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(71) Applicant: **Arcelormittal Poland S.A.**
41-208 Dabrowa Górnicza (PL)

(72) Inventors:
• **ZAK, Sylwester**
41-300 Dąbrowa Górnicza (PL)
• **WOZNIAK, Dariusz**
40-576 Katowice (PL)

(74) Representative: **Marek, Joanna**
ul. Wodzisławska 14
44-200 Rybnik (PL)

(54) **STRAIGHTENING ROLLER FOR A ROLLER STRAIGHTENING MACHINE**

(57) The subject-matter of the invention is straightening roller for a roller straightening machine intended specifically for straightening railway or tramway rails, characterised in that the working surface of straightening roller is concave over its entire length, while the level of concavity is variable from the extreme points described by radii, which are also the maximum width of the working

surface of the straightening roller, up to the centre of the straightening roller's axis of symmetry, where lines inclined towards each other at an obtuse angle between 178° and 179.5° converge and are smoothly joined by a radius - in this area the roller reaches its maximum difference in diameter at the extreme, most convex points and at the straightening roller's axis of symmetry.

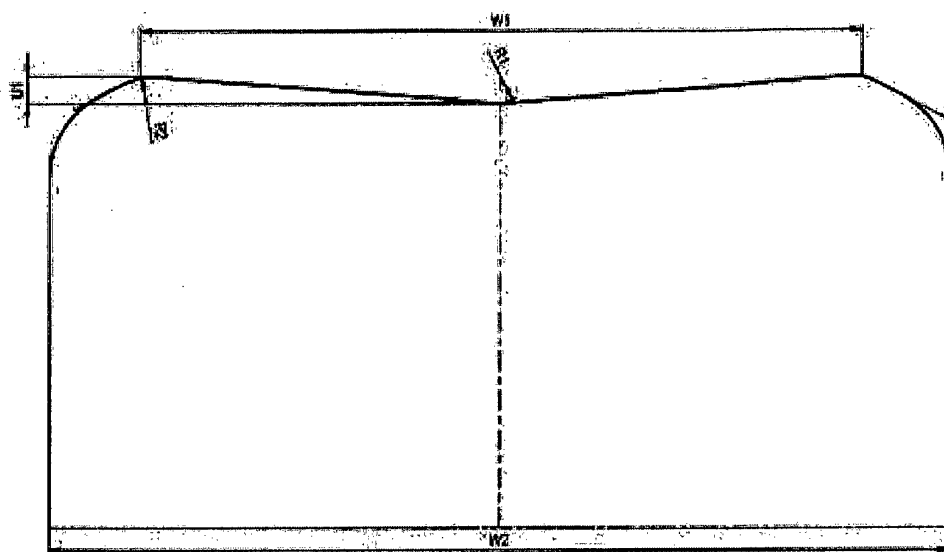


Fig. 1

Description

[0001] The subject-matter of the invention is straightening roller for a roller straightening machine, which is used in both horizontal and vertical straighteners intended for straightening railway and tramway rails (grooved rails).

[0002] The requirements for the straightness of rails along their entire length are contained in rail standards and define the maximum permissible deviations in vertical and horizontal planes. Since rails after rolling do not meet this straightness requirement, they must be subject to a straightening process, which is carried out in a unit comprising vertical and horizontal roller straighteners. Mostly 7-roller or 9-roller straighteners are used.

[0003] Solutions known in the state of the art are based on optimising the adjustments of rollers in order to reduce the level of internal stresses.

[0004] The Chinese patent description CN110538873A provides information on the method of controlling residual stresses in a foot of 100-metre steel rail - the invention belong to the field of steel rail production. In accordance with the method provided for in the invention, the steel rail is straightened after rolling and pre-bending, upper limit values of three process parameters: the total pressure value of horizontal straightening rollers, the difference in the pressure force of adjacent horizontal straightening rollers, and the straightening speed are adjusted during the straightening process, wherein, during the straightening process, the total pressure force of horizontal straightening rollers is adjusted so that it is within 55 mm, the difference in the pressure force of adjacent horizontal straightening rollers is adjusted, namely, the straightening force R2, R4, R6 and R8 is reduced in sequence, the difference in straightening force value between R2 and R4, R4 and R6, R6 and R8 is adjusted so that it is within 10 mm, 8 mm and 6 mm, respectively, and the straightening speed is less than or equal to 2.0 m/s. This method has beneficial effect due to the fact that residual stress - after straightening of a 100-metre steel rail - can be effectively adjusted, and the residual stress of rail foot is adjusted to be within 200 MPa.

[0005] Solutions involving the use of a set of additional rollers in a lateral and upper position in relation to the axis of the rail or one additional straightening roller with a smaller diameter in relation to main straightening rollers, which reduces lateral bending of the material being straightened, and consequently reduces the length of the non-straightened part, are known as well.

[0006] Optimising the adjustments of roller straightener can significantly worsen the straightness parameter of rails as a result of using too small bends. On the other hand, increasing the adjustment level of straightening rollers results in an increase in the pressure force of the rollers, and, therefore, increase in the level of residual stresses in the rail. This implies that, in practice, the optimisation of straightening roller adjustments is difficult, requires a great deal of knowledge and has a severely limited potential for lowering the level of residual stresses. Other solutions known from the state of the art involve the use of additional rollers. However, this requires alteration of the structure of straightening system, entails additional expenses and can result in increased failure rates of the straightening unit due to increased complexity of the equipment. The use of additional rollers makes it more difficult to find the correct roller adjustment parameters due to the increased complexity of the system and the need to predict the impact of additional elements acting on the rail during the complex rail straightening process that depends on many conditions.

[0007] The aim of the invention was to develop straightening rollers allowing to reduce the level of residual stress of rails being straightened while maintaining the required straightness of rail after the straightening process without interfering with the structure of straightening machines used in the state of the art.

[0008] The essence of the invention is a straightening roller for a roller straightening machine intended specifically for straightening railway or tramway rails (grooved rails), characterised in that the working surface of straightening roller is concave over its entire length, while the level of concavity is variable from the extreme points described by radii, which are also the maximum width of the working surface of the straightening roller, up to the centre of the straightening roller's axis of symmetry, where lines inclined towards each other at an obtuse angle between 178° and 179.5° converge and are smoothly joined by a radius - in this area the roller reaches its maximum difference in diameter at the extreme, most convex points and at the straightening roller's axis of symmetry.

[0009] It is preferable that the width of the working surface of straightening roller is between 50% and 55% of the width of the foot of the rail to be straightened.

[0010] The expression "working surface of straightening rollers" shall be understood as surface of roller located on the foot side of the rail to be straightened.

[0011] The lines inclined towards each other at obtuse angles and joined by an arc at the centre of the straightening roller's axis of symmetry are lines determining the inclination of the foot of the rail being straightened. Such a design of straightening roller's working surface minimises contact between the central surface of the rail foot and the straightening roller during the straightening process.

[0012] In the straightening rollers used to date, no modification has been made to the shape of their working surface over the entire range of contact between this surface and the surface of the rail to be straightened, so that the working surface of straightening rollers is described by inclined lines, passing into lines described by radii in important, sensitive places.

[0013] The width of the working surface of the roller is selected to be more than 50% of the width of the foot of the rail to be straightened, but not more than 55% of the width of the rail foot. This ensures that the outer parts of the straightening roller according to the invention are pressed against the corresponding length of the rail foot, i.e. at a point where the first inclination of the upper surface of the rail foot running from the web of the rail to the transition to the second inclination ends. Such a shape of straightening roller selected according to the invention allows to apply less force to straighten the rail, resulting in a reduced level of residual stresses in the area of rail foot, and ensuring better straightening of the rail after it leaves the straightening machine and greater control of the clamping of fishing (chamber). The modified working surface of the straightening roller according to the invention, which ensures smooth transitions described by radii between straight lines, results in such a distribution of residual stresses in the foot of the rail to be straightened that tensile stresses are introduced to a lesser extent, resulting in a reduced level of total residual stresses of rails in this area. There are no sharp edges at any point of the contact surface between the roller and the rail foot that would damage the surface of the rail foot causing scratches and sharp dents.

[0014] In addition, the use of the concave working surface of the straightening roller according to the invention on the foot side of the rail to be straightened increases the working surface area of the roller in comparison with rollers known from the state of the art, causing the forces acting during rail straightening to be distributed over a larger area and thus reducing unit stresses in all parts of the rail, i.e. foot, head and web.

[0015] New design of straightening roller shape according to the invention intended for use in roller straighteners also results in less roller action at the point where residual stresses of the rail to be straightened are measured, i.e. at the centre of symmetry of the rail foot, while at the same time, the increase in their working surface area in comparison with rollers known from the state of the art results in the distribution of the forces acting during straightening over a larger surface area and thus reduces unit stresses. The use of rollers according to the invention with newly developed design of their working surfaces results in the occurrence of compressive or low tensile internal stresses near the rail axis in the direction parallel to the rail axis. This allows to reduce residual tensile stresses measured during a rail slice cutting test according to EN13674-1 to values well below 50% of the requirements of EN13674-1, i.e. less than 125 MPa against a permissible level of 250 MPa. A suitable combination of the positioning of profile rollers according to the invention in a sequential arrangement on vertical straightening machine shafts even makes it possible to achieve residual stress levels in the range of 30-50 MPa. This proves that the use of rollers according to the invention with a modified shape of the working surface influences the level and type of residual stresses of the rail to be straightened and its distribution in the subsurface layer after straightening. Such a modification of the stress level in the rail foot consequently leads to a reduction of longitudinal tensile stresses in the whole foot volume.

[0016] By using straightening rollers for roller straightener machine according to the invention, a several-fold (up to a maximum of almost six-fold) reduction in the level of internal stresses in the rail foot was achieved compared to reference measurements (based on available data in the literature).

Table 1. Average levels of residual stresses in the rail foot obtained using profile rollers in different variants of their positioning.

Requirements of the standard	Conventional rollers (reference measurement)	Profile rollers - variant 1	Profile rollers - variant 2	Profile rollers - variant 3	Profile rollers - variant 4	Profile rollers - variant 5
250 MPa	190-230 MPa	70 MPa	30 MPa	50 MPa	125 MPa	112 MPa

[0017] The use of straightening rollers for a roller straightening machine also made it possible to maintain a high degree of straightness of the rail along its entire length in both vertical and horizontal planes after the straightening operation.

[0018] Straightening rollers installed in a straightening machine according to the invention can be used without the need to develop new roller straightener adjustments. They can also be used in straightening machines already in operation by replacing rollers known from the state of the art that have a flat working surface with straightening rollers according to the present invention.

[0019] Straightening rollers with a reshaped working surface can also be obtained by returning of the existing straightening rollers in order to give their working surface appropriate shape (pass design).

[0020] The use of rollers with a concave working surface has beneficial effect on railway safety due to the increased operational reliability of rails and reduction in their tendency to crack as a result of low levels of residual stresses from the manufacturing process.

[0021] The object according to the invention in the form of a straightening roller is shown in the figures:

Fig. 1 - drawing of a straightening roller according to the invention

Fig. 2 - example of the use of rollers according to the invention in a vertical straightener in schematic view.

[0022] Fig. 1 shows a drawing of straightening roller according to the invention with a width of W2, where the concave working surface of the roller is visible. The working surface of the roller is characterised by a variable level of concavity starting from the extreme points, described by the radius R2. The points of contact between R2 radii and inclination lines located on both sides of the straightening roller also represent the maximum width of the roller's working surface W1, up to the centre of the roller's axis of symmetry, where the inclination lines of the foot of the rail to be straightened converge and their smooth connection by the R1 radius is ensured. In this area W1, the roller reaches a maximum difference in diameter (indicated in the figure as U1) located at the extreme points - those most convex and in the axis of symmetry. The design of the working surface of straightening rollers according to the invention is described in the figure by two lines inclined towards each other at an obtuse angle.

[0023] Fig. 2 shows an example of the use of straightening rollers according to the invention in a 7-roller vertical straightening machine. The rail to be straightened is fed into the straightening machine via the UW input device and then moved between a series of adjustable rollers R2, R4, R6 and a series of driven rollers R1, R3, R5 and R7. Driven rollers R1, R3, R5 and R7 are rollers with a concave working surface and are located on the foot side of the rail to be straightened. Then, the rail is then taken out of the straightening machine by the RW vertical withdrawal roller.

Claims

1. Straightening roller for a roller straightening machine intended specifically for straightening railway or tramway rails, **characterised in that** the working surface of straightening roller is concave over its entire length, while the level of concavity is variable from the extreme points described by radii, which are also the maximum width of the working surface of the straightening roller, up to the centre of the straightening roller's axis of symmetry, where lines inclined towards each other at an obtuse angle between 178° and 179.5° converge and are smoothly joined by a radius - in this area the roller reaches its maximum difference in diameter at the extreme, most convex points and at the straightening roller's axis of symmetry.
2. Straightening roller according to claim 1, **characterised in that** the width of the working surface of straightening roller is in the range of 50% to 55% of the width of the foot of the rail to be straightened.

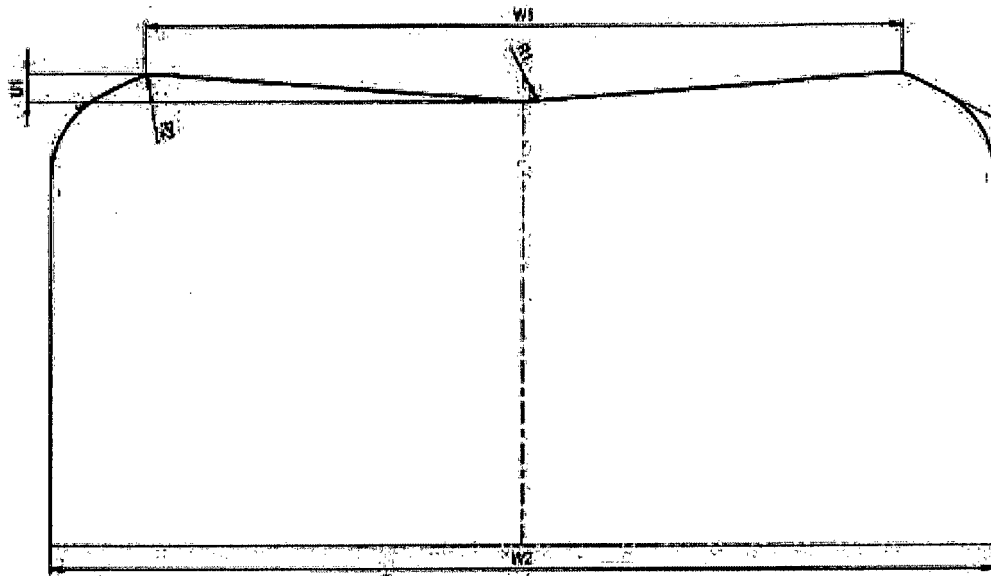


Fig. 1

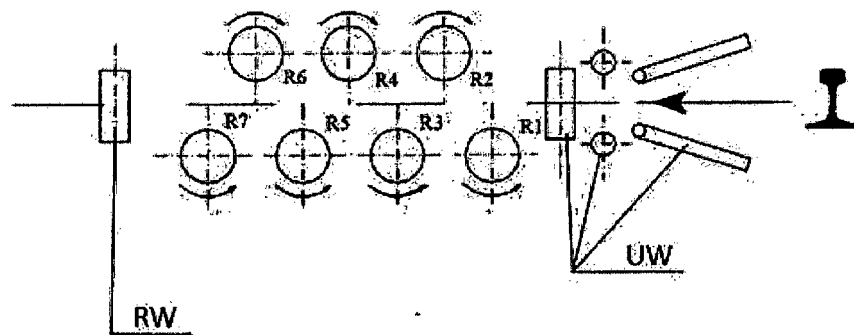


Fig. 2



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Application Number

EP 23 46 0019

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EPO FORM 1503 03.82 (P04C01)

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 2 October 2023	Examiner Stanic, Franjo
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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