

Internal distribution code:

- (A) [] Publication in OJ
(B) [] To Chairmen and Members
(C) [X] To Chairmen

D E C I S I O N
of 30 June 1997

Case Number: T 0692/96 - 3.2.1
Application Number: 92105463.1
Publication Number: 0506138
IPC: B21B 13/02, B21B 27/10,
B21B 37/00, B21B 28/04

Language of the proceedings: EN

Title of invention:
Rolling mill, hot rolling system, rolling method and rolling
mill revamping method

Applicant:
HITACHI, LTD.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-



Case Number: T 0692/96 - 3.2.1

D E C I S I O N
of the Technical Board of Appeal 3.2.1
of 30 June 1997

Appellant: HITACHI, LTD.
6, Kanda Surugadai 4-chome
Chiyoda-ku
Tokyo 101 (JP)

Representative: Beetz & Partner
Patentanwälte
Steinsdorfstrasse 10
80538 München (DE)

Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 27 November 1995
refusing European patent application
No. 92 105 463.1 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: F. A. Gumbel
Members: P. Alting van Geusau
G. Davies

Summary of Facts and Submissions

- I. European patent application No. 92 105 463.1 filed on 30 March 1992, claiming priority from the earlier applications JP 66007/91 and JP 20956/92 in Japan and published under the publication No. 0 506 138, was refused by a decision of the Examining Division dated 27 November 1995.

In that decision the Examining Division concluded that the subject-matter of the independent claims 1, 10, 11 and 15 then on file was not inventive having regard to the prior art disclosed in

D1: EP-A-0 184 481

D2: US-A-3 208 253

D3: PATENT ABSTRACTS OF JAPAN, vol. 11, No. 140
(M-586)(2587), 8 May 1987 & JP-A-61 279 305, and

D4: PATENT ABSTRACTS OF JAPAN, vol. 11, No. 356
(M-644)(2803), 20 November 1987 & JP-A-62 134 102.

- II. On 9 January 1996 a notice of appeal was lodged against that decision together with due payment of the appeal fee.

Together with the statement of grounds of appeal, claims 1 to 13 and new description pages 1 to 45 and Figures 1 to 16 were filed on 4 April 1996.

- III. An interview between the appellant's representative and the rapporteur took place on 15 May 1997 during which the clarity of and support for the claims were discussed.

IV. By letter dated 30 May 1997 the appellant filed new claims 1 to 12 and amended description pages 4, 6 to 9, 16, 19, 25, 26, 32, 33. A new claim 13 was filed by facsimile dated 20 June 1997.

By implication the appellant requests grant of a patent on the basis of these documents together with the description pages 1 to 3, 5, 10 to 15, 17, 18, 20 to 24, 27 to 31 and 34 to 45 and the Figures 1 to 16 filed with the statement of grounds of appeal.

The independent claims 1, 10, 11 and 13 read as follows:

- "1. A four-high hot rolling mill comprising
- a rolling housing (20),
 - a pair of work rolls (7) adjustably inclined in horizontal planes by adjusting means (10, 11) acting between the work roll chocks (16) and projecting blocks (30) of the housing (20), so that the axes of said work rolls (7) cross each other and also the axis of the rolled material (9), and
 - a pair of back-up rolls (8) arranged perpendicularly to the axis of the rolled material (9), wherein
 - a first axial thrust force (F_2) acts from each back-up roll (8) to the associated work roll (7) and a second thrust force (F_1) acts from said material (9) to the work roll (7) so that an actual thrust force acting on the work roll (7) is equal to a difference ($F_2 - F_1$) between said first and second thrust forces (F_2 and F_1), characterised in that

a lubricant supply device (1, 26-28, 50) is provided for controlledly supplying an axial thrust reducing lubricant which contains a lubricating oil mainly composed of a mineral oil to the entire length of the contact zone between each work roll (7) and the associated back-up roll (8) for reducing the first thrust force (F_2), so that said actual thrust force acting on said work roll (7) will be reduced to 5% or less of the maximum rolling load."

"10. A hot rolling system comprising a group of rough rolling mills (61) and a group of finish rolling mills (62), characterised in that

at least one rolling mill of the group of said finish rolling mills (62) is designed according to one of the claims 1 to 9."

"11. Method for hot rolling a flat material in a four-high rolling mill,

wherein for controlling the crown of the material (9) during rolling the axes of the work rolls (7) will be inclined relative to the axes of the back-up rolls (8) in a horizontal plane such that the axes of the work rolls cross axes of the back-up rolls and the axes of the work rolls cross each other,

wherein a first thrust force (F_2) acts from each back-up roll (8) to the associated work roll (7) in an axial direction opposite to the axial direction in which a second thrust force (F_1) acts from said material (9) to said work roll (7) so that an actual thrust force acting on the work roll (7) is equal to a difference ($F_2 - F_1$) between said first and second thrust forces,

characterised in that

a lubricant which contains a lubricating oil mainly composed of a mineral oil is controlledly supplied to the entire length of the contact zone between each work roll (7) and each back-up roll (8) during rolling for reducing said first axial thrust (F_2) so that said actual thrust force acting on said work roll (7) will be reduced to 5% or less of the maximum rolling load."

"13. A method of revamping a four-high hot rolling mill comprising the steps of:

providing a hydraulic device (10) on a position on the housing (20) which opposes a roll chock (16) of each work roll (7) in such a manner that said device can be operated in a direction in which a material (9) proceeds, so that said device (15) can incline the axes of the work rolls (7) relative to the back-up rolls (8) in a horizontal plane such that the axes of the work rolls cross axes of the back-up rolls and such that the axes of the work rolls cross each other,

providing another hydraulic device (21, 22) on the housing (20) in such a manner that the other device (21, 22) can be operated in an axial direction of each work roll (7), so that the other device (21, 22) can engage with the roll chock (16) of the work roll (7) to thereby move the work roll in the axial direction thereof,

said work rolls and said back-up rolls are arranged such that a first thrust force acts from each back-up roll to an associated work roll in a direction opposite to a direction in which a second thrust force acts from said material to the work roll so that an actual thrust force acting on the work roll is equal to a difference between said first and second thrust forces, and providing

an axial thrust reducing lubricant supply device for controlledly supplying an axial thrust reducing lubricant which contains a lubricating oil mainly composed of a mineral oil to the entire length of the contact zone between said work rolls and an associated back-up roll,

so that said actual thrust force acting on said work roll under the lubrication in said zone is not greater than 5% of a maximum rolling load acting on material being rolled during rolling operation of said rolling mill."

- V. The arguments submitted by the appellant in support for its request for grant of a patent can be summarised as follows:

The present application related to hot rolling mills with crossed working rolls. In such rolling mills extremely high axial thrust loads occurred which, because the work roll bearings could not be made as large as the bearings of the support rolls due to the limitations to the diameter of the work rolls, caused severe problems as regards the lifetime of the bearings of the work rolls. Furthermore the roll wear caused by the relative slip between the back-up roll and the work roll was another severe problem that limited the practical use of the crossed working roll type of rolling mill.

A generally known theoretical possibility for reducing wear of the rolls caused by friction as well as the excessive axial thrust was to supply a lubricant. However, so far the use of a lubricant in a hot rolling mill was found unsuitable in practice because the lubricant was either washed away by the large amounts of cooling water or led to insufficient bite in the rolling nip or unwanted deposits on the material to be rolled. Because of these drawbacks rolling mills with crossed working rolls were not used in practice despite their excellent suitability for controlling roll crown.

The present inventors found that, by introducing a suitable lubricant into the contact zone of the working rolls and the support rolls, friction between those rolls could be reduced dramatically and thus also the axial force working on the working roll bearings. Surprisingly the resulting axial thrust forces could be reduced to 5% or less of the rolling force which led to a possible use of work roll bearings of about the size usual for normal four-high rolling mills. The operational advantages were achieved by the use of the now claimed mineral-based lubricants. Such lubricants were hitherto regularly employed in the case of cold rolling since they had a low viscosity and a relatively low heat resistance so that they lost their lubricity in the roll gap. This latter feature was used with advantage in the hot rolling method to prevent the roll biting trouble.

In addition to the documents cited in the European search report (D1 to D11) and the document cited in the description of the application JP-A-47 27159 (D12) (with Abstract by Derwent), the appellant filed a number of additional documents to illustrate the problems encountered in the prior art with crossed working roll rolling mills or the lubrication of rolls of roll mills for reducing friction between the rolls.:

Enclosure A: The Iron Age, July 14, 1932, pages 54 and 55, CARL MOREY: "The Finishing of Rolls by Grinding II",

Enclosure B: Iron and Steel Engineer, August 1965, pages 73 to 81, DR. M. D. STONE: "Theory and Practical Aspects in Crown Control",

Enclosure C: Iron and Steel, April 1971, pages 103 and 104, G. NEPORT: " Application of a working lubricant on a wide hot strip rolling mill",

Enclosure D: Iron and Steel Engineer, October 1970, pages 66 to 69, M. ROBERT EDMUNSON: High Temperature Rolling Oils Aid Hot Rolling",

D13: Hitachi Review, December 1996, vol. 45 - No. 6
Y. IIDA et al: "Trends in Rolling Mill Facilities", pages 267 to 270,

D14: Hitachi Review,
December 1996, vol. 45 - No. 6
H. ONO et al: "Industrial Application of the HCX-Mill to Hot Strip Mills" pages 271 to 278.

Reasons for the Decision

1. The appeal is admissible.
2. *Amendments*
- 2.1 Claim 1 is based on the originally filed claims 1 and 6 (the lubricant contains a lubricating oil mainly composed of a mineral oil).

There is further specified in the current claim 1 that

- (a) the rolling mill is a four-high hot rolling mill,
- (b) the resultant force acting on the work rolls is equal to the difference between the axial thrust force acting between the back-up roll and the work roll and the thrust force acting on the work rolls from the rolling material,
- (c) the supply of lubricant is along the entire length of the contact zone between each work roll and the associated back-up roll,
- (d) the actual thrust force acting on the work roll is reduced to 5% or less of the maximum rolling load.

These features are supported by the following parts of the originally-filed application:

feature (a):

page 10, line 12 (hot rolling) and the embodiment of the rolling mill disclosed in respect to Figure 1 (four high rolling mill),

feature (b):

page 37, line 17 to page 38, line 5, Figure 17,

feature (c):

Page 8, lines 18 to 24 and Figure 2,

feature (d):

page 24, lines 24 to 25.

As to the feature (d) it is to be noted that in the originally filed description of the application a thrust value of 5% or less of the rolling load is given merely as a general design parameter in connection with the thrust bearing of the work rolls. However, it follows from the context of the application that such thrust value is considered to be the maximal allowable upper value and that the method disclosed in the application is intended not to exceed such value in crossed work roll rolling mills to which the present application relates (see also page 25, lines 1 to 11).

2.2 The subject-matter of the further claims is supported by the following parts of the description and drawings:

claims 2 and 9: see page 17, lines 12 to 16 and Figure 2,

claims 3, 4 and 12: see page 18, lines 5 to 19 and Figure 2,

claim 5: Figure 1 and 5, page 21, lines 14, 15

claim 6: page 19, lines 10 to 13 and Figure 5.

claim 7: Figure 1 and page 15, line 17 to page 16, line 4,

claim 8: Figure 4 and page 20, lines 1 to 7,

claim 10: Figure 18 and page 43, lines 3 to 27,

Independent method claim 11 is based on the same subject-matter as claim 1.

Independent claim 13: see page 41, lines 20 to 24 and the originally-filed claim 15.

In respect of claim 6 it is to be noted that in Figure 5 only the upper half of the cooling and lubricating arrangement is shown. It is considered to be self-evident that the lower half is symmetrically identical.

2.3 The amendments to the description concern the adaptations to the subject-matter now claimed, the acknowledgment of the closest prior art document EP-A-0 184 481 (D1) and corrections of language.

2.4 It is to be noted that the independent claim 13 is the only independent claim which is drafted in the one-part form.

This claim is related to a method for adapting a four-high hot rolling mill to become a rolling mill essentially in accordance with the four-high hot rolling mill of claim 1. Since no comparable conversion of a rolling mill is disclosed in any of the available prior art documents, the one part form of this claim is considered acceptable.

2.5 In view of the above assessments no objections arise under Article 84 or 123 (2) or Rule 29 (1) EPC against the present set of claims or the description.

3. *Novelty*

Novelty of the subject-matter of the independent claims 1, 10, 11 and 13 follows from the fact that none of the available documents of the prior art discloses either a four-high hot rolling mill or a method using or revamping such mill in which the work rolls are crossed and an axial thrust reducing lubricant

containing a lubricating oil mainly composed of a mineral oil is controlledly supplied to the entire length of the contact zone between the work rolls and the associated back-up roll, so that the thrust force acting on the work roll is not greater than 5% of the maximum rolling load.

4. *Inventive step*

4.1 The closest prior art is represented by the hot rolling method and four-high hot rolling mill disclosed in D1.

This prior art discloses a four-high hot rolling mill and a method for hot rolling a flat material in a four-high rolling mill which discloses the constructional features and most of the process features of the precharacterising portions of the independent claims 1 and 11, respectively, and as regards the thrust forces specified in these claims directly implies such thrust forces to act on the back-up work rolls.

4.2 In D1 the adjustable small inclination angle of 0.2 to 2° between the work roll axes and the axis of the flat material to be rolled allow improved crown control of the rolled strip but lead to exertion of considerable axial thrust to both the work rolls and the back-up rolls. This thrust which depends on the cross angle is about 30% of the rolling load and it is very difficult to achieve proper support of the work rolls with such high axial loads. Moreover the crossing of the work roll and the associated back-up roll causes a relative slip between the rolls, which generates unacceptable wear and due to the necessary frequent changing of the back-up roll greatly reduces the productivity of the rolling mill (see page 2, line 14 to page 3, line 22 of the present description).

Starting from the prior art four-high hot rolling mill and method of hot rolling disclosed in D1 the object of the present application can be seen in the prevention of excessive axial thrust loads on the work rolls as well as high wear of the back-up roll barrels and other components of the rolling mill (see page 6, last paragraph).

- 4.3 This object is achieved by subject-matter of the independent claims.

By selecting a lubricant which contains a lubricating oil mainly composed of a mineral oil and controlledly supplying the lubricant to the entire length of the zone between each work roll and the associated back-up roll the lubricating effect will be restricted to this contact portion only and together with the property of the mineral oil that the friction reduction ability is decreased at high temperatures (see Figure 11 of the present application) and is thus ineffective in the drawn-in zone of the roll gap, sufficient friction between the barrel surfaces of the work rolls and the material to be rolled will be retained (see page 8, lines 3 to 12).

An example of the oil used is disclosed on page 29 of the present application.

- 4.4 The rolling mill expert is well aware of the advantages that can be achieved in respect of reduced wear and friction in rolling mills by lubrication of the rolls. The following documents cited in the European search report relate to lubrication of rolling mills

D2: US-A-3 208 253

D4: Patent Abstracts of Japan, vol. 11, No. 356
(M-644) (2803), 20 November 1987 & JP-A-62 134102

- D5: Patent Abstracts of Japan, vol. 7, No. 50
(M-197) (1195) 26 February 1983 & JP-A-57 199501,
- D6: Patent Abstracts of Japan, vol. 8, No. 140
(M-305) (1577) 29 June 1984 & JP-A-59 039408,
- D9: World Patent Index, Section PQ, Week 7723, Derwent
Publications Ltd., London, GB; Class P51, AN
77-41042Y (23) & JP-B-52 017515,
- D10: IRON AND STEEL,
April 1971, Guildford GB, pages 103 to 104;
G. NEPORT: "Application of a working lubricant on
a wide hot strip rolling mill".

The problems encountered in the "bite" when using
lubrication of the working rolls is another phenomenon
well known to the skilled person in this field of
technique, as can be derived from D6.

4.5 There is further disclosed in:

- D11: IRON AND STEEL ENGINEER,
vol. 61, No. 10 October 1984, Pittsburgh US;
pages 26 to 33;
Hidehiko Tsukamoto et al.: "Shape and crown
control mill - Crossed roll system mill".

that systems in which only the back-up rolls are
crossed or systems in which only the work rolls are
crossed are not practical because of extensive roll
wear and considerable energy loss due to the relative
slip between the work roll and the back-up roll and
that therefore the pair-crossed roll arrangement (see
also D6) is preferred.

Also in "Enclosure B", cited by the appellant, there is stated that because of the large axial forces encountered in roll crossing systems (crossing the work or back-up rolls) such systems have never been successful as a practical crown control method in the metal rolling field.

On the basis of the available prior art the skilled person was therefore not led to develop the crossed working roll system in spite of its excellent crown control capabilities.

4.6 Furthermore, as far as lubrication is concerned in a rolling mill with paired cross rolls - thus in a crossed roll arrangement in which less friction and thrust is involved than in the crossed working roll arrangement - D6 points to the difficulties encountered in the bite if no additional measures for cutting down the lubrication are taken.

4.7 D2, which was considered pertinent in respect of lubrication of rolls in a rolling mill by the Examining Division, discloses a method of controlling interrupted application of rolling lubricant to avoid failure of the strip to enter the roll bite (column 1, lines 29 to 42). The rolling lubricant is applied either to the workpiece or rolls, or both. In hot-mill application the lubricant is preferably applied to the rolls (column 1, lines 43 to 47).

This prior art does not relate to the specific problems of thrust and friction in crossed work roll mills but merely concerns the lubrication of the combination of work rolls and rolled material and in which the lubrication of the work roll and back-up roll combination does not play a role of importance. Neither

the use of a lubricant based on a mineral oil nor a hint to a reduction of the thrust force to 5% or less of the rolling load obtainable with controlled lubrication is derivable from D2.

D9 does not appear to disclose more than what is known from D2.

D5 a document relating to hot oil-lubricated rolling discloses controlled lubrication for maintaining a sufficient friction coefficient of the work rolls and ensuring the bite of the material to be rolled. This document does not disclose more than that lubrication is generally recommended but should be controlled such that biting of the material to be rolled is not impaired. The lubricating oil is not specified. In accordance with D10 a mixture of mineral oil/fatty oil and an additive blend should be used as a lubricant in hot-rolling.

D6 relates to a paired, crossed rolls arrangement in which the rolls are lubricated to reduce friction and thrust between the rolls. Measures are disclosed as to how the friction coefficient can be increased to ensure biting of the material to be rolled.

Since the paired crossed roll system does not lead to the extensive friction and thrust encountered in the crossed work roll arrangement and no details of either the lubricant or amount of thrust reduction is available, also this prior art cannot give the skilled person any lead to the characterising features of the independent claims 1 and 11.

4.8 In summary, the Board is of the opinion that although the cited prior art discloses that controlled lubrication is an adequate measure to reduce friction and thrust in rolling mills this teaching is

essentially related to the combination of the work rolls and the material to be rolled. The lubrication is controlled so that during rolling the friction is reduced but during roll-in of the material the friction is increased to ensure biting.

No other information is available that would give the skilled person an incentive to solve the friction and thrust problems encountered in the crossed working roll arrangement by lubrication only, let alone the controlled supply of a lubricant which contains a lubricating oil to the entire length of the contact zone between each work roll and the associated back-up roll in a hot roll method or hot rolling arrangement.

In particular, no teaching is available in the cited prior art for selection of a lubricant which contains a lubricant mainly composed of a mineral oil and controlled supply to reduce the thrust in a crossed work roll arrangement to 5% or less of the maximum rolling load and which additionally, because of the decreased lubrication properties of the mineral oil at higher temperatures (see Figure 11 of the present application), makes further measures for ensuring a sufficient bite redundant.

- 4.9 For these reasons the subject-matter of the independent claims 1 and 11 is considered to be based on an inventive activity.

The subject-matter of the independent claims 10 and 13 is based on the same inventive features as those of claim 1 or claim 11 and these claims are therefore also considered acceptable.

5. The current description and drawings are in agreement with the wording and scope of the claims. Hence these documents are also suitable for grant of a patent.

Order

For these reasons it is 22 July 1997 decided that:

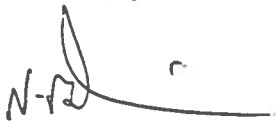
1. The decision under appeal is set aside.
2. The case is remitted to the Examining Division with the order to grant a patent on the basis of the following documents:

Claims: No. 1 to 12 filed 30 May 1997;
No. 13 filed 20 June 1997;

Description: pages 1 to 3, 5, 10 to 15, 17, 18, 20 to 24, 27 to 31, 34 to 45 filed 4 April 1996;
pages 4, 6 to 9, 16, 19, 25, 26, 32, 33
filed 30 May 1997;

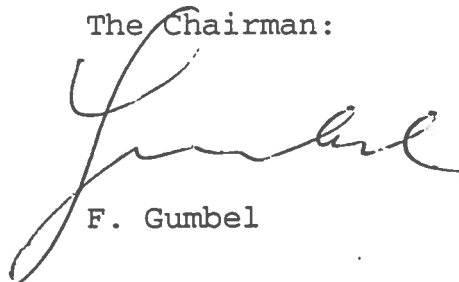
Drawings: Figures 1 to 16 filed 4 April 1996.

The Registrar:

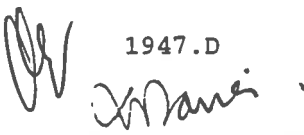


N. Maslin

The Chairman:



F. Gumbel



1947.D
J. Maslin

