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(54) Railway rails

(57) The disclosure relates to heavy-masse railway rails in which an increased fatigue resistance is achieved by increasing the moment of inertia of cross-section of rail and by increasing the ratio of fatigue loading, a sub-unity ratio given by the specific moments of fatigue of the two portions of cross-section of rail defined by the horizontal neutral axis of cross-section of rail, or by the squares of normal unity fatigue stresses, which are maximum at the two vertical extremities of cross-section of rail.

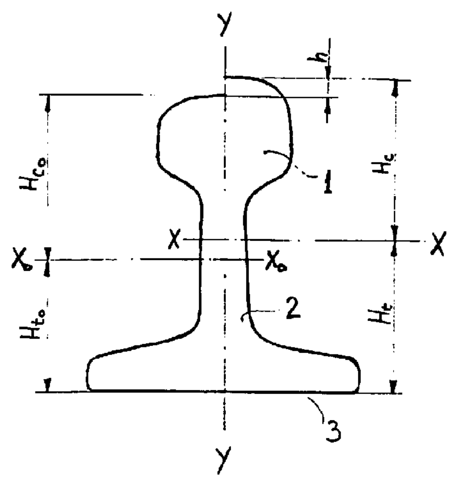

FIG. 1

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Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates to heavy-type railway rails for rolling stock capable of supporting an increased traffic on the track.

2. PRIOR ART

In the domain of high-speed and heavy-traffic railway rails, several types of heavy-masse railway rails are known in which such rails sustain increased loads as the area of cross-section of rail and the moment of inertia of cross-section of rail are increased as well. Among the widely used rail types are type UIC60, types 54E STAS 9592-74 and R65 STAS 11201-79 of Roumania, types S60 and S64 of Germany, types 112 lbs and 155 lbs of United States. These types can be found in an extented list of rail types given in "Schweisstechnisches Taschenbuch", Edition 1968, Elektro-Thermit Corp., Germany. Such rail types achieve increased loads solely by increasing the moment of inertia of cross-section of rail, with the result that the load of fatigue of rail increases at a lower rate compared to the moment of inertia of cross-section of rail, thus increasing the cost of railway. This result is more visible in case of heavier heavy-type rails.

However, no rail type with a masse greater than 51 Kg/l.m. is known in which the stress applied to the rail head is decreased by increasing the moment of inertia of cross-section of rail and by increasing a height between the rail base and the neutral axis of rail while the moment of fatigue of rail base and the moment of fatigue of rail head are so balanced as to obtain an increase of the endurance of the rail.

SUMMARY OF THE INVENTION

These disadvantages are overcome by the present invention by creating a novel heavy-masse rail type. The present invention comprises a rail composed of a rail base, a rail web and a rail head. It is an objective of the present invention to provide a rail having an increased moment of inertia of cross-section and an increased height from the lower side of rail base to the neutral axis of the rail. It is another objective of the present invention to obtain a balanced stress in the rail base and in the rail head by providing a rail in which the ratio of the moment of fatigue of rail base divided by the moment of fatigue of rail head is between 0.9 and 1.

It is further an objective of the present invention to provide a heavy-type rail with increased load of fatigue.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further illustrated by reference to the accompanying drawing, in which:

FIG. 1 is the schematic representation of a method of implementation of railway rails of heavy type with increased fatigue resistance, according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The description is made with reference to heavy-type railway rail, but this should not limit the scope or domain of application of the present invention.

The present invention introduces new relations related to endurance of materials, and of bars subjected to bending test, respectively. The general equation of bending momentum for a bar simple-standing loaded with a load of fatigue P_{ob} is given by the relation:

$$M_i = \iint \sigma \, dy \, d\Omega$$

The bending momentum is balanced by the sum of moments given by unitary normal stresses within the bar. It is known that such stresses are null upon the horizontal neutral axis and maximum at vertical extremities of the bar. It is derived that:

$$M_{ob_{sp_c}} = \sigma_{ob_c} \times H_c \times \omega \; [Kg \times mm] \qquad (1)$$

$$M_{ob_{sp_t}} = \sigma_{ob_t} \times H_t \times \omega \; [Kg \times mm]$$

where:

$$M_{ob_{sp_c}}$$

is the specific moment of fatigue of the upper side of rail head,

$$M_{ob_{sp_t}}$$

is the specific moment of fatigue of the lower side of rail base,

$$\sigma_{ob_c} \text{ and } \sigma_{ob_t}$$

are the unity normal stresses of fatigue of upper side of rail head and lower side of rail base, respectively,

H_c is the height of rail head with respect to the horizontal neutral axis of rail,

H_t is the height from the lower side of rail base to the horizontal neutral axis of rail,

$\omega \rightarrow 1\,mm^2$ is the minimum area element.

The present invention introduces the loading factor of fatigue of cross-section of rail, defined as:

$$R_{i_{ob}} = \frac{M_{ob_{sp_t}}}{M_{ob_{sp_c}}} \quad (2)$$

$$R_{i_{ob}}$$

has a sub-unity value given by the ratio of the two specific moments of fatigue. Developing the ratio in relation (2), it is obtained:

$$\frac{\sigma_{ob_t}}{\sigma_{ob_c}} = \frac{H_t}{H_c} \quad (3)$$

It is derived that R_{iob} is alternatively given by the ratio of squares of the heights of rail base and rail head, respectively, with respect to the horizontal neutral axis of cross-section:

$$R_{i_{ob}} = \frac{H_t^2}{H_c^2} \quad (4)$$

With these relations it is derived: $$R_{i_{ob}} = \frac{W_{x_c}^2}{W_{x_t}^2}$$

where:

$$W_{x_c}$$

is the modulus of toughness of rail head,

$$W_{x_t}$$

is the modulus of toughness of rail base.

With the characteristics of laminated material for rail, which generally is $\sigma_r = 90\ Kg/mm^2$, it is obtained a maximum unity stress of fatigue equal to

$$\sigma_{ob_c} = \frac{1}{3}\sigma_r = 30\,Kg/mm^2,$$

for a number of fatigue cycles $N \cong 10^7$, for rails which do not exceed a certain average height.

Considering

$$\sigma_{ob_c} = \sigma_{ob_{adm}}$$

in relation (1), it is known from the curves of Woehler that as the area of cross-section of rail increases,

$$\sigma_{ob_{adm}}$$

decreases, and this is the case of heavy-type railway rails. From relation (1) it is derived that

$$M_{ob_{adm}} = 2280\ Kg \times mm,$$

which is used for dimensional designing.

If has been discovered that when the loading factor of fatigue of cross-section of a railway rail of heavy type with a masse of at least 51 Kg/l.m. is between 0.9 to 1, the unity normal fatigue stresses in the lower and upper cross-section portions are well balanced and the lifetime of rail, or alternatively, the sustained traffic, is significantly increased.

A rail according to the present invention is composed of a lower and upper cross-section portions determined by the horizontal neutral axis of cross-section. The loading factor of fatigue is given by the specific moments of fatigue of the cross-section portions or by the squares of heights of the cross-section portions.

Refering to the drawing, the rail according to the preferred embodiment of the present invention for increasing the lifetime of heavy-type rails, is shown in FIG. 1. The left side with respect to vertical axis Y-Y represents the current standard rail, while the right side represents the rail of the present invention. Each of these rails is composed of a rail head 1 at its upper side, a rail web 2 at its center side and a rail base 3 at its lower side. The difference between the two rails is given by the height h, located at the upper side of rail head of standard rail.

The standard rail has the moment of inertia

$$I_{x_0}$$

and the height

$$H_{c_0} > H_{t_0} \ ,$$

where

$$H_{c_0} \text{ and } H_{t_0}$$

represent the heights of cross-section with respect to its horizontal neutral axis Xo-Xo.

The upper side of rail head is increased with a height h, which makes Hc to slightly increase with respect to Hco. However, Ht increases significantly with respect to Hto, considering the rising of the center of weight, and the new axis X-X, respectively. The increase of the moment of inertia Ix is significant by increasing the height of the entire cross-section, while the increase of the loading factor of fatigue:

$$R_{i_{ob}} = \frac{H_t^{\ 2}}{H_c^{\ 2}}$$

is augmented by the significant increase of H_t with respect to H_c.

There are further given three examples of calculus and the advantages obtained following the conclusions above.

A. Rail type UIC60

General characteristics:

M = 60.34 *Kg/l.m.*; S = 76.86 cm^2; I_x = 3055 cm^4;

$$W_{x_c} = 335.5\, cm^3;$$

L_t = 150 *mm*; H = 172 *mm*; H_c = 91 *mm*; H_t = 81 *mm*

$$M_{ob_{adm}} = 2280\ Kg \times mm \ \text{ for } \sigma_r = 90\ Kg/mm^2,$$

with

$$\sigma_{ob_c} = \frac{1}{3}\sigma_r$$

and $N \cong 10^7$ *cycles* for the same characteristics of material. It is obtained:

$$\sigma_{ob_c} = \frac{M_{ob_{adm}}}{H_c \times \omega} = \frac{2280}{91 \times 1} = 25.05\ Kg/mm^2$$

$$\sigma_{ob_t} = \sigma_{ob_c} \times \frac{H_t}{H_c} = 22.3\ Kg/mm^2$$

In the case of a rail simple-standing on two supports with an opening of 1 m, the moment of fatigue is:

$$M_{ob} = \sigma_{ob_c} \times W_{x_c} = 2505 \times 335.5 = 840000\ Kg \times cm$$

and the load of fatigue is:

$$P_{ob} = \frac{4 \times M_{ob}}{100} = 33.6\ t$$

$$\text{with } R_{i_{ob}} = \frac{H_t^{\ 2}}{H_c^{\ 2}} = 0.792 \text{ and } \frac{P_{ob}}{S}\ 437\ Kg/cm^2$$

B. Rail type UIC60' (modified)

The geometry of rail is modified by increasing the height of rail head at the upper side with a height $h = 6\ mm$, such that:

$$H' = H + h = 178\ mm$$

The width of rail base is increased to 76.2 mm to make possible a comparisson with similar rails.

General characteristics obtained:

$M' = 64.7\ Kg/l.m.$; $S' = 82.44\ cm^2$; $I'_x = 3460\ cm^4$;

$$W'_{x_c} = 381\ cm^3;$$

$L_t = 150\ mm$; $H' = 178\ mm$; $H'_c = 90.8\ mm$; $H'_t = 87.2\ mm$;

The position of the new center of weight, or the height H'_c of the horizontal neutral axis, respectively, is computed through the method of static moments with respect to the upper side of the new rail head. The moment of inertia I'_x is computed with respect to the new neutral axis. It results:

$$\sigma'_{ob_c} = \frac{M_{ob_{adm}}}{H'_c \times \omega} = \frac{2280}{90.8 \times 1} = 25.1\ Kg/mm^2$$

$$\sigma'_{ob_t} = \sigma'_{ob_c} \times \frac{H'_t}{H'_c} = 24.1\ Kg/mm^2$$

$$M'_{ob} = \sigma'_{ob_c} \times W_{x_c} = 2510 \times 381 = 956000\ Kg \times cm$$

$$P'_{ob} = \frac{4 \times M'_{ob}}{100} = 38.24\ t$$

$$R'_{i_{ob}} = \frac{H'^{\,2}_t}{H'^{\,2}_c} = 0.922$$

$$\frac{P'_{ob}}{S'} = \frac{38240}{82.44} = 464.5\ Kg/cm^2$$

c. Rail type R65

General characteristics:

$M = 64.93\ Kg/l.m.$; $S = 82.65\ cm^2$; $I_x = 3540\ cm^4$;

$$W_{x_c} = 358\ cm^3;$$

$L_t = 150\ mm$; $H = 180\ mm$; $H_c = 98.7\ mm$; $H_t = 81.3\ mm$

It is obtained:

$$\sigma_{ob_c} = \frac{M_{ob_{adm}}}{H_c \times \omega} = \frac{2280}{98.7 \times 1} = 23.1\ Kg/mm^2$$

$$\sigma_{ob_t} = \sigma_{ob_c} \times \frac{H_t}{H_c} = 19.03\ Kg/mm^2$$

$$M_{ob} = \sigma_{ob_c} \times W_{x_c} = 2310 \times 358 = 827000\ Kg \times cm$$

$$P_{ob} = \frac{4 \times M_{ob}}{100} = 33.1\ t$$

$$R_{i_{ob}} = \frac{H_t^2}{H_c^2} = 0.678$$

$$\frac{P_{ob}}{S} = \frac{33100}{82,65} = 400\ Kg/cm^2$$

It is observed that for the rail of type UIC60' (modified) a significant increase of the moment of inertia of cross-section of rail is surprisingly obtained at the same time with balancing the unity stresses of fatigue in the two cross-section portions of rail, reaching a load of fatigue greater with 15.5% than in the case of rail R65, even for a masse and height of rail smaller than in case of rail R65, assuming the same characteristics of material.

The data presented as general characteristics for examples A, B, C is taken from official national standards and from "Schweisstechnisches Taschenbuch" of Elektro-Thermit Corp.

Although one embodiment of the invention has been illustrated in the accompanying drawing and desribed in the foregoing Detailed Description, it will be obvious to those skilled in the art that the invention is not limited to the embodiment disclosed, but is capable of many rearrangements, modifications and substitutions of parts and elements without departing from the scope and spirit of the invention, and the invention includes all such rearrangements, modifications and substitutions.

Claims

1. A railway rail of heavy type with a masse of at least 51 Kg per linear meter, said rail being composed of a rail head, a rail web and a rail base, wherein an upper portion and a lower portion of cross-section of said rail are defined with respect to a horizontal neutral axis of cross-section of said rail, characterized in that a loading factor of fatigue determined by a ratio of a specific moment of fatigue of said lower portion of cross-section of said rail and of a specific moment of fatigue of said upper portion of cross-section of said rail, is between 0.9 to 1.

2. A rail according to claim 1, wherein said loading factor of fatigue, determined by a ratio of square of a height of said lower portion of cross-section and a square of a height of said upper portion of cross-section of said rail, is between 0.9 to 1.

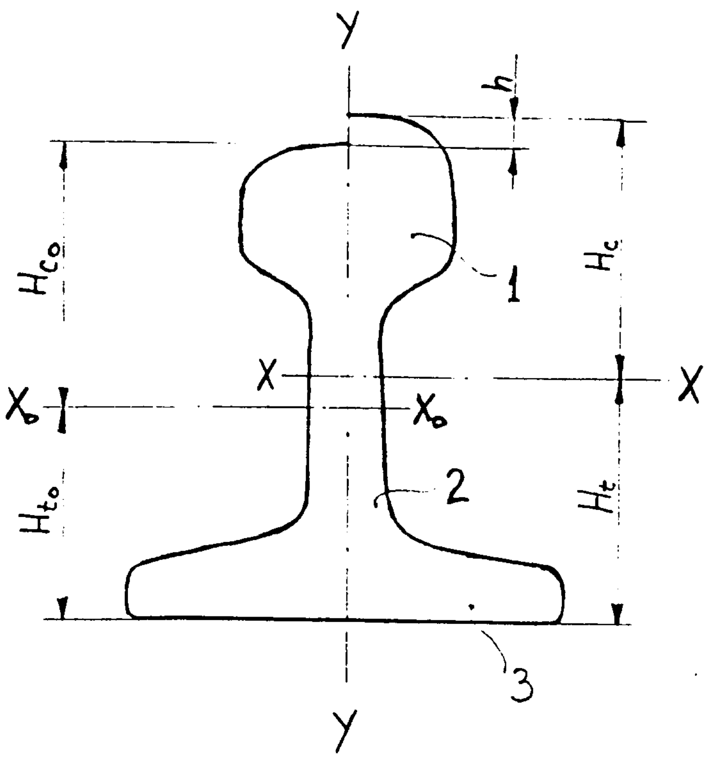

FIG. 1