Title: METHOD FOR CONTINUOUS BALANCING OF LONG FLEXIBLE ROLL TUBES

Abstract: A method for continuous balancing of long flexible tubular rollers (1), where the balancing mass is placed inside tubular roller (1). The eccentricity (e) of the centre of gravity of the mass of each wanted cross section level, located in the cross section level of the tubular roller, is from the centre and its direction (θe) determined in measuring the circularity of corresponding cross section level of roller and deviations from it, the additional mass and its angle of direction (θe + Π) required by each said cross section level is calculated, the fluid and hardening additional mass (9) is sprayed to roller (1) inner surface in order to compensate
METHOD FOR CONTINUOUS BALANCING OF LONG FLEXIBLE ROLL TUBES

The method relates to continuous balancing of long flexible tubular rollers, where additional mass corresponding to each calculated cross section level is placed inside the tubular roller in each cross section level.

Previously known from the Finnish patent publication 98404 B1 is a method for continuous balancing of a flexible roller or cylinder, in which method the measured imbalance is compensated making new grooves or pockets in the roller or changing existing grooves or pockets. By balancing such a cylinder the grooves must be machined separately on the cylinder surface or there must be grooves before. For instance, in an uncovered paper machine tubular roller the surface is of metal and it is not allowed to make any grooves in it. On the other hand, making grooves in the inner surface of such a cylinder makes the construction weaker and the grooves also have an effect on the behaviour of such a cylinder by calendar nip contact. Making grooves on the roller inner surface is also a complicated and expensive stage.

By means of the method according to this invention the problems in connection with balancing of tubular rollers are solved and the quality and accuracy of balancing improved remarkably. The method according to the invention is characterized in that the eccentricity of the centre of gravity of each wanted additional mass in the tubular roller cross section level, from the centre and the direction is determined measuring the circularity of the tubular roller of the corresponding cross section level and the deviations from it, additional mass needed by each wanted cross section level and its angle of direction is calculated, and fluid and hardening additional mass sprayed on the roller inner surface in order to compensate the eccentricity of the location of the centre of gravity in wanted tubular roller cross section levels.

Additional features or alternatives characteristic for the method according to this invention are presented in the enclosed dependent claims.

The advantage of the method is that the inner surface of the tubular roller must not be separately machined because of balancing. In the method the shape of the inner surface
and the eccentricity error caused by it is has been taken notice of in the form the inner surface has. Necessary data to be measured from the tubular roller can in the advantageous embodiment of the invention be received by measuring from the tubular roller outside, whereat measuring is easily carried out. When the eccentricity values are measured along the whole roller length and registered at the roller cross section level, the track of the centre of gravity can be determined from roller end to end, which is the condition for continuous compensation of eccentricity. Compensation takes place by means of spraying mass simply on the roller inner surface without any grooves or pockets. The method does not cause any disturbance in the roller behaviour.

In the following the method is disclosed with reference to the enclosed drawing, where

Fig. 1 shows the tubular roller from the side.

Fig. 2 shows the profile of form errors emphasized.

Fig. 3 shows cross-cuttings of figure 2.

Fig. 4 shows measuring of roller scatterings and dimensions.

Fig. 5 shows the tubular roller from the end with coordinates added.

Fig. 6 shows the tubular roller, which has eccentricity and additional mass, from the end.

Fig. 7 shows the tubular roller with a sprayed homogenous tape inside.

Fig. 8 shows the tubular roller into which additional mass is sprayed.

Fig. 9 shows the eccentricity value along the tubular length in x and y coordinates.

There is in figures 1-3 a tubular roller 1, which has, independent from different ways of manufacturing, always errors. There is in the tubular roller circularity errors and since it has an inner hole resulting in that the wall thickness also changes. These facts mean that the centre of gravity cannot be held in the centre, i.e. on the line of roller axis. Also the porosity of the roller material or other local density differences of material move the centre of gravity corresponding to the controlled cross section spot, off the line of axis.

In the method as per the invention the qualities of the tubular roller are measured from sequential cross sections chosen at wanted frequency. In figure 4 a measuring situation is presented, where measuring device 2 includes a measuring head indicating the circularity of the circle points of the outer circle of the tubular roller. Thus the measuring indicates
scattering AR in the cross section in question. As sensor there is a precise untouchable distance gauge known per se.

Measuring sensor 3 measures the wall thickness by ultra sound principle, whereat an emulsion required by measuring is fed from nozzle 4 between measuring head and roller surface.

The roller is rotating during measuring and its angle positions and measured values corresponding to them are most suitably registered into a computer connected to measuring device 2. Measuring device 2 is moved in the roller direction, whereby at wanted frequency from the whole tubular roller a map of its form errors is achieved and it is possible to calculate the eccentricity value e and its angle of direction θ per each chosen unit of length. The track of the roller centre of gravity, which is a continuous curve, is detected and by means of it, it is possible to determine the compensation mass coming to the roller opposite surface. By measuring it is possible to detect the volume of the tubular roller in the cross section, when to the cross section area also the lengthwise travel of the roller is always connected, may it then be a differentially short travel. When the density of such a differentially thick ring is assumed to be constant, the position and direction of the centre of gravity can be determined in the way described above.

Figure 5 shows eccentricity e in a spot and figure 6 shows the location of compensation mass 9 in the opposite surface of eccentricity e.

Figure 9 shows how the measured and calculated eccentricity e can be indicated in the x coordination and y coordination as function L of the length of the tubular roller. By means of these ones it is possible to determine into which angle position θ + Π the compensation mass in each position of roller length L shall be placed. The mass 9 size in each spot is determined by the size of eccentricity e.

Figure 8 shows spraying of compensation mass 9 on tubular roller inner face 1. The sprayer has a shaft 7 and a nozzle 8 in its top. Most suitably nozzle 8 is moved axially and the roller rotated in the way required by the angle positions. Roller 1 can also stay put,
while the nozzle is turned and moved axially. Since the quantity of mass varies axially, can its size, e.g. the thickness of layer s coming to its surface can be determined by means of nozzle 8 transporting speed. Another alternative is to adjust within the time unit the quantity of mass 9 discharging from nozzle 8, for instance adjusting the nozzle opening or adjusting the nozzle pressure.

Most suitably compensation mass 9 is a hardening mass 9, which is fluid material sprayed through nozzle 8. Its hardening can take place independently, by means of heating or light, as by means of ultra violet light. Compensation mass 9 becomes homogenous tape, the thickness and/or width of which varies inside the tubular roller, and which moves from one roller end to the other on the inner surface along a track determined by the angel positions received by the measurements and the calculations.
CLAIMS

1. A method for continuous balancing of long flexible tubular rollers (1), where the balancing mass is placed inside tubular roller (1), characterized in that the eccentricity (e) of the centre of gravity of the mass of each wanted cross section level, located in the cross section level of the tubular roller, is from the centre and its direction (θe) determined by measuring the circularity of the corresponding cross section level of roller (1) and the deviations from it, the additional mass and its angle of direction (θe + Π) required by each said cross section level, is calculated, the fluid and hardening additional mass (9) is sprayed on roller (1) inner surface in order to compensate the eccentricity (e) of the location of the centre of gravity in wanted cross section levels.

2. A method according to claim 1 characterized in that the circularity of the cross section level and deviations from it are measured by rotating the roller (1) and moving the measuring device (2) in the direction of said roller and recording the measuring results as function of the roller length and angle of rotation (θ).

3. A method according to claim 1 characterized in that the measurements are carried out from roller (1) outside.

4. A method according to claim 1 characterized in that the roller density data is measured by means of a method of measurement clarifying the magnetic features of mass, the density of penetration of known radiations or density and or porosity of other corresponding mass, and received density data is taken notice of determining the eccentricity value (e) calculated by means of the mass volume and its location.

5. A method according to claim 1 characterized in that the additional mass (9) is sprayed on roller inner surface as continuous spraying into an angle position determined by the calculated angle of rotation (θe + Π) and by adjusting the quantity of mass (9) either by increasing or decreasing the quantity of mass discharging in a time unit or by increasing or decreasing the transportation speed of the mass nozzle in regard to the roller.
6. A method according to claim 1 characterized in that the surface area and its shape in the cross section level is determined by measuring the wall thickness of the corresponding spot and the distance from the centre of the circle points of the outer circle of the corresponding spot.

7. A method according to claim 1 characterized in that additional mass (9) is sprayed by moving mass nozzle (8) axially and rotating roller (1) into an angle position corresponding to each axial position.

8. A method according to claim 1 characterized in that additional mass (9) is sprayed by moving mass nozzle (8) axially and rotating different axial positions to corresponding angle positions with roller (1) staying put.
# INTERNATIONAL SEARCH REPORT

**International application No.**

**PCT/FI 03/00206**

## A. CLASSIFICATION OF SUBJECT MATTER

**IPC7:** D21G 1/00R4, F16F 15/32, G01M 1/32

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:** D21G, F16F, G01M

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

SE, DK, FI, NO classes as above

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

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 4170896 A (G.J. KORKOSZ), 16 October 1979 (16.10.79), see entire document</td>
<td>1-8</td>
</tr>
<tr>
<td>A</td>
<td>FR 2071543 A (DAMON, F.), 17 Sept 1971 (17.09.71)</td>
<td>1-8</td>
</tr>
<tr>
<td>A</td>
<td>DE 4417194 A1 (DÖRRIES GMBH), 23 November 1995 (23.11.95)</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>US 5096734 A (O. NIKULAINEN ET AL), 17 March 1992 (17.03.92)</td>
<td></td>
</tr>
</tbody>
</table>

[X] Further documents are listed in the continuation of Box C.  
[X] See patent family annex.

* Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier application or patent but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed
  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "&" document member of the same patent family

Date of the actual completion of the international search: **11 June 2003**

Date of mailing of the international search report: **13-06-2003**

Name and mailing address of the ISA/Swedish Patent Office:
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer: Annette Riedel / MRo
Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>US 5397291 A (J. JÄRVELÄ), 14 March 1995 (14.03.95)</td>
<td>--</td>
</tr>
<tr>
<td>A</td>
<td>US 4545021 A (M. SUZUKI ET AL), 1 October 1985 (01.10.85)</td>
<td>--</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>US 4170896 A</td>
<td>16/10/79</td>
<td>AU 524289 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 4540779 A</td>
</tr>
<tr>
<td>FR 2071543 A</td>
<td>17/09/71</td>
<td>NONE</td>
</tr>
<tr>
<td>DE 4417194 A1</td>
<td>23/11/95</td>
<td>NONE</td>
</tr>
<tr>
<td>US 5096734 A</td>
<td>17/03/92</td>
<td>FI 80954 B,C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FI 883084 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5170547 A</td>
</tr>
<tr>
<td>US 5397291 A</td>
<td>14/03/95</td>
<td>AT 125603 T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2084493 A,C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69203702 D,T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0545880 A,B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SE 0545880 T3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FI 89737 B,C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FI 915750 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5331737 A</td>
</tr>
<tr>
<td>US 4545021 A</td>
<td>01/10/85</td>
<td>DE 3175173 D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 0052015 A,B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 1439171 C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 57083746 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 62047249 B</td>
</tr>
</tbody>
</table>