(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 705 151 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
10.09.1997 Bulletin 1997/37

(21) Application number: **94918483.2**

(22) Date of filing: **23.06.1994**

(51) Int. Cl.[6]: **B21B 37/16**, B21B 37/00

(86) International application number:
PCT/GB94/01364

(87) International publication number:
WO 95/00265 (05.01.1995 Gazette 1995/02)

(54) CONTROL OF SINGLE STAND/REVERSING MILLS

REGELUNG VON EINGERÜSTIGEN REVERSIERWALZWERKEN

PROCEDE DE COMMANDE DE LAMINOIRS REVERSIBLES A UN SEUL MONTANT

(84) Designated Contracting States:
BE DE ES FR GB IT

(30) Priority: **23.06.1993 GB 9312998**

(43) Date of publication of application:
10.04.1996 Bulletin 1996/15

(73) Proprietor: **DAVY McKEE (SHEFFIELD) LIMITED**
Sheffield S9 4EX Yorkshire (GB)

(72) Inventor:
BURNAND, Peter William,150 Prospect Road
Bradway, Sheffield S17 4HX (GB)

(74) Representative: **Kirk, Geoffrey Thomas**
BATCHELLOR, KIRK & CO.
2 Pear Tree Court
Farringdon Road
London EC1R 0DS (GB)

(56) References cited:
DE-A- 2 808 194 **GB-A- 2 137 778**
US-A- 4 907 433

- **PATENT ABSTRACTS OF JAPAN vol. 10, no. 100 (M-470) 16 April 1986 & JP,A,60 234 713 (ISHIKAWAJIMA HARIMA JUKOGYO K.K.) 21 November 1985**
- **PATENT ABSTRACTS OF JAPAN vol. 6, no. 210 (M-166) 22 October 1982 & JP,A,57 115 913 (TOKYO SHIBAURA DENKI K.K.) 19 July 1982**
- **PATENT ABSTRACTS OF JAPAN vol. 4, no. 154 (M-038) 28 October 1980 & JP,A,55 106 617 (TOSHIBA CORP.) 15 August 1980**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 705 151 B1

Printed by Rank Xerox (UK) Business Services
2.14.12/3.4

Description

This invention relates to a single stand rolling mill to roll metal strip and to the operation of a single stand rolling mill.

A single stand rolling mill for rolling metal strip is normally set to run at a rolling speed determined by the mill operator. After the strip has been threaded into the mill, the mill is accelerated up to a speed level which is fixed by the operator. The mill speed remains at this level while most of the strip is rolled and, when the tail end of the strip approaches the mill, the speed is reduced in order for the tail end to be rolled and handled without damage. To adjust the speed of the mill, the operator alters a mill speed reference signal applied to the closed loop speed control system and the control system follows this reference.

It is usual for the rolling mill to have its rolls rotated at a constant speed and the uncoiler from which the strip is uncoiled and the coiler onto which the strip is coiled then take up appropriate speeds which are determined by the entry/exit speeds of the mill and the tension levels between the uncoiler and the mill and between the mill and the coiler, respectively. If one of these tension levels changes, the speed of the respective uncoiler or coiler is changed to re-establish the original tension level.

Mill speed is usually the term applied to the circumferential speed of the mill rolls and is usually taken to be an indicator of the speed of the outgoing rolled strip; however, this is not strictly true because there is "forward slip" between the rotating rolls and the strip. This is created by the mechanics of the roll bite and it changes under the influences of; lubrication between the rolls and the strip; of rolling load and of tension deviations. Roll load variations occur as a result of changes in strip entry thickness requiring load changes needed to remove these thickness variations.

In GB-A2137778 (nearest prior art) there is disclosed a forward slip control system for a rolling mill which comprises a sensor for detecting the velocity of strip leaving the mill, a sensor for detecting the peripheral velocity of one of the rolls, and an arithmetic unit for calculating the forward slip of the strip relative to the roll. From this value of forward slip a drive controller is arranged to control the actual peripheral velocity of the other roll in order to achieve the desired forward slip value.

Speed variations in outgoing strip from the rolling mill necessitate corresponding variations in the speed of rotation of the coiler. The inertia of a coiler varies in dependence of the thickness of the coil of strip which is wound on the coiler, the inertia being a maximum for a full coil. This variation in inertia puts a strain on the drive motor for the coiler and a high inertia increases the response time of the control circuit.

It is an object of the present invention to operate a single stand rolling mill such that unwanted effects of slip variation on the quality of the rolled strip are reduced.

According to the present invention, in a method of controlling the operation of a single stand strip rolling mill wherein the strip leaving the mill is coiled on a coiler wherein,

> a signal representing the speed of the strip at a position between the mill and the coiler is obtained and characterised in that said signal is compared with a signal representing the desired speed of the strip leaving the mill to produce an error signal which is used directly or indirectly to control the roll drive means and hence the speed of rotation of both mill rolls in the sense to reduce the error signal substantially to zero.

According to the invention a rolling mill is provided including the combination of features set out in independent claim 4.

An advantage of the invention is to keep a substantially constant coiling speed thereby reducing the demands of the exit tension controller, thereby holding more constant the level of outgoing tension, thereby producing strip of a more constant thickness and coiled tension.

In order that the invention may be more readily understood, it will now be described, by way of example only, with reference to the accompanying drawings, in which:-

> Figure 1 is a schematic circuit diagram of the usual drive arrangement for a single stand rolling mill; and Figures 2 and 3 are schematic circuit diagrams showing the drive arrangement for a single stand rolling mill in accordance with alternative embodiments of the present invention.

A single stand rolling mill 1 has its work rolls driven by separate drive shafts from a drive motor 3 via a gear box 5. A coil of strip 7 on a driven pay-off reel 9 is threaded through the mill and on to a coiler 11. Tachometers 13 and 15 driven by the strip measure the ingoing and outgoing speeds of the strip, respectively.

The main drive motor 3 is connected to a tachometer 17 and a signal from this tachometer is compared in a comparator 19 with a signal from an adjustable speed reference source 21. The difference signal is used to control a thyristor power unit 23 in the sense to adjust the motor speed to the value set by the reference source. Although the speed of rotation of the mill rolls is kept substantially constant by the power unit 23, the linear speed of the outgoing strip from the mill changes due to the variation of forward slip.

Referring to Figure 2, the tachometer 15, which provides a signal proportional to the speed of the strip immediately prior to it being coiled, is connected to the comparator 19 instead of the main drive tachometer. In the comparator the signal is compared with the speed reference signal from the source 21. Any difference

between these signals is amplified and fed to the thyristor power unit 23 where it is used to control the operation of the motor 3. Thus, the exit speed of the strip material is kept substantially constant and the level of outgoing tension is held more constant. The relationship between the ingoing and outgoing speed of the strip is substantially constant so entry speed changes are reduced.

In an alternative embodiment, shown in Figure 3, the main drive motor tachometer 17 is retained in the motor control loop and a trim signal added to the speed reference signal from the source 21. The comparator 19 receives signals from the tachometer 17 and a speed reference 21 and also a trim signal obtained indirectly from the exit tachometer 15. This signal from the tachometer 15 and the speed reference signal are applied to a control amplifier whose output representing speed deviation serves as the trim signal. This trim signal is applied to the main drive motor control loop in order to hold constant the exit speed for small perturbations in exit speed. Large perturbations in exit speed will cause main drive speed trim to hold steady (as the control amplifier 24 saturates) and then the coiler is allowed to accelerate taking the main drive speed trim into its active region.

In similar fashion, a high pass filter 25 could be fitted into the main drive speed trim line thus allowing the main drive motor to compensate for short term perturbations in exit speed and the exit coiler to compensate for long term perturbations in exit speed. These alternatives are shown by the routing of exit speed signal in the dotted or dashed lines.

As a result of the invention, the mill exit speed is kept substantially constant during the rolling of all but the front and tail ends of the strip during which the strip is deliberately accelerated and decelerated respectively. The entry speed of the strip is also kept substantially constant. This results in reduced entry tension changes and gauge errors of strip rolled in the mill are reduced.

Claims

1. A method of controlling the operation of a single stand strip rolling mill (1) wherein the strip leaving the mill is coiled on a coiler (11) wherein,

   a signal representing the speed of the strip at a position between the mill and the coiler is obtained and

   characterised in that said signal is compared with a signal representing the desired speed of the strip leaving the mill to produce an error signal which is used directly or indirectly to control the roll drive means (3) and hence the speed of rotation of both mill rolls in the sense to reduce the error signal substantially to zero.

2. A method as claimed in claim 1 wherein both rolls are driven by a single drive motor and characterised in that said error signal is employed directly to control the speed of rotation of the drive motor.

3. A method as claimed in claim 1 wherein both of the rolls are driven by a single drive motor, the speed of rotation of the motor is compared with a desired speed of rotation to produce an error signal which is employed to control the speed of the motor in the sense to reduce the error signal substantially to zero and characterised in that the error signal representing the difference between the actual and desired speed of the strip is employed as a trim signal to control the speed of rotation of the motor.

4. A single stand strip rolling mill (1) having drive means (3) for driving the mill rolls, a driven coiler (11) downstream of the stand, means (15) for determining the speed of the strip between the mill stand and the coiler,

   characterised in the provision of means (19) for comparing the speed of the strip with a desired speed of the strip to produce an error signal which serves to control the drive means (3) of the rolls in the sense to reduce the error to zero.

5. A single stand strip rolling mill as claimed in claim 4 including means for determining the speed of rotation of the drive motor, means for comparing the speed of rotation with the desired speed of rotation of the rolls and the error signal representing the difference between the actual speed and desired speed of the strip to produce a control signal for controlling the speed of rotation of the rolls.

Patentansprüche

1. Verfahren zum Steuern des Betriebs eines eingerüstigen Bandwalzwerkes (1), wobei das Band, welches das Walzwerk verläßt, in einem Coiler (11) aufgewickelt wird, wobei ein Signal, welches die Geschwindigkeit des Bandes an einer Position zwischen dem Walzwerk und dem Coiler darstellt, erhalten wird, und
   dadurch gekennzeichnet, daß das Signal mit einem Signal verglichen wird, welches die gewünschte Geschwindigkeit des Bandes darstellt, welches das Walzwerk verläßt, zum Erzeugen eines Fehlersignals, welches direkt oder indirekt zum Steuern der Walzenantriebseinrichtung (3) und daher der Rotationsgeschwindigkeit der beiden Walzwerk-Walzen verwendet wird, um das Fehlersignal im wesentlichen auf Null zu verringern.

2. Verfahren nach Anspruch 1, bei welchem beide Walzen durch einen einzelnen Antriebsmotor angetrieben werden,
   dadurch gekennzeichnet, daß das Fehlersignal

direkt zum Steuern der Rotationsgeschwindigkeit des Antriebsmotors verwendet wird.

3. Verfahren nach Anspruch 1, bei welchem die durch einen einzelnen Antriebsmotor angetriebenen Walzen und die Rotationsgeschwindigkeit des Motors mit einer gewünschten Rotationsgeschwindigkeit verglichen werden, um ein Fehlersignal zu erzeugen, welches zum Steuern der Geschwindigkeit des Motors verwendet wird, um das Fehlersignal im wesentlichen auf Null zu verringern, und dadurch gekennzeichnet, daß das Fehlersignal, welches die Differenz zwischen der momentanen und der gewünschten Geschwindigkeit des Bandes darstellt, als Einstellsignal zum Steuern der Rotationsgeschwindigkeit des Motors verwendet wird.

4. Eingerüstiges Bandwalzwerk (1) mit einer Antriebseinrichung (3) zum Antreiben der Walzwerk-Walzen, einem angetriebenen Coiler (11) materialflußabwärts des Gerüstes, einer Einrichtung (15) zum Bestimmen der Geschwindigkeit des Bandes zwischen dem Walzwerkgerüst und dem Coiler, dadurch gekennzeichnet, daß eine Einrichtung (19) zum Vergleichen der Geschwindigkeit des Bandes mit einer gewünschten Geschwindigkeit des Bandes vorgesehen ist, zum Erzeugen eines Fehlersignals, welches die Steuerung der Antriebseinrichtung (3) der Walzen unterstützt, um den Fehler auf Null zu verringern.

5. Eingerüstiges Bandwalzwerk nach Anspruch 4, mit einer Einrichtung zum Bestimmen der Rotationsgeschwindigkeit des Antriebsmotors, einer Einrichtung zum Vergleichen der Rotationsgeschwindigkeit mit der gewünschten Rotationsgeschwindigkeit der Walzen und dem Fehlersignal, welches die Differenz zwischen der momentanen Geschwindigkeit und der gewünschten Geschwindigkeit des Bandes darstellt, zum Erzeugen eines Steuerungssignals zum Steuern der Rotationsgeschwindigkeit der Walzen.

Revendications

1. Procédé de commande du fonctionnement d'un laminoir réversible (1) à un seul montant dans lequel la bande quittant le laminoir est enroulée sur un bobinoir (11), dans lequel,

   un signal représentant la vitesse de la bande à une position située entre le laminoir et le bobinoir est obtenu et

   caractérisé en ce que ledit signal est comparé à un signal représentant la vitesse souhaitée de la bande quittant le bobinoir pour produire un signal d'erreur qui est utilisé directement ou indirectement pour commander les moyens d'entraînement (3) des cylindres et ainsi la vitesse de rotation des deux cylindres du laminoir afin de ramener le signal d'erreur sensiblement à zéro.

2. Procédé selon la revendication 1, dans lequel les deux cylindres sont entraînés par un moteur d'entraînement unique et caractérisé en ce que ledit signal d'erreur est utilisé directement pour commander la vitesse de rotation du moteur d'entraînement.

3. Procédé selon la revendication 1, dans lequel les deux cylindres sont entraînés par un moteur d'entraînement unique, la vitesse de rotation du moteur est comparée à une vitesse de rotation souhaitée pour produire un signal d'erreur qui est utilisé pour commander la vitesse du moteur afin de ramener le signal d'erreur sensiblement à zéro et caractérisé en ce que le signal d'erreur représentant la différence entre la vitesse réelle et la vitesse souhaitée de la bande est utilisé comme signal d'ajustement pour commander la vitesse de rotation du moteur.

4. Laminoir réversible (1) à un seul montant comprenant des moyens d'entraînement (3) permettant d'entraîner les cylindres du laminoir, un bobinoir entraîné (11) en aval du montant, des moyens (15) permettant de déterminer la vitesse de la bande entre le montant du laminoir et le bobinoir,

   caractérisé par la présence de moyens (19) permettant de comparer la vitesse de la bande à une vitesse souhaitée de la bande pour produire un signal d'erreur qui sert à commander les moyens d'entraînement (3) des cylindres afin de ramener l'erreur à zéro.

5. Laminoir réversible à un seul montant selon la revendication 4, comprenant des moyens permettant de déterminer la vitesse de rotation du moteur d'entraînement, des moyens permettant de comparer la vitesse de rotation à la vitesse de rotation souhaitée des cylindres, et le signal d'erreur représentant la différence entre la vitesse réelle et la vitesse souhaitée de la bande pour produire un signal de commande destiné à commander la vitesse de rotation des cylindres.

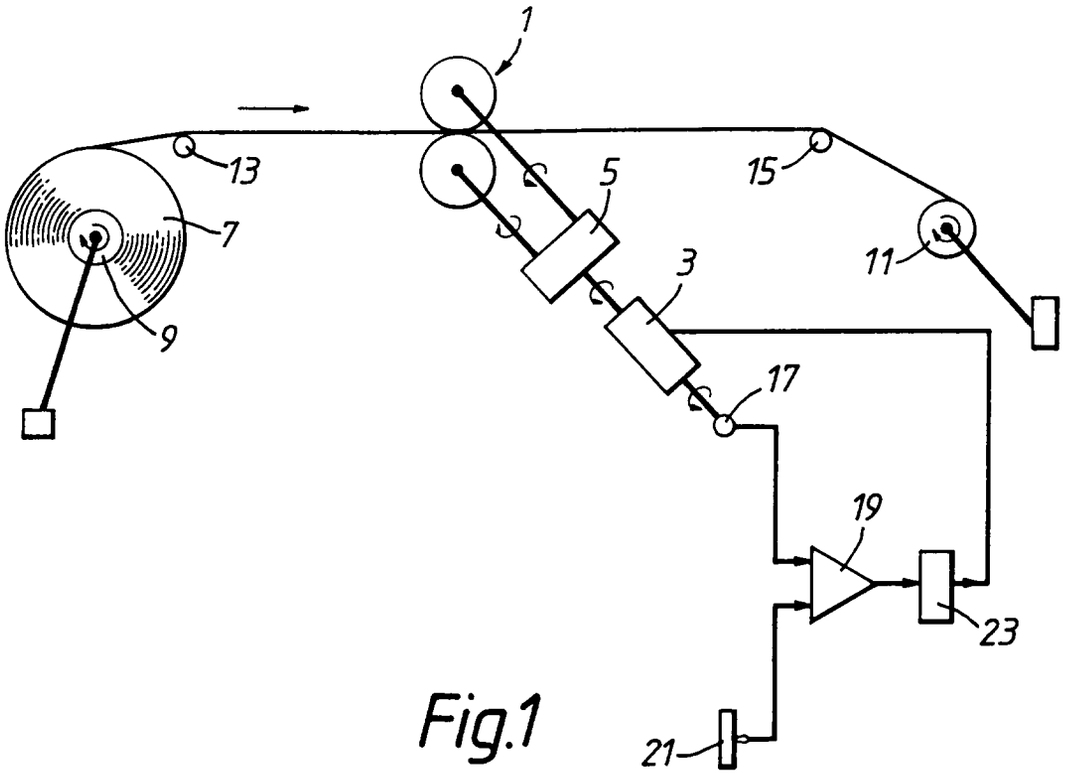

Fig.1

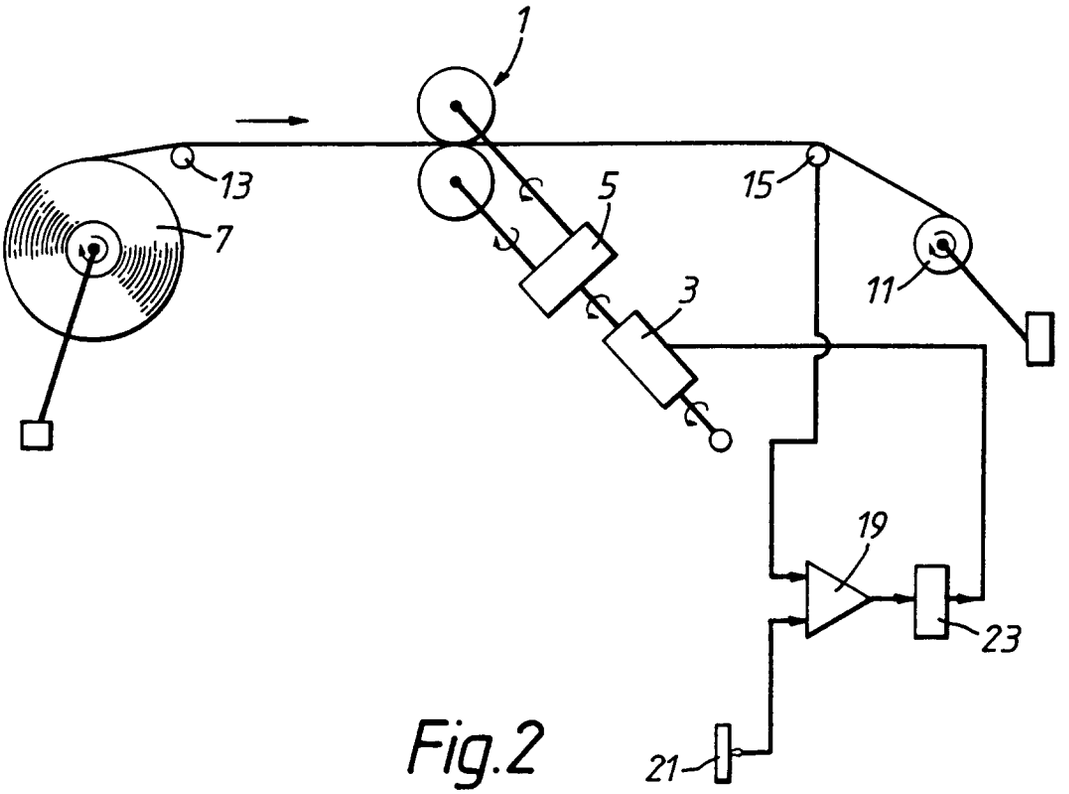

Fig.2

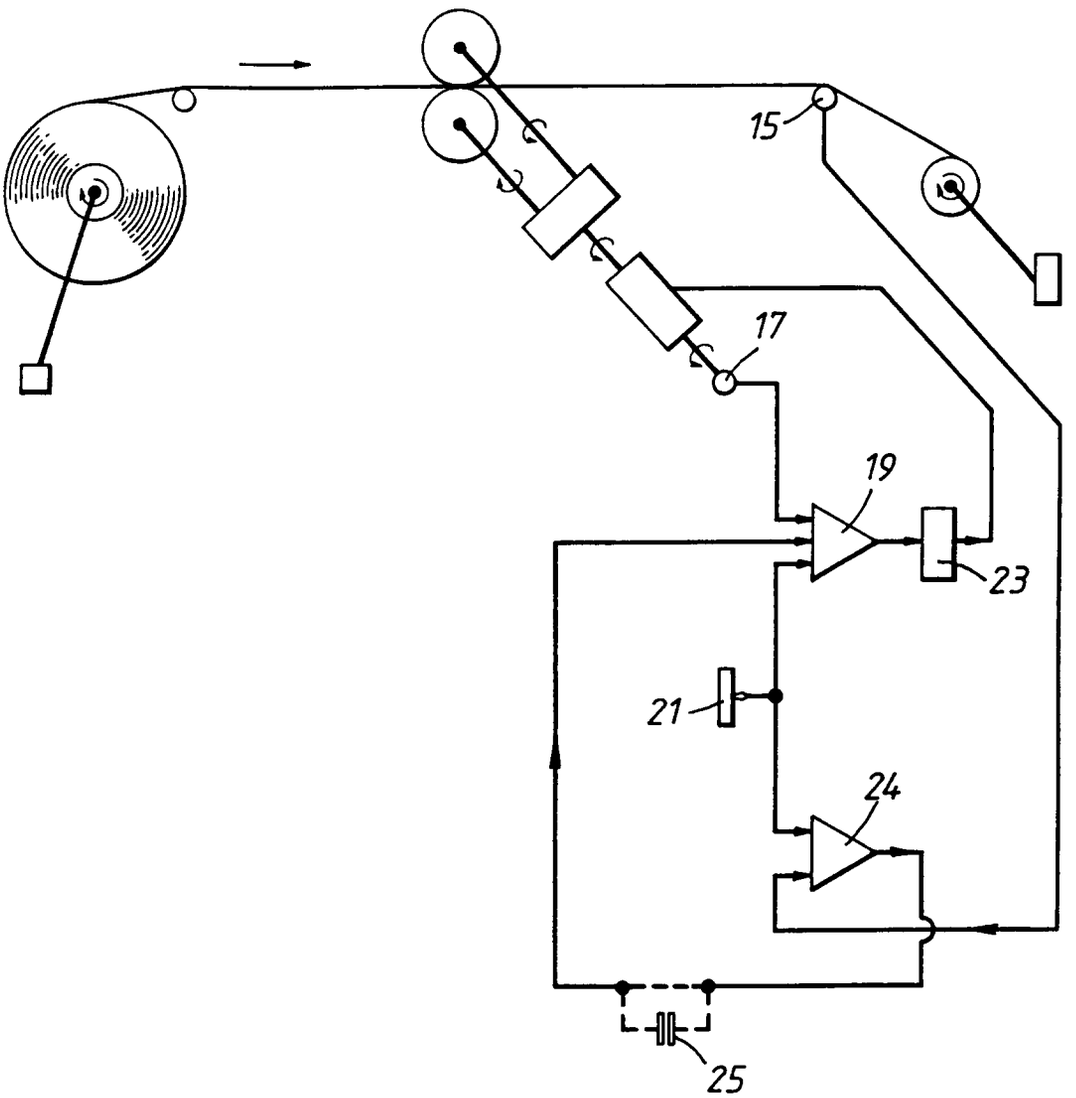

Fig.3