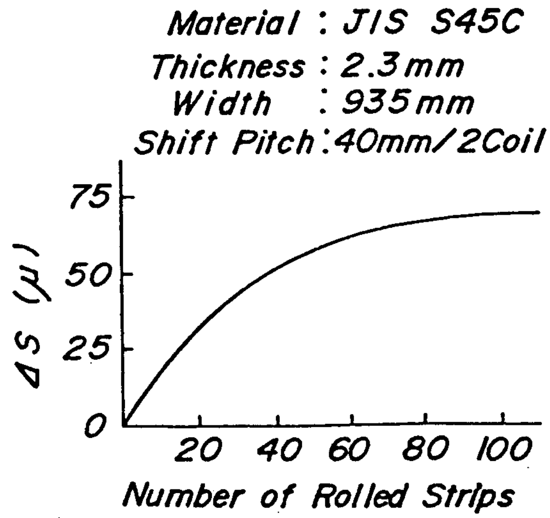


FIG_26

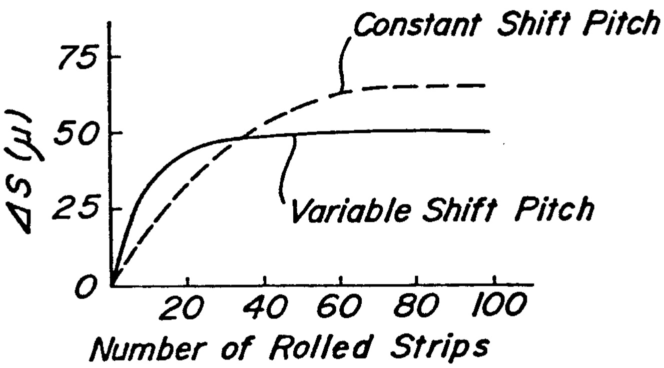


FIG_27

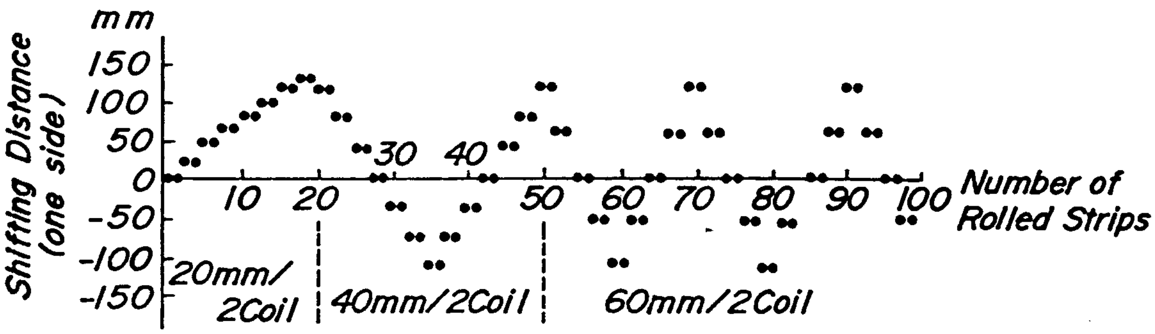


FIG_28