

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
28 March 2002 (28.03.2002)

PCT

(10) International Publication Number
WO 02/24964 A1

(51) International Patent Classification⁷: **C21D 1/06**, 9/36

(21) International Application Number: PCT/FI01/00792

(22) International Filing Date:
12 September 2001 (12.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
20002045 15 September 2000 (15.09.2000) FI

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(81) Designated States (national): AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA,

CH, CN, CO, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR MAKING A ROLL SHELL OF A ROLL USED IN THE MANUFACTURE OR FURTHER PROCESSING OF PAPER AND/OR BOARD

(57) Abstract: The invention relates to a method for making a roll shell of a roll used in the manufacture or further processing of paper and/or board. In the method, a shell blank of the roll shell is made of steel and the shell blank is subjected to heat treatments comprising heating for hardening, quenching and tempering treatments. In accordance with the invention, in heat treatment, the quenching is carried out such that hardening takes place in a directed manner from the outer surface of the roll shell inwards. The quenching is carried out such that neutral or compression stress is produced in the surface of the roll and that the formation of tensile stress in the surface of the roll is prevented by means of quenching.



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Method for making a roll shell of a roll used in the manufacture or further processing of paper and/or board

5 The present invention relates to a method for making a roll shell and, more particularly, the invention relates to a method for making a roll shell of a heatable roll, i.e. a so-called thermo roll, which roll operates in practice as heated to a high temperature.

10 More specifically, the invention relates to a method for making a roll shell of a roll used in the manufacture or further processing of paper and/or board, in which method a shell blank of the roll shell is made of steel and the shell blank is subjected to heat treatments comprising heating for hardening, quenching and tempering treatments.

15 In prior art there is known a solution in which a wrought steel shell is subjected to surface hardening by means of induction. A considerable drawback with this is, however, that the method is remarkably expensive and, in addition, that long and large-diameter roll blanks cannot be hardened economically by induction. Surface
20 hardening by induction requires that expensive ancillary equipment shall be arranged for the sole purpose of hardening. It has been necessary to separately provide large-diameter rolls which cannot be hardened economically by induction, for example, with a wear-resistant hard coating. If again it were contemplated that, for example, the quenching of a large-diameter roll blank is carried out into a
25 water basin, both sides of the shell will undergo hardening and tensile stress will be created in the surface. Because of the risk of breakage, it is very harmful when tensile stress remains in the roll surface.

30 With respect to the state of the art, reference is further made, for example, to US patent 5,546,856 describing a paper finishing method in which a long nip calender is made use of. By a long nip calender is generally meant a calender in which a nip

is formed between a heatable steel roll and a belt. The nip pressure in the long nip calender can be regulated in the cross direction of the machine, i.e. in the CD direction, whereby, for example, the thickness of paper can be profiled. The long nip calender can be formed of a belt calender in which a belt is passed, while
5 guided by auxiliary rolls, around one nip roll serving as a backing roll for a thermo roll. Thus, the long nip is formed between the thermo roll and said nip roll loading the belt. The most common long nip calender is a shoe calender in which the belt is arranged to run around a stationary support structure and in which the belt is loaded against a thermo roll by means of a loading shoe which is located inside
10 the loop of the belt and supported on the support structure. In the shoe calender, the long nip is formed between the thermo roll and the shoe loading the belt. Thus, the loading shoe of the shoe calender determines the length of the nip.

In the shoe calenders which represent the state of the art and which are in use, the
15 length of the nip is typically in a range of 50-70 mm, i.e. the dwell time of the web in the nip is considerably below 10 ms. The surface temperature of the thermo roll serving as the backing roll of the shoe roll is in a range of 70-300 °C, and the maximum pressure of the nip is in a range of 5-10 MPa. The hardness of the calender belt in the shoe calender is in a range of 70-100 ShA. Longer nips of
20 about 270 mm have been used in presses that are based on a shoe roll.

The method of making a roll according to the invention is not suitable for use in making rolls which are used in long nip calenders according to the state of the art.

25 The aim of the present invention is to provide a novel method for making a roll shell, which method allows drawbacks and problems associated with the state of the art to be avoided or at least substantially reduced. With a view to achieving this aim, the invention is mainly characterized in that in heat treatment, quenching is carried out such that hardening takes place in a directed manner from the outer
30 surface of the roll shell inwards.

In accordance with the invention, a tubular shell of a thermo roll is made of an alloy steel, for example, of a quenching and tempering steel such that a wrought steel blank is first made which is heat-treated after that in a suitable manner in order to achieve desired properties. The heat treatment is carried out in a manner
5 in which formation and decomposition of austenite occurs. The aim of the heat treatment is to provide the roll shell with a hard and wear-resistant surface so that the roll is suitable as such for use, for example, as a heatable roll in a calender. On the other hand, the surface produced and the basic structure of the material of the roll shall be such as to be suitable for being coated and/or uncoated. Further, the
10 properties of the material of the roll after heat treatment shall be such that in the roll shell there are no harmful stresses, which might cause the roll to break as a result of abrupt temperature variations.

The roll shell according to the invention is manufactured of a well-hardening steel,
15 for example, of a quenching and tempering alloy steel and, as one very usable grade, 34NiCrMo 6 steel is suitable for manufacture. The desired properties are attained such that, when the shell blank (steel blank) has been made, it is heat-treated such that the blank is subjected to heating for hardening to a high temperature above the temperature of formation of austenite, to a range of about 820-
20 920 °C. The quenching of the blank is performed after that in order to harden the blank, i.e. to form martensite in the structure. The quenching is carried out into a medium, for example, in a basin. The medium can be a liquid, for example, water or a liquid mixture, a gas mixture or a combination of a liquid and a gas mixture. The quenching can also be carried out by a fluidized bed method. It is essential
25 that before quenching the ends of the shell blank are closed, or water or another quenching medium is prevented by some other means from getting into the interior of the blank, to the inner surface of the blank. This provides the benefit that in connection with quenching, hardening, i.e. formation of martensite begins only from the outer surface of the shell blank, from which cooling proceeds in a directed manner in the material inwards. Consequently, in the invention, the inner
30 parts of the roll material are not hardened, as a rule, completely at any rate. When

in the invention, for example, the through hardening of the wall of the material is inhibited, the wear resistance of the roll material is improved. Tempering and relieving of residual stresses can be carried out after quenching. When manufactured according to the method of the invention, the roll shell is made metallurgically very stable. If the invention is intended particularly for the manufacture of a thermo roll shell, the shell shall be additionally provided with perforations for circulation of a heating medium. These holes or axial bores can be formed in the roll shell either before hardening or after hardening.

Thus, the change of the microstructure of the material from a martensitic structure to a bainitic or a bainitic-martensitic or a bainitic-ferritic structure or to combinations of them occurs steplessly. This enables neutral or compression stress to be formed advantageously in the outer surface of the shell from which cooling begins, because with the progress of cooling the increase in the volume of material becomes smaller in the direction from the surface towards the interior. Since a neutral stress state or compression stress is created in the outer surface, the shell is not prone to damage or breakage even when abrupt variations of temperature occur in a finished roll which is in use. Such variations are possible if, for example, a liquid, e.g. water, is passed to a hot roll surface. If tensile stress remained in the surface, rapid cooling of a hot roll might cause the roll to break. The formation of tensile stress in the surface of the roll is prevented by means of the invention.

In the following, one method of making a roll shell is described by way of example.

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The steel used as material:

- DIN 34NiCrMo 6, number identification 1.6582

Analysis:

30 - C% 0.30-0.38, Si% ≤ 0.4 , Mn% 0.5-0.8, P% < 0.035 , S% ≤ 0.035 , Cr% 1.3-1.7, Mo% 0.15-0.30, Ni% 1.3-1.7

Mechanical values:

- Tensile strength 1000-1200 N/mm²
- Elongation from a transversely taken tension test bar $\leq 12\%$
- 5 - Hardness 350-500 HV₂₀
- Heat resistance 300 °C about -15%

Microstructure in the surface:

- 100% tempered martensite

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The melting of steel takes place in an electric arc furnace (EAF) and the alloying proper as well as the setting of temperature take place in a holding furnace (LF), which is provided with electromagnetic stirring. Casting is carried out by up-running casting into an ingot mould. When the casting has solidified and cooled to about 600 °C, it is moved to a forge, into a heating furnace in which it is heated to a temperature of about 1200-1285 °C at which forging is started and which is the temperature of the furnace.

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The roll shell (tube) is made out of the casting by forging as a free forging. Advantageously, a sturdy hydraulic press is employed in forging, which makes it possible to use sturdy tools, by means of which the low density in the middle of the casting can be compressed. In a tubular forging, the low density portion in the middle is cut off so as to form a blank for a centre hole to be made. Slag materials and other defects collected in the casting are removed from the cast mass in connection with forging. The manufacture of a tubular forging takes place by pressing on a mandrel. When forged in the manner described above, the degree of deformation of the roll tube can be made uniformly good.

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After forging, heat treatments are carried out such that there is first cooling in the air. This is immediately followed by normalizing to 820-920 °C, from which cooling takes place freely into the air. Immediately after that, soft annealing is

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carried out at about 630-700 °C, which is followed by cooling to room temperature. The thus heat-treated steel is fine-grained, soft annealed for a quenching and tempering treatment.

- 5 Since the surface of the blank must become clean, the blank is subjected to rough machining before it is quenched and tempered to a desired strength/hardness level. In that connection, soft annealing is of advantage because normally a large amount of material has to be removed. Quenching and tempering, i.e. heating to the austenite range and tempering after hardening are carried out in a furnace. The
- 10 quenching can be carried out into a liquid basin, for example, into an oil basin or water basin, or quenching can be carried out as air quenching. Since the strength level requirements of the piece are high, it is advantageous that the roll shell blanks are quenched into water. Tempering is carried out immediately after quenching at a temperature of about 340-660 °C. Since it is a question of making a
- 15 roll shell of a so-called thermo roll, the shell shall be provided further with substantially axial peripheral bores for circulation of a heating medium in the finished roll. These peripheral bores can be made when the shell is in a quenched and tempered state.
- 20 The invention is not strictly confined to the description given above nor to the specific mode of operation of the invention set forth in the description, but the different modes of operation of the invention may vary within the inventive idea defined in the accompanying claims.

Claims

1. A method for making a roll shell of a roll used in the manufacture or further processing of paper and/or board, in which method a shell blank of the roll shell is made of steel and the shell blank is subjected to heat treatments comprising heating for hardening, quenching and tempering treatments, **characterized** in that, in heat treatment, the quenching is carried out such that hardening takes place in a directed manner from the outer surface of the roll shell inwards.
2. A method according to claim 1, **characterized** in that the quenching is carried out into a medium.
3. A method according to claim 2, **characterized** in that, in the quenching, the quenching medium is prevented from getting to the inner surface of the roll shell.
4. A method according to any one of the preceding claims, **characterized** in that the quenching is carried out into a liquid and/or gas mixture.
5. A method according to any one of the preceding claims, **characterized** in that the quenching is carried out by means of a fluidized bed method.
6. A method according to any one of the preceding claims, **characterized** in that the quenching is carried out such that neutral or compression stress is produced in the surface of the roll.
7. A method according to any one of the preceding claims, **characterized** in that the formation of tensile stress in the surface of the roll is prevented by quenching.
8. A method according to any one of the preceding claims, **characterized** in that the roll shell is provided with through holes or equivalent bores extending mainly in the axial direction before heat treatment or after heat treatment.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 01/00792

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G21D 1/06, G21D 9/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4444556 A (ANDERSSON), 24 April 1984 (24.04.84), claim 1, abstract --	1-8
A	GB 906029 A (AEI-BIRLEC LIMITED), 19 Sept 1962 (19.09.62) -----	1-8

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

21 January 2002

Date of mailing of the international search report

75.02.02

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INTERNATIONAL SEARCH REPORT

Information on patent family members

27/12/02

International application No.

PCT/FI 01/00792

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	4444556	A	24/04/84	DE	3217081 A	02/12/82
				GB	2098631 A,B	24/11/82
				JP	57203719 A	14/12/82
				SE	437675 B,C	11/03/85
				SE	8103029 A	15/11/82

GB	906029	A	19/09/62	NONE		
