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D E C I S I O N
of 24 September 2002

Case Number: T 1093/00 - 3.2.1

Application Number: 91105966.5

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IPC: B21B 13/14

Language of the proceedings: EN

Title of invention:
4-High rolling mill

Patentee:
Hitachi, Ltd.

Opponent:
(01) Mannesmann Aktiengesellschaft
(02) SMS Demag AG

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56

Keyword:
"Novelty (yes)"
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 1093/00 - 3.2.1

D E C I S I O N
of the Technical Board of Appeal 3.2.1
of 24 September 2002

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 7 September 2000 revoking European patent No. 0 451 874 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: S. Crane
Members: J. Osborne
G. Weiss

Summary of Facts and Submissions

I. European patent No. 0 451 874 was granted on 27 December 1995 on the basis of European patent application No. 91 105 966.5.

II. The granted patent was opposed by the present respondents (opponents 01 and 02) on the grounds that its subject-matter lacked novelty and/or inventive step (Article 100(a) EPC).

The state of the art relied upon included the following documents:

(D1): DE-A-3 602 698
(D8): JP-A-57 181 708 (with English language abstract)
(D9): EP-A-0 294 544
(D11): Iron and Steel Engineer, Vol. 65, No. 12, December 1988, pp. 45-54.

III. With its decision posted on 7 September 2000 the Opposition Division revoked the patent. It held that the subject-matter of granted claim lacked inventive step with respect to the teachings of document D1.

IV. A notice of appeal against this decision was filed on 30 October 2000 and the fee for appeal paid at the same time. The statement of grounds of appeal was filed on 17 January 2001.

With the statement of grounds the appellants (proprietors of the patent) submitted an amended claim 1, which reads as follows:

"A 4-high rolling mill comprising

- a pair of upper and lower work rolls (1, 2) for rolling a flat material (3),
- a pair of upper and lower backup rolls (21, 22) supporting said upper and lower work rolls, respectively;
- a roll bending device (11, 12) for applying a bending force to said upper and lower work rolls; and
- a roll shift device (16) for shifting said upper and lower work rolls in an axial direction of said work rolls;
- each of said upper and lower work rolls (1, 2) having a convex curved initial crown portion (1a, 2a) formed on one side of the effective work roll barrel and disposed oppositely relative to each other in the axial direction of said work rolls, and a cylindrical initial crown portion (1b, 2b) formed on the remainder of said work roll barrel,

characterized in that

- said convex curved initial crown portions (1a, 2a) of said upper and lower work rolls (1, 2) are tapered from the inner end of the cylindrical barrel portions (1b, 2b) toward the ends thereof and the length of these curved portions (1a, 2a) are not less than a half of the length of said work roll barrel (1, 2),
- the curve of said convex curved initial crown portion (1a, 2a) is represented by the formula $y = x^n$, where $2.5 \geq n \geq 1.5$, and
- said convex curved initial crown portions (1a, 2a) of said upper and lower work rolls (1, 2) are always disposed in overlapping relation to each other at at least part thereof."

V. In a communication pursuant to Article 11(2) RPBA posted on 8 February 2002 the Board indicated its

preliminary opinion that, having regard to the amendment of claim 1, document D8 should be regarded as constituting the closest state of the art.

VI. Oral proceedings before the Board were held on 24 September 2002. Opponents 01, who had taken no active part in the appeal proceedings, did not attend, having already indicated their intention in this respect in a fax dated 16 September 2002.

The appellants submitted revised claims 2 to 10 and a revised description to accompany claim 1 submitted with the statement of grounds of appeal and requested maintenance of the patent in amended form on the basis of these documents together with the drawings as granted (main request).

Claims 2 to 4 relate to preferred embodiments of the rolling mill according to claim 1, claim 5 to a rolling method using a rolling mill according to claim 2 and claims 6 to 10 to preferred embodiments of the method according to claim 5.

Subsidiarily the appellants requested maintenance of the patent in amended form with claim 1 of the main request replaced by claim 1 submitted with their letter dated 27 August 2002 (auxiliary request).

The arguments brought forward by the appellants can be summarized as follows:

The aim of the invention was to enable good profile control of the material being rolled over a wide range of strip widths, thus allowing schedule-free rolling to be performed.

The essential concept underlying the invention involved using work rolls which had convex initial crown portions of a particular form over at least half of the length of the work roll barrels, the remainder being cylindrical, and arranging the work rolls so that for all strip widths at least part of the strip was rolled between the convex portions. None of the prior art documents relied upon by the respondents contained anything which could be equated to this concept.

The respondents requested dismissal of the appeal and argued substantially as follows:

The subject-matter of claim 1 lacked novelty with respect to both documents D8 and D9.

In particular, document D8 disclosed that the convex initial crown portions could extend over one half of the length of the work roll barrel, so that when arranged as shown in Figure 2 of the drawings the degree of overlap of these convex portions would be considerable. Furthermore, the amount of crown was stated to be 0.1 to 0.5 mm, which corresponded to the amount of 0.3 mm to be found in the Figure 12 embodiment of the opposed patent. It was plainly evident to the person skilled in the art that the only practical form of convex curve compatible with this amount of crown was a parabolic one, ie with $y = x^2$, which lay in the middle of the range contemplated in claim 1. Thus all of the features of the claim were, at least implicitly, disclosed in this state of the art.

As for the document D9, this disclosed work rolls with a profile defined by a fifth order polynomial, for example as shown in Figure 9. It was well known in the relevant art, see for example Figure 8 and the relevant description of document D11, that such a polynomial with appropriately determined term coefficients would

generate a roll profile with a cylindrical portion and a convex initial crown portion represented by $y = x^n$, wherein $2.5 \geq n \geq 1.5$, as presently claimed. This was in fact confirmed by a statement to this effect in the original application.

Even if novelty with respect to documents D8 and D9 were to be recognised then any distinctions over the prior art lay, within the normal constructional competence of the person skilled in the art, as could be seen from document D11.

Reason for the Decision

1. The appeal complies with the formal requirements of Articles 106 to 108 and Rules 1(1) and 64 EPC. It is therefore admissible.

2. In comparison with granted claim 1 it has been made clear in claim 1 of the main request that the initial crown portion of each work roll is convexly curved along its whole length from the point where it adjoins the cylindrical portion to the end of the roll barrel. This clarification is consistent with the description and drawings of the preferred embodiments disclosed and clearly distinguishes the claimed subject-matter from the state of the art document D1 relied upon by the Opposition Division, in which the work roll profile comprises a short cylindrical portion at one end and a convex portion at the other end with a concave portion disposed therebetween.

Furthermore, the statement in claim 1 that the curve of the initial crown portion "approximates to a curve represented by an expression of the "n^{th}" order, where $n \geq 1.5$" has been replaced by the statement that this

curve is "represented by the formula $y = x^n$, where $2.5 \geq n \geq 1.5$". This amendment was originally objected to by the respondents as being both an addition of subject-matter and an extension of scope of the claim (Articles 123(2) and (3) EPC), but the objections were not pursued at the oral proceedings. The basis of the objections had been the contention that both the granted claim as well as the original application had purposely only envisaged an "approximation" to a curve represented by the formula in question, so that an exact correlation as now claimed had not been originally disclosed, nor was it within the ambit of the granted claim.

However, the original application contains a number of indications that the form of the initial crown portion is indeed represented by a curve of the formula now claimed and not just an approximation to it. Referring to the published A-document passages of relevance in this respect are to be found for example at page 6, lines 2 and 3 ("represented by an expression of the "n^{th}" order and is mainly a quadratic curve") and page 10, line 57 ("a curved initial crown represented by $y = x^n$ ($n \geq 1.5$ to 2.5)"). These indications have been retained in the patent specification and in the light of them there is no possibility that the reference to an "approximation" in granted claim 1 would be understood (against normal linguistic practice) as excluding an exact relationship.

The respondents relied in part on a passage at page 11, lines 2 to 6, of the original application where it is stated that in a modified form of the invention a special initial crown is represented by an expression of the fifth order over the whole roll length and that this initial crown approximates to the initial crown of the embodiment of Figure 12, ie that represented by the formula $y = x^n$ ($n \geq 1.5$ to 2.5), see above.

That passage is not present in the patent specification but in any case, through its reference to a "modification", it serves more to reinforce the idea that an initial crown represented by the formula $y = x^n$ where $2.5 \geq n \geq 1.5$, as presently claimed, was preferred and intended, rather than to undermine it.

Having regard to the above considerations the Board is of the opinion that claim 1 of the main request meets the requirements of Articles 123(2) and 3 EPC.

At the oral proceedings the respondents took issue for the first time with the meaning of the requirement "represented by the formula $y = x^n$, where $2.5 \geq n \geq 1.5$" without however formally raising an objection of lack of clarity under Article 84 EPC. The point the respondents sought to make was that the value of "y" (representing the amount of crown) at a point "x" along the length of the initial crown portion measured from the cylindrical portion cannot be calculated directly from the given formula since for example in the embodiment of Figure 12 the amount of crown is 0.3 mm at the end of the work barrel whereas "x" is 1100 mm; in other words a constant is missing from the formula. In this context the Board takes the view that the claim requires that the curve of the initial crown portion be represented by the formula without on the other hand giving absolute values of "y" in terms of "x". The value of the coefficient necessary to obtain those absolute values for practical implementation of the teachings of the patent specification can be determined in a routine manner by the person skilled in the art.

3. The patent specification relates to a 4-high rolling mill of well known basic construction comprising a pair of work rolls, a pair of back-up rolls, a roll bending device for applying bending force to the work rolls and a roll shifting device for shifting the work rolls axially.

In general terms the aim of the invention is to enable good control of the shape of the material being rolled over a wide range of strip widths and in a schedule-free manner (ie without the need to adhere to a specific sequence of strip width in operation of the mill). To this end each of the rolls is provided with a convex initial crown portion of a defined form and a length equal to at least half of the length of the work roll barrel being cylindrical. The initial crown portion of the two work rolls are arranged oppositely to each other and the set-up is such that there is always at least a partial overlap of the initial crown portions (ie for all envisaged strip widths).

4. The preamble of claim 1 is based on document D8, which was already mentioned in the original application. This document discloses a 4-high rolling mill of the basic type outlined above wherein both the work rolls and the back-up rolls are formed with convex initial crowns of 0.1 to 0.5 mm formed over ≤ 1/2 of their length. More specifically, it can be seen from Figure 2 that the remaining portion of each work roll is cylindrical and that the initial crown portions are arranged oppositely to each other. The respondents argued that the document also disclosed that the initial crown portions were in an overlapping relationship. Certainly, the reference in the English language abstract to the work rolls being arranged "to overlap the crowns alternately to each other" could be seen as supporting the view of the respondents. However, it is plainly evident from Figure 2, which accompanies the abstract, that no such

overlap is present. In view of this inconsistency a more plausible interpretation of the passage in question is that the crown portions are arranged oppositely ("alternately") to each other in an axial direction. In any case, there is clearly no disclosure in document D8 of the set-up of the rolling mill being such that there is always an overlapping relationship of the crown portions, as required by claim 1 under consideration.

Furthermore, document D8 (contains no indication of the nature of the curve of the initial crown portion, apart from the indication that the amount of crown is in the range of 0.1 to 0.5 mm.

The argument of the respondents in this respect that the person skilled in the art would recognise that the only practical form of curve to achieve this amount of crown would be a quadratic one, ie $y = x^2$, thus falling squarely within the claimed range cannot be followed as it is pure supposition. For example, the work rolls of document D8 have an overall form which is similar to that of the "K-WRS" roll shown in Figure 8 of document D11, which roll has a crown portion defined by a fourth order polynomial. Thus, contrary to the opinion of the respondents, the subject-matter of claim 1 is novel with respect to document D8.

5. The respondents also called into question the novelty of the claimed subject-matter with respect to the teachings of document D9. This document relates to a particular form of work roll profile for use for example in a 4-high rolling mill, the profile being a modification of the well-known concave-convex "CVC" profile of the respondents and comprising (see claim 1) portions of maximum gradient on either side of the centre line, where there may be a further portion of

maximum gradient. According to dependant claim 2 the profile in question is represented by a fifth order polynomial, ie:

$$r(x) = a + bx + cx^2 + +dx^3 + ex^4 + fx^5$$

As shown in the embodiment of Figure 9 the profile comprises an essentially linearly tapering central portion with a concave and a convex portion at respective ends.

The respondents argued that the person skilled in the art would be able without any difficulty to determine the constants of the polynomial in such a way as to generate a roll profile which was indistinguishable from that defined in claim 1 under consideration. In their view this fact had already been conceded by the appellants in the passage of the original application at page 11, lines 2 to 6, as mentioned above. From a mathematical point of view the contention of the respondents is undoubtedly correct. However, the reference to the generalized form of a fifth order polynomial does not constitute a disclosure of all possible profiles which can be generated from it by suitable choice of the constants involved and is certainly not a disclosure of the particular profile stated in present claim 1. It must also be added in this context that any profile represented by a fifth order polynomial as proposed in dependent claim 2 of document D9 must also be a profile which corresponds with the particular form of profile required by claim 1 of that document. As can be seen from the above description of that profile this is however not consistent with the requirement already stated in the preamble of claim 1 under consideration that the work roll barrel consists of contiguous cylindrical and convex crown portions.

The attack on the novelty of the subject-matter of claim 1 based on document D9 must therefore also fail for the above reason alone. Even if the Board had come to a different conclusion on this it would still have been necessary to determine whether document D9 disclosed all of the other structural and operational features set out in claim 1, in particular the one concerning the overlapping relationship of the convex initial crown portions. Here the Board notes that it is an essential characteristic of the work roll pairs disclosed in document D9 that the working gap is defined between a convex portion of one roll and a complementary concave portion of the other and vice versa.

6. For the consideration of inventive step the closest state of the art is that disclosed in document D8. The distinctions of the claimed subject matter over this art are apparent from the discussion in point 4 above relating to the question of novelty. There is nothing in the state of the art which could encourage the skilled person to provide initial crown portions of the claimed form along at least half of the length of the work roll barrel and to arrange the work rolls so that there is always overlap between these initial crown portions. Since the respondents relied much more on their arguments with respect to novelty and put forward nothing cogent on the question of inventive step, further explanations from the Board are unnecessary.

Order

For these reasons it is decided:

1. The decision under the appeal is set aside.

2. The case is remitted to the first instance with the order to maintain the patent in amended form on the basis of the following documents:

   Claim 1 submitted with the statement of grounds of appeal;

   Claim 2 to 10 and description submitted at the oral proceedings;

   Drawings as granted.

The Registrar: The Chairman:

S. Fabiani S. Crane