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CONTROL ARRANGEMENT FOR LEVEL ROLLING METAL PLATES AND SHEETS IN REVERSIBLE ROLLING MILLS

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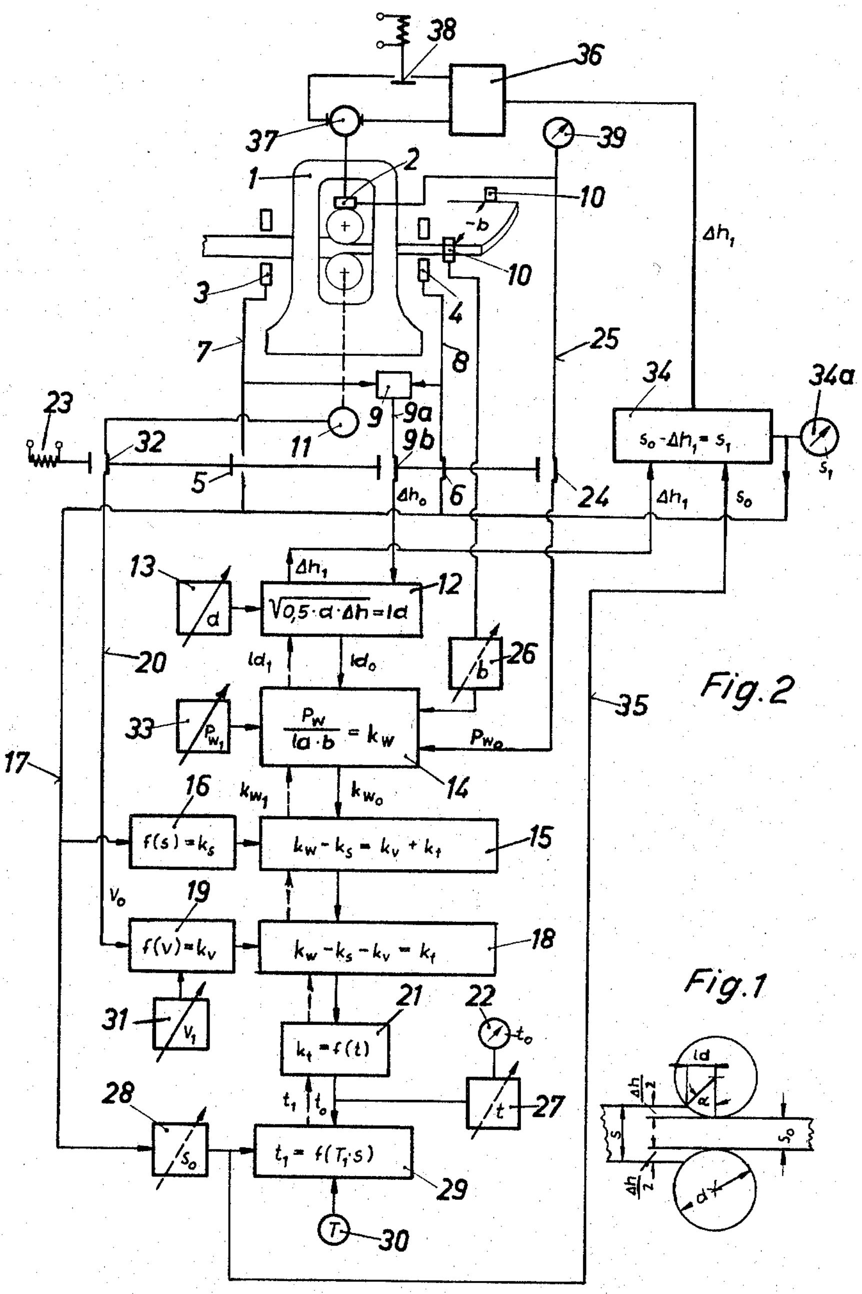
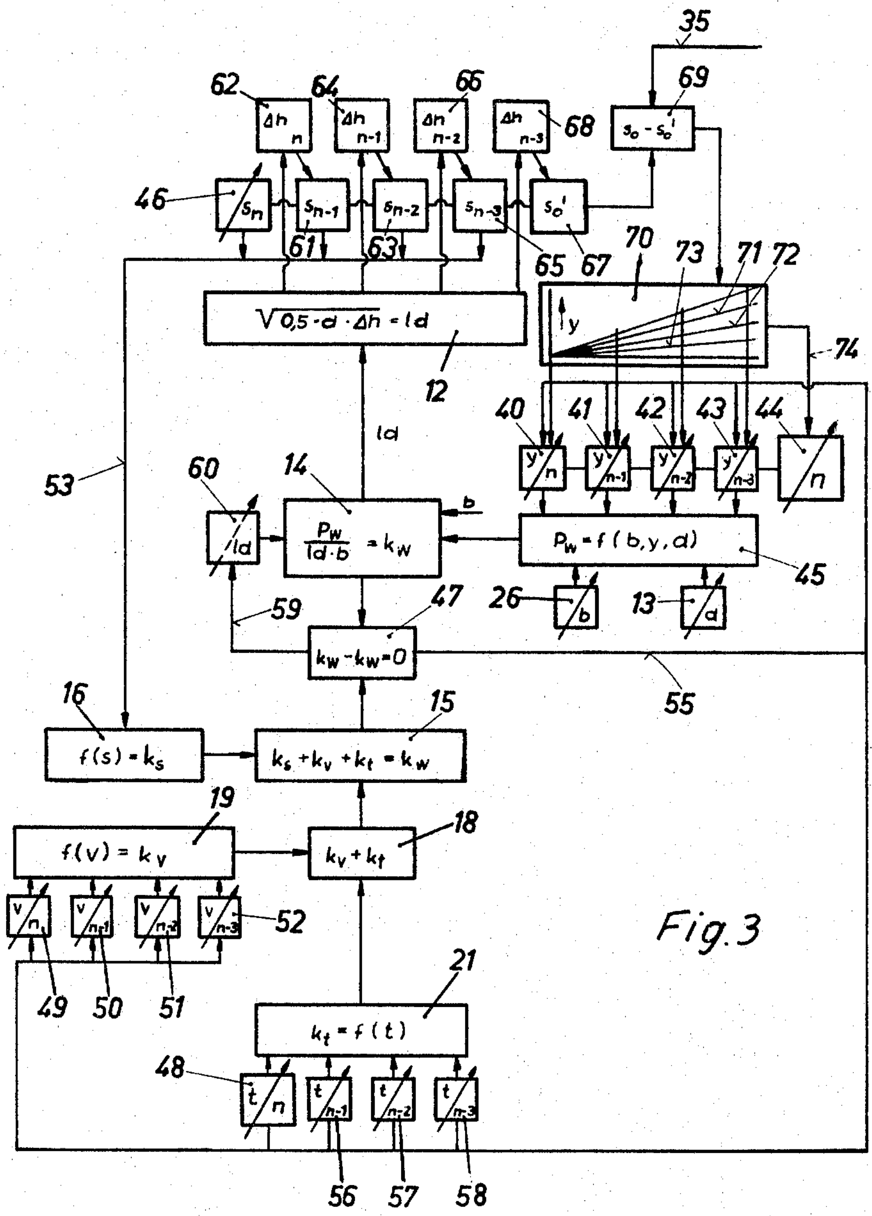


Fig. 2

Fig. 1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$\sqrt{0{,}5 \cdot d \cdot \Delta h} = ld$
ld
$\frac{P_W}{ld \cdot b} = k_W$
b
$P_W = f(b, y, d)$
$k_W - k_W = 0$
$f(s) = k_s$
$k_s + k_v + k_t = k_W$
$f(v) = k_V$
$k_V + k_t$
$k_t = f(t)$
$s_o - s_o'$

Fig. 3

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CONTROL ARRANGEMENT FOR LEVEL ROLLING METAL PLATES AND SHEETS IN REVERSIBLE ROLLING MILLS

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13 Claims. (Cl. 72—13)

The invention relates to a control arrangement for level rolling metal plates and sheets, and more particularly to a control arrangement in which the rolling action produces a correct overall flow of the rolled material to provide a level surface and an even thickness of the plates and sheets.

A correct flow control in rolling metal sheets is particularly important in the final passes so as to prevent that the rollers exert varying pressures either in the center or along the edges because of the roller deflection due to the rolling pressure. In a correct flow controlled rolling operation the sheet "flows," i.e. is stretched or pressed uniformly over its entire width.

It is in the nature of the product, namely the flat metal sheet, that during rolling between flat rollers the sheet has a tendency not to come out straight with respect to the mill. The sheets are thus rolled by conducting them centrally of the groove caused by the deflection of the work rollers. The metal sheet has thus a greater thickness at the center than at the edges. For this reason it is necessary to apply smaller rolling pressures during the final passes in order that the roller deflection becomes smaller and to have a metal sheet which comes out of the last pass with surfaces which are as much as possible parallel to each other. Even in the final pass some deflection of the smooth rollers will occur so that even in the case of hot rolled metal sheets there is always a greater thickness in the center than along the edges, even if it is only a few hundreds of a millimeter.

In the last series of passes it is therefore necessary to consider, aside from adjusting the amount of reduction to be rolled, also the need for a lower pressure in order to carry out the final pass with a predetermined rolling pressure at which the roller deflection, considering a certain camber in the grinding of the rollers, would produce only a very small guide groove. For this reason it has been the practice for the operator to set the reduction during the final series of passes with decreasing values according to a previously determined pass schedule, but largely according to his own judgment in the expectation that with this reduction the rolling pressure would also drop. But this is not always the result, considering for example the case where between two passes an extended pause may occur during which the rolled material cools down. Consequently the material would have a higher specific deformation resistance so that in spite of a decreased reduction relative to the previous pass, the rolling pressure predetermines the roller deflection and the formation of the groove is the same or larger than in the previous pass. Only experience and good judgment of the operator can produce a good result with the operating methods practiced hitherto.

A particular difficulty resides in the fact that the rolling pressure should not drop linearly in a uniform manner, but that it should drop relatively more during the first passes of the last series of passes, and less during the final pass because the rolling action takes place only in that case with a correct flow control and without the formation of folds. It is practically impossible for the operator to correctly observe the curve according to which the

rolling pressure should drop merely by actuating the adjusting device, thus by reducing the passes.

Accordingly it is an object of the invention to make the flow controlled rolling independent of the experience or judgment of the operator by means of a novel electronic control arrangement.

Control arrangements are already known in which during the rolling operation the rolling pressure, the thickness of the reciprocating metal sheet and the width of the sheet are measured and are used as basis for the pass reduction in the subsequent passes, wherein the values are derived during the rolling operation from sample sheets and merely serve for the subsequent controlled rolling of the sheets having the same dimensions and of the same quality steel. The meaning of the term "pass reduction" as herein employed signifies the amount by which the thickness of the rolled sheet is reduced with each pass, as indicated in FIGURE 1 at Δh. But it is known that in mills for rolling coarse stock varying end thicknesses are often rolled from one sheet to the next. It is therefore another object of the invention to derive from the measurement values of an existing guide pass the pass reduction for the subsequent pass of the same sheet according to a predetermined rolling pressure schedule.

The control arrangement of the invention includes also the continuously increasing deformation resistance of the sheet during cooling so that in the calculated pass reduction also the cooling during operation stoppage between two passes is taken into consideration.

Instead of introducing the decreasing rolling pressure according to a predetermined rolling pressure schedule, the control arrangement of this invention proposes to determine the rolling pressure by introducing the width of the sheet according to a predetermined schedule of the roller deflections which decrease toward the last pass, wherein the pass reductions are pre-calculated for the passes which follow the guide pass, and whereby a check is made to see if the sum of the pass reductions corresponds to the difference between the cross-sectional sheet thickness s_o measured in the guide pass and the desired final thickness s_n of the sheet.

In case of a deviation the pre-calculation is to be repeated with a different characteristic of roller deflection or a different number of passes in the last series of passes until the difference s_o-s_n corresponds to the sum of the pass reductions.

The invention comprises also a method of operating the novel control arrangement according to which the precalculation of the last series of passes is repeated with each pass of this series while decreasing the set number of passes.

The invention is described hereafter by way of examples, but without limitation thereto, in conjunction with the accompanying drawings showing the control arrangement in the form of block diagrams and in which:

FIG. 1 shows a rolling process and illustrates clearly the significance of the symbols employed in the formulas given in this description;

FIG. 2 shows a block diagram of a control arrangement for determining the pass reduction of the passes following a guide pass based on a predetermined rolling pressure; and

FIG. 3 shows a block diagram of the same control arrangement for calculating a pass series after the introduction of the characteristics of the desired course of the roller deflection.

The mathematical basis for the control arrangement of the invention is the so-called Eckelund formula

$$P_w = l_d.b.K_w$$

in which

$$l_d = \sqrt{0.5.\Delta h.d}$$

In this formula P_w is the rolling pressure. The value l_d is the so-called "pressed length" which may be seen from FIG. 1 and depends on the roller diameter d and the reduction Δh according to the formula given here. The sheet width b is also variable, even when the rolling operation is started with the slabs having the same dimensions, because during the first passes not only longitudinally pressing passes are carried out, but after turning the slab by 90° transversely pressing passes are also made, so that the width is not always the same at the beginning of the final pass series. The value K_w is the specific deformation resistance of the work material and depends on the thickness s of the work material, the rolling speed v and the work material temperature t. It is equal to the sum of the existing specific deformation resistances K_s (influence of the outlet thickness s of the work material), K_v (influence of the work material speed v) and K_t (influence of the rolled material temperature t). The course of the values of the existing specific deformation resistances as functions of s, v and t is obtained from known values. The values increase with the increase of the rolling speed and with the reduction of the outlet thickness s and temperature t. We have thus:

$$K_w = K_s + K_v + K_t = f(s) + f(v) + f(t)$$

From FIGURE 1 we obtain for a subsequent reverse pass additionally

$$s_o - s_1 = \Delta h$$

The control diagram illustrated in FIGURE 2 is designed for the purpose of determining, at the beginning of the final pass series in which a decreasing rolling pressure speed w is applied, the values P_w, Δh and b by measurements and to derive therefrom the specific deformation resistance K_w of the particular sheet. Conversely the reduction Δh_1 of the sheet for the subsequent pass is calculated from the probable K_w-value for the subsequent pass and from the predetermined rolling pressure over the pressed length l_d. The width of the rolled material b remains the same because in this instance no widening passes are carried out.

The operation of the control arrangement illustrated is as follows:

The frame **1** of the reversible mill is provided with the pressure gauge box **2** for measuring the rolling pressure P_w. Thickness measuring devices **3** and **4** are mounted on both sides of the frame and in each case only the measuring device which lies behind the frame in the rolling direction will feed its value into line **17**. This is obtained by alternately connectible contacts **5** and **6** in lines **7** and **8**. In the case illustrated, in which the sheet is rolled from left to right, contact **6** is closed and contact **5** is opened, so that only the measured value of the thickness gauge **4** is relayed as absolute value. In a comparison device **9** the difference Δh_o between the measurement values of the thickness gauge devices **3** and **4** is obtained, which is introduced over line **9a** and closed contact **9b** into a calculator **12**. A width gauge **10** which is illustrated only schematically and which operates appropriately by a photoelectric scanning of the sheet edges, may be disposed on either side of the frame, and furnish continuously measurement values, as the sheet width does not change for several passes upon starting the control for carrying out the last pass series. After a speed increase of the rollers the rolling speed v is taken from the number of revolutions of the rollers and is calculated and indicated in device **11**.

The effect of the control is the following: The derived reduction Δh_o from comparison device **9** enters calculator **12** into which the roller diameter d is also fed from the adjusting device **13**. In calculator **12** the pressed length l_{do} is calculated according to the formula indicated above and fed to calculator **14**. The sheet width b from measuring device **10** and the existing rolling pressure P_{wo} from pressure gauge box **2** are also fed to this calculator. The specific deformation resistance K_w of the just worked sheet is calculated from these values according to the formula indicated and is fed to a device **15**. A function element **16** is associated with calculator **15** and the outlet strength s_o from the thickness measuring device is introduced into this element over line **17**. It furnishes the existing deformation resistance K_s depending on the sheet outlet thickness s_o according to the function $f(s)$, which is introduced into the device according to known values. In the device **15** K_s is deducted from K_w so that at rest the two existing values $K_v + K_t$ are obtained. This sum is conducted further into the device **18** in which the existing deformation resistance K_v based on the rolling speed is deducted. K_v is furnished by the function device **19** into which the rolling speed V_o passes over line **20** and into which the dependence value $K_v = f(v)$ is fed.

From device **18** the rest value K_t goes into the function element **21** into which the dependence $K_t = f(t)$ is fed so that the work material temperature t is eliminated at the outlet and may be read on the indicator **22**. In this respect the calculator system is employed also to determine the actual temperature of the work material.

From this point on all the calculations are directed to determining through the k_w-value which is correct and changed for the subsequent pass and through a smaller rolling pressure a new reduction Δh_1. The k_w-value changes due to cooling of the metal sheet which depends on the time t between the two passes and the sheet thickness s.

After a measurement value for temperature t is available the same instruments may be employed for the reverse calculation in a second calculating operation only when the flow of the first calculating operation in the direction described so far is interrupted. While the sheet is still being worked this is obtained by actuating a solenoid **23** for the contacts **5**, **6**, **9b**, **24** and **32** in such a manner that the lines **8** for the value s, **9b** for Δh_o, **25** for the value P_w and **32** for the value V are interrupted without closing line **7** of gauge **3**. But some values must be retained or stored for the reverse calculation such as the sheet width b in device **26**, temperature t in device **27** and the initial thickness s in device **28**. The measured temperature t_0 of the guide sheet is fed into calculator **29** which in reference to the time and the measured s_o-value feeds a continuously decreasing temperature value t_1 into the calculator **21**. The time factor is introduced by a timing device **30** into the calculator **29** while the value s_o is introduced through device **28**. The value s_o remains constant until the beginning of the following pass, thus until a new measurement value which must come from the gauge **3**.

The continuously decreasing temperature value furnishes in device **21** a new higher K_t-value which is fed into device **18** . For the following pass a greater rolling speed V_1 is employed which is set at the adjusting device **21** and fed into the function device **19**. This device furnishes a new and increased K_v-value which is processed in device **18** and forms at the outlet a new value $K_v + K_t$ fed to the calculator **15**. Since in the first calculating pass a new sheet thickness s is not yet available, rather the original K_s-value is present, a K_{w1}-value is fed from calculator **15** into device **14** which value is corrected only in view of the decreasing temperature and the increased rolling speed.

With the new value K_{w1} a new l_{d1} value is calculated in device **14** from the available sheet width b from device **26** and from the pre-selected decreased rolling pressure P_w from the adjusting device **33**. The device **12** derives now from the introduced value l_{d1} a new reduction Δh_1. However, this value cannot be correct yet because the existing deformation resistance K_s has not been changed yet. In order to obtain a provisional new outlet thickness s_1 for the following pass Δh_1 is fed to a calculator **34** into which through a line **35** also the outlet thickness s_o retained by device **28** is introduced by the running pass. The difference $s_o - \Delta h_1$ is formed in device **34** which provides the new approximate sheet thickness s_1 which is indicated in device 34*a*. The value s_1 is fed into line 17 and furnishes now over the function device 16 a new value K_s which is introduced into device 15 and after being added to the constantly received values K_v+K_t, of which K_t changes constantly under the influence of the running time factor, is added thereto and provides an improved value K_{w1}. After repeating the calculating processes in devices 14 and 12 an improved value Δh_1 is obtained and over device 34 an improved value s_1, which in turn causes a new calculating operation through device 16. To the extent that the calculating operations are constantly repeated in circuits 17, 16, 15, 14, 12 and 34 a correct reduction Δh_1 is derived in a constantly approaching manner for the subsequent pass. From the differential device 34 the reduction Δh_1 is fed to device 36 for the following pass. This value Δh_1 which changes mainly due to the influence of the constantly running time factor determines in device 36 the number of the revolutions for the adjusting motor 37 which is operated through switch 38. The value Δh_1 may change under the influence of the running time factor until starting the rolling of the work material in the reverse pass, but thereafter is blocked in a manner not shown in detail. The actual reduction Δh_1 is equal to the adjusting value of the upper roller when working always with the same rolling pressures since the reduction in the previous guide pass is determined with the frame under load so that the roller gap is eliminated. Due to the decreasing rolling pressure which takes place during this process a correction factor may be determined in the adjusting device 36 in a known manner not shown in detail. This correction factor is comparatively the same as the decreasing roller gap and corrects the reduction Δh_1 determined for the following pass to a smaller adjustment than Δh_1. Accordingly the difference between two rolling pressures $P_{w0}-P_{w1}$ from device 33 and the spring constant of the frame would have to be introduced into the adjusting device 36.

In the case where the functions introduced into devices 16, 19, 21 and 29 are correct the rolling pressure which was pre-selected at 33 must be shown at the indicator instrument 39. If this is not the case the reason for this can be, aside from the exactness in collecting the measurement values, only in that roller wear has occurred or that the roughness of the rollers is changing. As only small deviations are expected in this respect it is possible to adjust during the rolling operation the value for the roller diameter set at 13 also while the work material passes between the rollers in order to obtain the pre-selected rolling pressure at 39. As the diameter of the rollers and their surface conditions changed only slowly such corrections will be necessary only from time to time. On the basis of test values one could also consider a change of the value in device 13 from pass to pass in very small magnitudes automatically.

During the second pass and after carrying out any necessary corrections at device 13 the solenoid 23 is so actuated that switches 5, 9*b*, 24 and 32 are closed while switch 6 remains open. In this manner the running pass is again a guide pass for a subsequent third pass.

The operation described so far forms the basis for further automation especially in view of the fact that the relationship between the pre-selected, decreasing rolling pressures and the consequently decreasing roller deflection depend up to an extended parallel condition of the roller jacket lines in the rolling gap on the sheet width. In this respect it should be understood that with the same rolling pressure the rollers will exhibit a greater deflection the smaller the sheet width. In the case of a narrow sheet width the rolling pressure acts more as a point load and in the case of a greater sheet width more as a stretch or area load. The goal should therefore be that after the first guide pass the last desired rolling pressure is determined in reference to the sheet width *b* which varies from sheet to sheet, under which pressure the roller deflection

forms the smallest possible groove, thus rolling a finished sheet with optimum tolerance throughout its width.

In reference to FIGURE 3 a control diagram is shown which is necessary as a supplement to the diagram of FIGURE 2 when after a guide pass it is desired to change to a determination of the reductions going backwards from the last pass. The guide pass is still necessary in order to retain the values of the sheet width, the temperature and the rolling speed, because the temperature and the rolling speed must be determined for the last pass according to the novel process.

The control arrangement of FIGURE 3 corresponds to the devices of FIGURE 2 with regard to the calculating devices 12, 14, 15, 16, 18, 19 and 21. The starting point for the calculations are the values of the roller deflection Y which beginning at the last pass with the index "*n*" have the smallest value and which are set in the example illustrated up to the fourth last pass by the index "*n*—3" at the devices 40–43. Depending on whether the guide pass goes to the right or to the left the number *n* of the passes following the guide pass is also set in the device 44 so that the work material is rolled in the final pass to the exact point without requiring an empty pass. In setting the number of passes *n* in device 44 it is determined also how many of the devices 40–43 are to furnish the values.

At the beginning the minimum roller deflection Y_n is fed from the device 40 into a function device 45 in which the rolling pressure is calculated as function of the sheet width *b*, the roller diameter *d* and the roller deflection Y. The sheet width *b* is furnished by device 26 of the arrangement of FIGURE 2. The rolling pressure calculated for the last pass is fed into calculator 14 into which the sheet width *b* is also introduced. The pressed length l_d which is initially set at random is fed from the adjusting device 60 into device 14.

In the device 14 a K_w-value is derived which is fed into a differential device 47 where it is compared with a K_w-value derived from devices 15, 16, 18, 19 and 21 in the manner described above in order to determine the value for the final pass *n*. The end temperature t_n is set in device 48 with a free selection and is fed into device 21 in order to determine the existing deformation resistance K_t. Also the rolling speed must be set according to the number of passes by means of devices 49, 50, 51 and 52. During the first calculating process the value V_n is taken from device 49 and the pertaining K_v-value is calculated in device 19. From the previously set desired value of the sheet thickness s_n which comes into device 46 through line 53 the K_s-value is calculated in device 16 and fed to device 15.

In the case where the comparison of the K_w-values in device 47 produces a difference which deviates from zero an impulse is fed to the adjusting device 60 and changes the pre-selected value l_d taken there at random in a direction corresponding to the sign of the deviation until through device 14 a K_w-value is fed into the comparison device which is equal to the value in the device 15. At the same time the value l_d is fed into device 12 in which the reduction Δh_n of the last pass is calculated which is fed into the device 62.

As soon as in device 47 the difference which is equal to zero is set, a pulse is fed through line 55 to the adjusting device 41 for the ruler deflection Y_{n-1} of the next to the last pass in order to feed now this value for the following calculation to device 45. While this takes place the value Y_n from device 40 is cancelled. The pulse in line 55 which initiates the determination of the values for the next to the last pass is also fed to the adjusting devices 49–52 in order to cancel the value from 49 and to feed the value from 50 together with V_{n-1} into device 19. Furthermore adjusting devices 56, 57 and 58 are provided in front of device 21 in which the temperature differences are pre-set from pass to pass and in which during the second calculating process the temperature t_{n-1} is taken from device **56**. In order to consider the sheet thickness during the determination of K_s in the function device **16** the sum which represents the next to the last sheet thickness s_{n-1} is determined from the desired thickness s_n in device **46** and the already determined reduction Δh_n in device **61**. This value is fed to the device **16** during the second calculating process.

After determining the K_w-value a zero difference cannot exist now in calculator **47** because the new rolling pressure calculated which pertains to the next to the last pass is still coupled in device **14** with the previous l_d-value. The difference which is obtained again from device **47** is conducted again over line **59** to device **60** in which the pressed length l_d is adjusted until the value fed into device **14** leads to a K_w-value which corresponds to the K_w-value from devices **15**, **18** and **21**. With the adjustment of the value l_d in device **60** the device **14** furnishes to device **12** the l_d-value which approaches a border value and from which now the reduction Δh_{n-1} of the next to the last pass is calculated and conducted to device **64**.

As soon as any values are obtained in devices **64** or **63** the previously adjusted fixed values for the imaginary second to the last pass is taken off in a conventional manner not described in detail by a feed back coupling from devices **42**, **57** and **51** with the index "n—2." A new reduction Δh_{n-2} is finally obtained at **66** and in device **65** a new sheet thickness s_{n-3}. In a corresponding manner the reduction Δh_{n-3} is obtained after a fourth calculating process in device **68** and in device **67** the sheet thickness s_o' is derived before the fourth last pass.

In the case of an assumed pass number $n=4$ the value s_o' would have to be equal to the outlet thickness s_o of the running guide pass when the course of the Y-values which determine the rolling pressure has been correctly set over the four imaginary passes. In order to control this s_o' is compared in device **69** with the s_o value available from line **35**. The difference is fed to a function device **70** into which various functions of y depending on the number of passes are fed, as the four lines in FIGURE 3 indicate. y_n, which is the permissible deflection of the rollers in the last pass, must be constant as starting point. Depending on whether the difference s_o-s_o' is positive or negative a function different from the original function is set in the function device **70** by means of a signal from device **69**. In the case where the original function was set along line **71** and the difference s_o-s_o' is positive the calculated reductions are too large i.e. another function of y must be set which represents smaller deflection values for example the function along line **72**. With these y-values the pre-calculation is repeated and in certain cases repeated several times until with a difference s_o-s_o' is zero the correct function of y is set. The resulting values for the rolling pressures P_w in device **45** represent then the correctly decreasing rolling pressure for the adjusting device **33** shown in FIGURE 2.

Into the function device **70** only functions of y between two border values may be introduced as each course of y or P_w must satisfy the requirement for a correct flow adjusted rolling operation. In the case where a large difference s_o-s_o' exists it is possible that from **69** no flatter or no steeper course of y may be set over n, $n-1$, $n-2$, $n-3$ at device **70**. In that case the number of passes must be changed.

For this purpose a connection **74** is provided from the function device **70** to the adjusting device **44** for the pass number n. Over this line the difference s_o-s_o' is conducted to **44** in case it is too large in order to be able to adjust at **70** another one of the introduced functions of y. If for example at **70** the border value function according to line **73** is set and s_o-s_o' is still positive it is possible to reduce the sum of the reductions Δh only by a reduction of the number of passes in order to obtain a smaller s_o'. This is obtained through device **44** by means of a signal from device **70** when this device can no longer process a pulse which it has received.

In device **44** the pass number is adjusted appropriately by an even number, at least by 2, so as to avoid an empty pass. In the assumed case the values at **42** and **43** and correspondingly at **57**, **58** and at **51**, **52** would be cancelled. As the temperature of the guide pass is available from device **27** in FIGURE 2 and since now only a temperature drop over two succeeding passes needs to be considered the values at **48** and **56** should be corrected simultaneously.

A new calculation with only two remaining passes will produce at **69** a negative difference s_o-s_o' as at **70** the function according to line **73** is still set, and this difference causes at **70** a larger value y_{n-1} in that a function of y with a steeper characteristic is set until the difference is equal to zero. The rolling pressures P_w derived at **35** are conducted into the adjusting device **33** shown in FIGURE 2.

The device **70** changes thus within permissible limits ultimately the rolling pressure course within a predetermined number of passes without deviating from the principle of a correct flow adjusted rolling. Only when the values conducted to device **70** are "out of range" for this device they are conducted into device **44** in order to change the pass number.

The values derived from the pre-calculation according to FIGURE 3 may be used in various ways for further rolling operations. First of all it is possible to store from devices **62**, **64**, **66** and **68** the reductions in device **36** of FIGURE 2 and to employ them before each reversing step of the rolling operation. But as indicated above the values P_w for the rolling pressure may be supplied from device **45** and fed according to need to the adjusting device **33** of FIGURE 2. In this case the rolling mill is controlled, as stated at the start, over the rolling pressure course now determined with greater exactness, from device **33** wherein each pass may be again the guide pass for the following pass in order to control the temperature continuously and so as to consider work stoppages.

It should also be pointed out that in the control arrangement according to predetermined rolling deflections according to FIGURE 3 the sheet end thickness s_n is the basis for determining the existing deformation resistance K_s at **16** for the final pass because the determining initial thickness s_{n-1} is still not available.

From the resulting value $s_n < s_{n-1}$ which provides too large a reduction Δh_n an s_{n-1} value is calculated at **61** from which an improved K_s is obtained at **16** and over the zero-comparison at **47** etc., a Δh_n value which is again improved is obtained which, in a continuing approximation finally provides the correct initial thickness s_{n-1} for the final pass. Only when the values at **62** or **61** have adjusted the predetermined values with the index "n—1" may be employed for the second calculating process.

The same applies to the prior passes because first the initial sheet thickness must be available with as much exactness as possible before a correct K_s-value is available as basis for the calculation.

What is claimed is:

1. In a reversible rolling mill having at least one pair of opposed rollers for reducing the thickness of a metal sheet having a specific deformation resistance which varies as a function of its temperature during a series of passes including at least a pair of passes therethrough, and means for varying the spacing of said rollers, the improvement comprising: first means for generating a first signal indicative of the reduction in thickness taking place as said sheet is passing through said rollers during the first of said pair of passes; second means for generating a second signal indicative of the width of said sheet; third means for generating a third signal indicative of the pressure being exerted by said rollers on said sheet during said first of said pair of passes; fourth means for

generating from said first, said second, and said third signals, a fourth signal indicative of said specific deformation resistance of said sheet; fifth means for conducting said first, said second, and said third signals to said fourth means; sixth means for selectively preventing said fifth means from conducting said first and said third signals to said fourth means; said fourth means including means, operable when said sixth means is preventing conduction of said first and said third signals to said fourth means for generating a fifth signal indicative of the continuously changing specific deformation resistance of said sheet; said fourth means further including means for generating from said fifth signal, a sixth signal indicative of a reduced roll spacing corresponding to a desired change in thickness of said plate during said second pass of said at least one pair of passes which will produce a predetermined desired pressure on said sheet in the second pass of said at least one pair of passes; sixth means responsive to said sixth signal for causing said means for varying the spacing of said rollers to move said rollers to said reduced spacing subsequent to said first pass and prior to said second pass.

2. The improvement as defined in claim **1** wherein said first means further includes means for generating a seventh signal indicative of the thickness of said sheet resulting from said first pass; and wherein said fourth means further includes means for deriving an eighth signal indicative of the outlet thickness of said sheet which will result from said reduced spacing during second pass, and means responsive to said seventh signal for modifying said sixth signal to cause said sixth signal to more accurately indicate the reduced roll spacing corresponding to a desired change in thickness of said plate during said second pass of said at least one pair of passes which will produce a predetermined desired pressure on said sheet in the second pass of said at least one pair of passes.

3. The improvement as defined in claim **1** wherein said means for generating said sixth signal generates a signal which produces a reduced roll pressure during said second pass of said at least one pair of passes.

4. The improvement as defined in claim **1** wherein said fourth means further includes means for generating, from the known permissible deflection of said rollers during the last pass of said series of passes, signals indicative of the desired rolling pressures for each pass of said series of passes.

5. The improvement as defined in claim **4** wherein said fourth means further includes means responsive to said signals indicative of the desired rolling pressures for said series of passes for pre-calculating the required change in roller spacing for each pass of said series of passes.

6. The improvement as defined in claim **5** wherein said means for pre-calculating the required change in roller spacing for each pass of said series of passes includes means for causing said pre-calculation to be repeated with each pass of the series of passes while decreasing the number of passes in said series of passes.

7. The method of controlling screw settings in a reversible hot rolling mill for the flow adjusted level rolling of plates and sheets comprising during a first operating the steps of measuring during a guide pass the rolling force, the inlet and outlet thickness, the speed and the width of the work material, computing the parameters measured to develop under the terms of a rolling formula a first signal responsive to the partial specific deformation resistance K_w of the guide work material, developing a second signal resonsive to the partial specific deformation resistance K_s in function of the actual thickness of the work material, developing a third signal responsive to the partial specific deformation resistance K_v in function of the actual speed of the work material, subtracting said second and third signal from said first signal to establish a fourth signal responsive to the remaining partial specific deformation resistance K_t being dependent on the actual work material temperature, eliminating from said fourth signal a fifth signal t_o responsive to the actual temperature of the work material, and comprising during a second operation the steps of switching off all measured values, storing the fifth signal t_o and the outlet thickness value s_o, developing a fictive temperature t_1 as sixth signal in function of the outlet thickness value s_o and the time lapse given by chronometer, developing a fictive value responsive to the partial specific deformation resistance K_t as seventh signal, adding said second and third signal to said seventh signal to produce a fictive value responsive to the specific deformation resistance K_{w1}, pre-setting a rolling force value for the following pass less than the value measured during the guide pass, and computing said fictive, pre-set and stored parameters to establish under the terms of said rolling formula and output signal Δh_1 responsive to the pass reduction for the following pass, each following pass serving as guide pass for the next pass.

8. The method according to claim **7**, in which during the second operation a new pre-set speed value v_1 is introduced to adapt said third signal to the conditions of the following pass.

9. The method according to claim **7**, in which during the the second operation a fictive outlet thickness value S_1 of the material to be rolled in the following pass is developed from said outlet thickness value s_o of the guide pass and the determined pass reduction value Δh_1 for steady correction of said first signal, resulting in a corrected pass reduction value Δh_1, this operation being terminated by switching in all measured values with the beginning of the following pass.

10. The method according to claim **7**, in which the rolling force to be pre-set during the second operation steps is scheduled for pass-by-pass decreasing rolling force.

11. The method of controlling screw settings in a reversible hot rolling mill for the flow adjusted level rolling of plates and sheets comprising during a first operation the steps of measuring during a guide pass the rolling force, the inlet and outlet thickness, the speed and the width of the work material, computing the parameters measured to develop under the terms of a rolling formula a first signal responsive to the specific deformation resistance K_w of the guide work material, eliminating a second signal responsive to the partial specific deformation resistance K_t dependent on the actual work material temperature, and comprising during a second operation the steps of switching off all measured values, steadily correcting said second signal K_t in function of the time lapse given by a chronometer, reestablishing a fictive value K_{w1} of said first signal, pre-setting a rolling force value for the following pass, and computing said fictive preset values with stored measured values to establish under the terms of said rolling formula an output Δh_1 responsive to the pass reduction for the following pass, each following pass serving as guide pass for the next pass.

12. The method according to claim **11**, wherein during the second operation steps a rolling force schedule is established in advance for a pre-set number of passes of a last pass series, comprising the steps of pre-setting for each pass a roll deflection value y_n, y_{n-1}, y_{n-2}, y_{n-3}, from which values the last y_n corresponds to the permissible and necessary roll deflection during the final pass and the foregoing values are chosen in accordance with the desired flow adjusted level of rolling operation, computing each deflection value to establish a corresponding rolling force schedule in function of said deflection values, the measured width of the work material and the diameter of the rolls, simulating the rolling operation backwards from the final pass and the desired final thickness s_n of the work material by adding the sum of pass reduction values computed for each fictive pass under the terms of a rolling formula and said rolling force schedule to said desired final thickness value s_n, comparing this sum s_o' with the measured outlet thickness value s_o of the guide pass, repeating said simulating operation in the case a difference is obtained in said comparison.

13. The method according to claim **12**, in that for each pass of the simulated rolling operation a speed value and a temperature value is preset and a fictive pass reduction value Δh_n, Δh_{n-1}, Δh_{n-1}, Δh_{n-2}, Δh_{n-3} is computed to establish a first signal responsive to the specific deformation K_w of the work material in function of the preset speed and temperature values and the thickness values developed from the pass reduction values for each fictive pass, said specific deformation values K_w being compared with the corresponding values eliminated from the computing operation under the terms of a rolling formula, the

output of said comparison is made and held zero by varying a parameter l_d proportional to the computed pass reduction values.

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