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(54) RIBBED REINFORCING BAR

(57) The invention is directed toward the creation of a ribbed reinforcing bar without longitudinal ribs, which provides improved reinforcement for reinforced concrete structures and can also be used as a ground anchor and as a fastening element for formwork and other mechanical connecting and anchoring devices. This technical result is achieved in that a ribbed reinforcing bar has a core with a circular cross-section and inclined crescent-shaped transverse protuberances arranged in four rows over the surface of the bar. In order to allow two-high rolling without the formation of longitudinal ribs, the peaks of the transverse protuberances are arranged in a checkerboard fashion along a spiral line over the entire surface of the core. The peaks of adjacent longitudinal rows of transverse protuberances are situated in inclined axial planes of the bar which lie at angles of from 20° to 70° adjacent to axial planes which coincide with the rolling axes of the bar. The protuberances can be arranged on the surface of the bar such as to form a spiral thread.

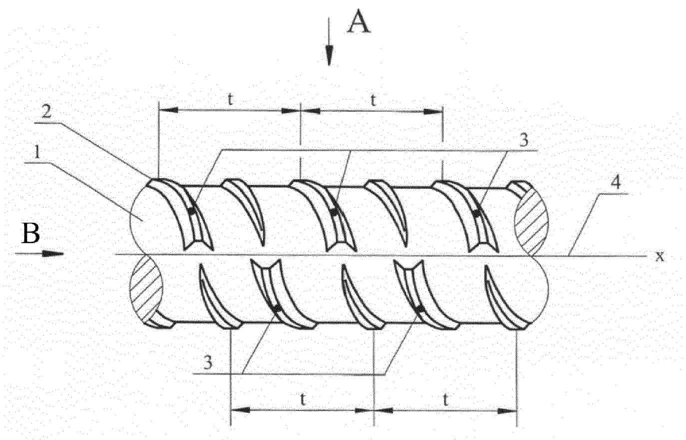

Fig. 1

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Description

[0001] This invention relates to the building art, and more particularly to structural concrete reinforcing bars, as well as to ground anchors, formwork fasteners, pipeline fasteners, and other construction components.

[0002] One known spiral-shaped reinforcing bar comprises a circular cross-section core and two rows of inclined transverse ribs (protuberances) that are arranged on its surface and extend along a single-start right-hand or left-hand spiral line /1/.

[0003] This approach is disadvantageous in that the bar cross-section ovalization occurring during rolling adds difficulty to the bending operations indispensable to the preparation of structural concrete reinforcing members. Furthermore, with the two-row arrangement of the protuberances with an angle of each row's coverage at the core surface of about 120°, the thrusting forces produced when the reinforcing bars bind with the concrete are uniaxial, resulting, under adverse conditions (such as, where the amount of crosswise reinforcement is insufficient) in reduced load bearing capacity of the reinforced concrete structure.

[0004] Another known ribbed reinforcing bar has on its surface oppositely arranged longitudinal ribs and spirally oriented inclined ribs which at their one end are adjacent to the longitudinal ribs and at the other end are gapped therefrom, the inclined ribs' adjunction to each longitudinal rib is being provided with alternating gaps between them, the gaps amounting to 0.15 to 0.3 of the distance between the longitudinal ribs along the bar cross-section arc /2/.

[0005] This approach is disadvantageous in that there are longitudinal ribs and intersections between the longitudinal and the inclined ribs. The longitudinal ribs reduce the strength of bond to the concrete due to the inclined ribs' reduced surface area in contact with the concrete and prevent formation of a spiral thread on the bar surface, which could have been used for the bar splicing and anchoring with sockets and nuts. Concentration of stresses when dynamic loads are applied to the bars at the intersections between the longitudinal and the inclined ribs reduces their strength under alternate and cyclic loads.

[0006] Closest to this invention is a reinforcing bar with four rows of ribs, where the peaks of adjacent rows of crescent-shaped transverse protuberances are arranged in mutually perpendicular axial planes with an angle of the core surface coverage by a protuberance of 140 to 180° and a ratio of the transverse protuberance maximum height to pitch of 0.12 to 0.3 /3/.

[0007] This solution is disadvantageous in that the transverse protuberances in the adjacent rows are distinct in their form and their peaks are arranged in mutually perpendicular horizontal (x) and vertical (y) coordinate axial planes of the bar. Therein, the bar's horizontal axis (x) coincides with the reinforcing bar horizontal axial rolling plane, resulting in formation of longitudinal ribs that reduce the relative rib area of transverse ribs in these rows (according to G. Rehm criterion) separating them into two half-crescents with a lesser total area, reducing cyclic and dynamic load strength, and preventing formation of a spiral thread for screwing on splicing sockets and retainer nuts on the bar surface.

[0008] The technical problem is to provide a ribbed circular cross-section reinforcing bar without longitudinal ribs, with inclined crescent-shaped equiform transverse ribs uniformly arranged on the bar surface for efficient bonding between the reinforcing bars and the concrete, and to enable formation of a spiral threaded shape by rolling in a two-high mill.

[0009] The problem is solved by providing, according to the invention, a ribbed reinforcing bar having a circular cross-section core and inclined open crescent-shaped transverse protuberances arranged along its surface in four rows, designed for rolling in a two-high mill without longitudinal rib formation, the peaks of the transverse protuberances being arranged in a checkerboard fashion along a spiral line over the core surface, the peaks of adjacent longitudinal rows of transverse protuberances being situated in the bar's inclined axial planes whose adjoining angles of inclination to the axial planes, coinciding with the reinforcing bar rolling axes, are 20° to 70°, preferably 45°. Herein, the crescent-shaped transverse protuberances may be arranged on the core surface such as to form a spiral thread. To provide for efficient bonding between the concrete and the bar, its transverse protuberances' dimensions are defined in height by outer circular contours with the radii of 0.5 to 0.6d whose centers are displaced from the bar core symmetry axes to a distance of 0.07 to 0.1d.

[0010] The reinforcing bar of the present invention is different from the prior art in that it is produced by rolling in a two-high mill without longitudinal rib formation, the peaks of the transverse protuberances are arranged in a checkerboard fashion along a spiral line over the core surface, the peaks of adjacent longitudinal rows of transverse protuberances being situated in the bar's inclined axial planes whose adjoining angles of inclination to the axial planes, coinciding with the reinforcing bar rolling axes, are 20° to 70°, preferably 45°. Herein, the reinforcing bar may also be configured such that the transverse crescent-shaped protuberances form a spiral thread on its surface. To provide for efficient bonding with concrete, its transverse protuberances' dimensions are defined in height by outer circular contours with the radii of 0.5 to 0.6d whose centers are displaced from the bar core symmetry axes to a distance of 0.07 to 0.1d.

[0011] The reinforcing bar produced by rolling in a two-high mill is ribbed without longitudinal ribs, with the transverse protuberance peaks of the same asymmetric crescent-like shape arranged in a checkerboard fashion, wherein the maxim height points, i.e. the peaks of adjacent longitudinal rows of transverse protuberances, lie in the bar's inclined axial planes whose adjoining angles (α) of inclination to the bar rolling horizontal (x) and vertical (y) axial planes are 20° to 70°. The axial planes' inclination angle is preferably 45°, and the transverse protuberances may be arranged over the core surface such as to form a spiral thread configuration.

[0012] The technical result consists in providing optimal conditions for the reinforcing bar bonding with the concrete through reducing the thrusting forces by evenly distributing the transverse protuberances over the bar surface, in improved cyclic and short-term dynamic load strength due to the absence of longitudinal protuberances and, therefore, their intersections with transverse protuberances, in the possibility to mechanically splice and anchor the bars, without welding or overlapping, via threaded screw sockets and nuts, and the possibility to produce the bars using the two-high rolling mill process commonly used for reinforcing bar production.

[0013] Fig. 1 shows a ribbed reinforcing bar; Fig. 2 is View A of Fig. 1; Figs. 3, 4, 5 show View B of Fig. 1 (reinforcing bar embodiments with various angles α).

[0014] A reinforcing bar has a core 1 with a circular cross-section and the diameter d, transverse protuberances 2 with the maximum height h_{max} and a coverage angle smaller than 180°, whose peaks 3 are arranged along the bar in a checkerboard fashion along a spiral line with the pitch t. The peaks 3 (the maximum height points) of adjacent transverse protuberances lie in the bar's inclined axial planes whose adjoining angles (α_x and α_y) to the horizontal (x) 4 and vertical (y) 5 axes of the bar's longitudinal axial rolling plane are 20° to 70°, preferably 45°.

[0015] The crescent-shaped transverse protuberances may be arranged over the core surface such as to form a spiral thread configuration. (ref. to Fig. 1, Fig. 2).

[0016] The parameter commonly used to evaluate a ribbed reinforcing bar efficiency in terms of bonding with concrete is the relative area of reinforcing bar rib bearing on concrete or the G. Rehm criterion:

$$f_R = \frac{1}{\pi d_H} \sum_{n=1}^{k} \frac{F_{CM}}{t}$$

where dH is the reinforcing bar nominal diameter (mm);

k is the number of transverse protuberance rows (k=4 for the ribbed shape in Figs. 1, 2, 3, 4, 5);

F_{CM} is the area of one row protuberance bearing equal to the area of the protuberance projection on a plane perpendicular to the bar longitudinal axis (mm^2);

t is the protuberance pitch in each row (mm).

[0017] As the F_{CM} value is in direct relationship with the transverse protuberance height h and configuration varying with the arrangement of peaks and the protuberance pitch t, it is obvious that the reinforcing bar efficiency in terms of the strength of its bond with concrete may be improved by increasing the h value, by displacing the rib peaks with respect to the cross-section axes x and y, and/or by reducing the pitch t.

[0018] Experiments proved that the strength of bond between a ribbed bar and concrete increases with increasing f_R value within certain limits. For commonly used reinforcing bars, the level above which no improvement in bonding occurs is believed to be the range of f_R values = 0.075 to 0.08.

It has also been found that the firmness of bond between a reinforcing bar and concrete depends on the h and t values /4/.

[0019] In the ribbed reinforcing bar of the present invention, the protuberances along the length of one pitch in the projection on a plane normal to the bar's longitudinal axis are of a crescent-like asymmetric shape (Figs. 3, 4, 5).

[0020] Asymmetric shape of the crescent-like transverse ribs of the present invention with adjacent ribs' peaks situated on opposite sides with respect to the x axis (Fig. 3, 4, 5) of the horizontal axial reinforcing bar rolling plane allows spiral reinforcing bars to be produced by the hot rolling process which is common in the metals industry and uses two-high mills, in particular that used for rolling single-start spiral bars without longitudinal ribs /1/.

[0021] According to the invention, the peaks of asymmetric equiform ribs are arranged with respect to each other over the bar core surface in a checkerboard fashion, thus making it possible to change, with various positions of the peaks relative to the x and y axes, the ribs' configuration, to minimize their thrusting action by distributing them over the reinforcing bar perimeter and length while retaining a high level of the f_R value, and, therefore, to provide for the required strength, firmness and reliability of bonding between the bar and the concrete, specifically in its plastic deformation area, to improve reinforced concrete structure reliability. With such arrangement of the transverse protuberances, they may also be arranged along a discontinuous spiral line such as to form a bar surface configuration suitable for providing threaded connections with sockets and end anchor nuts.

[0022] Displacement of both adjacent transverse protuberances' peaks relative to the x axis by an angle α_x>70°, where α_y<20°, is inadvisable due to the formation in this event of a bar similar in form to the known two-sided crescent-shaped European bar with its inherent drawbacks, i.e. reduced strength of the bar bonding resulting from increased uniaxial oppositely directed thrusting forces and loss of the reinforcing effect from the combined stress stage of the inter-rib serpentine concrete key. Therein, conditions of interaction between the concrete and the reinforcing bars are deteriorated due to a limited potential for coarse aggregate embedding between the bar's transverse protuberances during concrete placement resulting from reduced clearance between them in the protuberance peak location areas and reduced area of their contact with concrete at the bar surface.

[0023] Where α_x<20° and α_y>70°, it is technologically difficult to form, by rolling in a two-high mill, any proper transverse ribs providing efficient bonding with concrete without longitudinal rib formation.

[0024] According to the invention, due to the pass cutting process conditions, to properly form the bar shape and to meet the requirement of $f_R \geq 0.07$, the transverse protuberances shall be defined in height by outer circular contours with the radii of 0.5 to 0.6d whose centers are displaced from the bar core symmetry axes to a distance of 0.07 to 0.1d. Herein, optimum engagement of the bar shape with sockets and nuts' threads and bonding with concrete will be provided. Due to the absence of longitudinal ribs on the bar surface and of their intersections with transverse ribs, as well as the absence of any stress concentration locations, the reinforcing bars' fatigue strength is improved. With equiform crescent-shaped transverse protuberances oriented on the bar surface along a spiral line and distributed along the bar length and perimeter, threaded splice connections may be provided along the bar length via sockets, and end anchors may be provided in the form of reusable nuts with low thrusting action and, therefore, high strength.

[0025] Tests performed to compare the reinforcing bars of the novel configuration with foursided arrangement of transverse ribs providing for even distribution of thrusting forces along the bar core perimeter and length with the bars with two-sided arrangement of transverse ribs (a crescent-shaped two-sided European bar) demonstrated that, with an equal length of embedment into concrete, the bonding strength of the bars with the shape of the first type increases by 20 to 30% as a function of the bar diameter. Therein, loss of bonding between the concrete and the newly-designed bars when the yield point in a bar is reached occurs at plastic deformations by 3 to 4 times exceeding those in the bars of the two-sided crescent-like European shape.

[0026] In this way, bonding strength of reinforced concrete structure reinforcing bar anchoring areas at a beyond-the-limit stage of resistance to external impacts after reaching the yield point in the reinforcing bars may be maintained. This effect is of particular importance for ensuring safety of buildings under specific emergency, blasting and seismic loads.

[0027] Cutting of passes for the new reinforcing bar rolling does not involve any increase in labor intensity. Since the new reinforcing bars are produced by the same two-high rolling mill process commonly used in the metals industry, rolling mill output and product quality are maintained at a high level. The new bar's high degree of asymmetry and a large number of ribs provide for sustainably high strength properties of the bars as a result of more efficient thermomechanical hardening. Absence of longitudinal ribs, in combination with efficient thermal hardening that increases, at no extra cost, the reinforcing bars' strength performance, allows the bar's mass per unit length to be reduced by as much as 10% while retaining its design nominal diameter used in reinforced concrete reinforcement design, thus providing for high technical and economic performance of this product for the manufacture and the customer.

[0028] Finishing passes for the new reinforcing bars shall be cut on the roll groove surface by milling transverse recesses at both sides of a groove such as to arrange neighboring recesses in a checkerboard fashion along the groove length and to provide the necessary constant angle of recess inclination relative to the groove longitudinal axis. The transverse recesses may be milled either in a row-by-row, or in a mixed manner. The thread-like spiral shape of the bars is provided by synchronized rotation of rolls within a stand during rolling. By using four crescent-shaped transverse ribs instead of two to provide discontinuity along the bar's spiral thread length, the amount of metal necessary to form the thread may be reduced and the threaded connection strength may be increased due to an increased contact surface evenly distributed over the perimeter and length.

[0029] By forming a spiral thread on a reinforcing bar, its operational capabilities may be extended, while preserving its high useful qualities. Thus, reinforcing bars of this type may be provided with weldless connections via threaded sockets and may be anchored via nuts. Spiral-shaped reinforcing bars may also be widely used as ground anchors, formwork panel tie members for cast-in-place construction, and as anchoring and fastening members for various process and household applications. It is proposed to produce reinforcing bars of the new type according to the present invention on a large scale to substitute the existing types of ribbed reinforcing bars.

[0030] In this way, construction quality and safety may be improved, while reducing its cost, and potential may be opened for using spiral reinforcing bars with a 1.5 to 2-fold reduction in their cost and for meeting both industrial and household demand for such reinforcing bars.

[0031] Thus, the ribbed reinforcing bar of the present invention is configured and geometrically arranged such as to improve interaction between the reinforcing bars and the concrete within a finished structure, to improve ribbed reinforcing bars' functional capabilities and to expand their application fields. The novel reinforcing bar meets the requirements to manufacturability applicable in the rolled product and hardware production industries, as well as those applicable to reinforcement installation and other operations.

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[0032]

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Claims

1. A ribbed reinforcing bar having a circular cross-section core and inclined open crescent-shaped transverse protuberances arranged along its surface in four rows, **characterized in that** the reinforcing bar is designed for rolling in a two-high mill without longitudinal rib formation, the peaks of the transverse protuberances are arranged in a checkerboard fashion along a spiral line over the core surface, the peaks of adjacent longitudinal rows of transverse protuberances being situated in the bar's inclined axial planes whose adjoining angles of inclination to the axial planes, coinciding with the reinforcing bar rolling axes, are 20° to 70°.

2. The reinforcing bar of Claim 1, **characterized in that** the peaks of adjacent longitudinal rows of transverse protuberances situated in the bar's inclined axial planes whose adjoining angles of inclination to the axial planes, coinciding with the reinforcing bar rolling axes, are preferably 45°.

3. The reinforcing bar of Claim 1, **characterized in that** the crescent-shaped transverse protuberances are arranged on the core surface such as to form a spiral thread.

4. The reinforcing bar of Claim 1, **characterized in that** the transverse protuberances are defined in height by outer circular contours with the radii of 0.5 to 0.6d whose centers are displaced from the bar core symmetry axes to a distance of 0.07 to 0.1d.

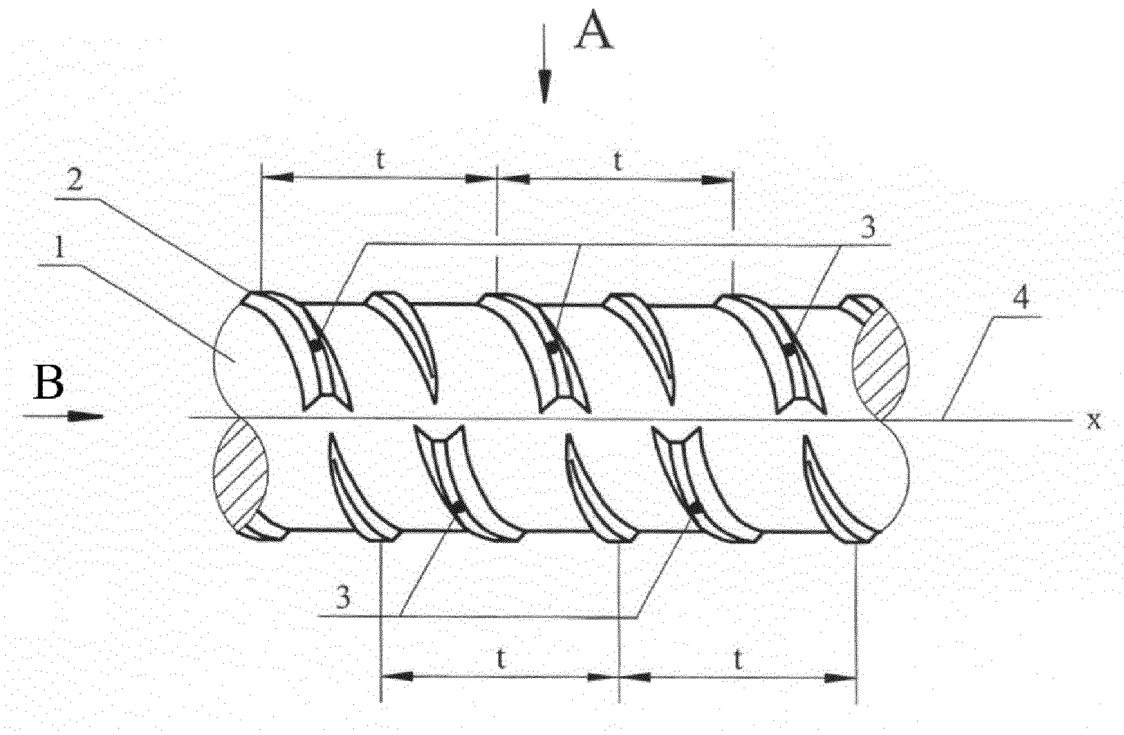

Fig. 1

View A

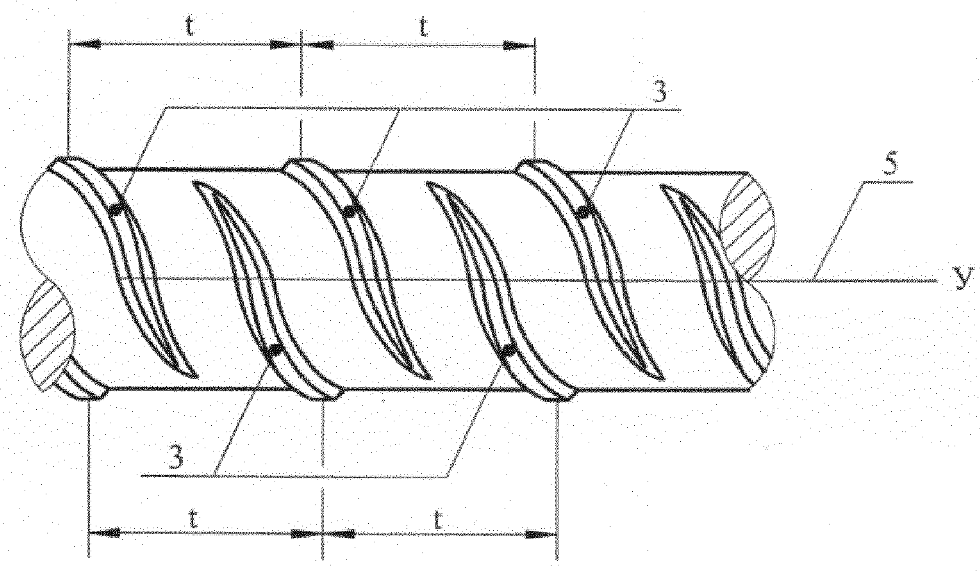

Fig. 2

View B

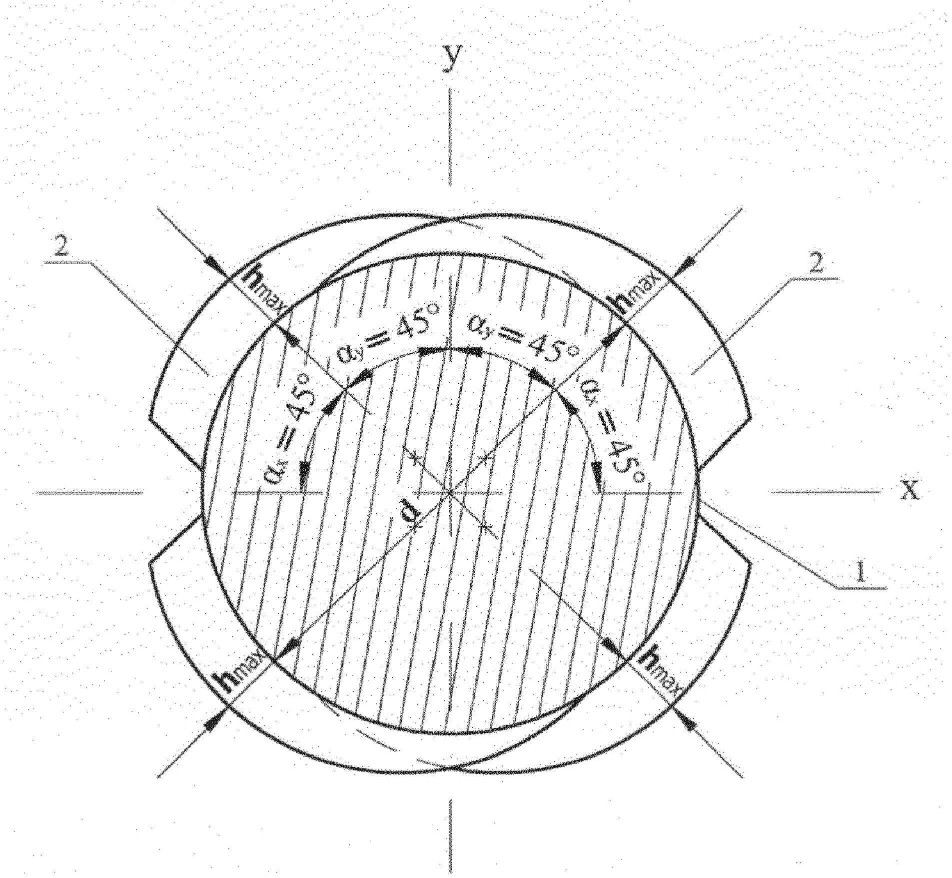
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Fig. 3

View B

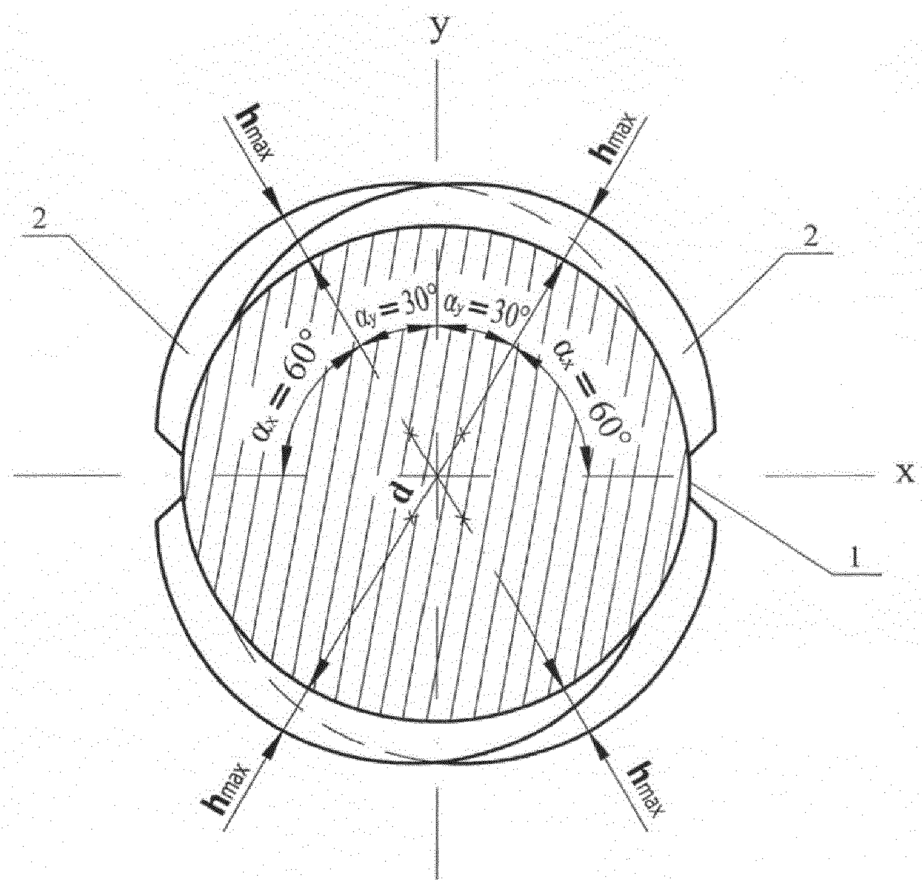
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Fig. 4

View B

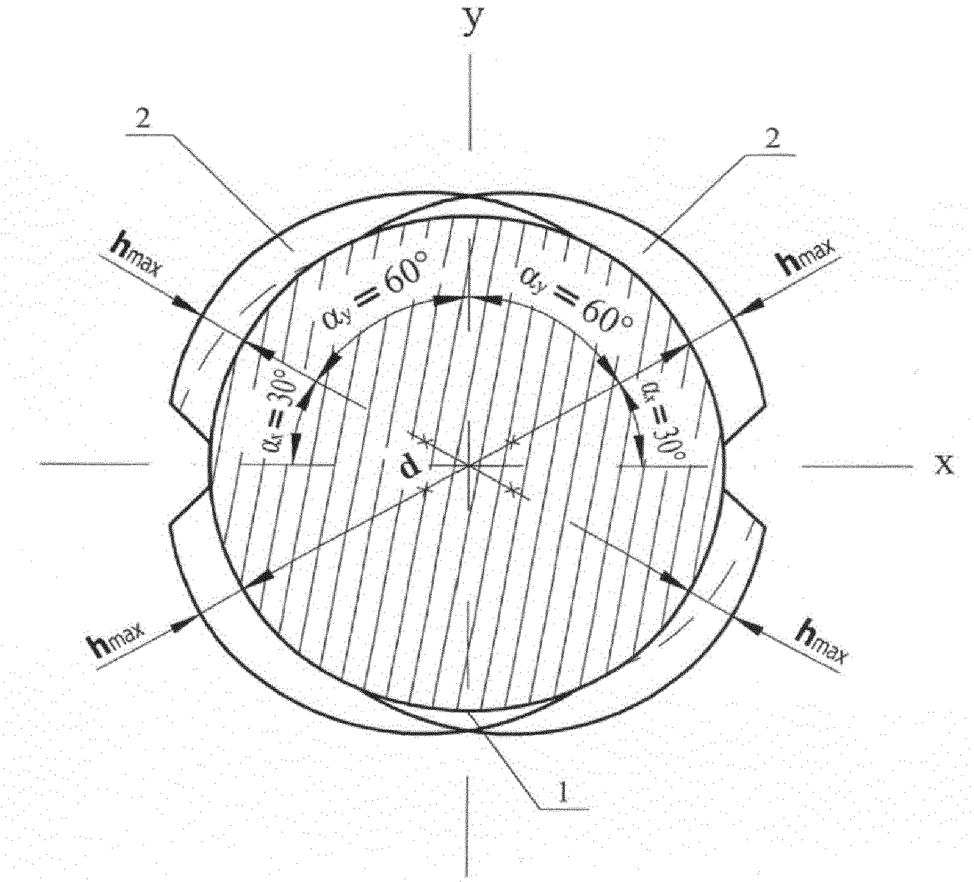
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Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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