

Method for producing steel fibres

The invention concerns a method of producing steel fibres, preferably
5 for use as a concrete additive, and for the supply thereof in the production
of steel fibre concrete. It has proven to be advantageous in many areas of
use to add steel fibres to concrete instead of or in addition to the usual
structural steel mats, whereby in particular the formation of microcracks in
the new concrete is prevented. In addition the simple processing affords
10 enormous labour savings and gives the concrete a longer service life.
Depending on the respective situation of use it is also possible to achieve a
higher level of tensile and flexural strength as well as a higher load-bearing
capacity.

Nonetheless the production of the steel fibres is complicated and
15 expensive as they have to be either milled, cut in the form of sheet metal
fibres from sheets or strips, stamped and shaped or shaped, bent and cut
to length in the form of wire fibres individually or in packets.

The object of the invention is to provide a method of the kind set
forth in the opening part of this specification, which permits simple and
20 inexpensive production of steel fibres.

According to one aspect of the invention, there is provided a method of
producing steel fibres, suitable for use as concrete additive, and for the supply
thereof in the production of steel fibre concrete, in which to form the steel fibres
firstly a sheet metal strip is notched either on one side or both sides, whereby
25 steel fibre veins are formed, which are initially still connected together by limbs,
that further for subsequently converting the limbs into thin easily mutually
separable separation limbs forming separation surfaces which are fracture-
rough and low in burring upon separation the steel fibre strip is subjected to a
flexing process in which each limb is subjected to multiple bending deformation
30 about its longitudinal axis in such a way that incipient cracks are produced in
the region of the limbs due to fatigue fracture and thus the separation limb is

produced, whereupon in the notching operation the steel fibre veins are provided with anchorage means formed by interruptions in the notching operation.

5 An advantage achieved by the invention is essentially that a sheet metal strip is used as the starting material for the steel fibres, whereby not only is an advantageous starting material available, but in addition shaping of a multiplicity of steel fibre veins can be effected.

10 Moreover, the anchorage means represent local cross-sectional enlargements due to upsetting in the notching operation and in comparison with the notched cross-section of the steel fibres. Those interruptions can be provided in relation to the notching projections in the rolling tool whereby the production of steel fibre veins with anchorage means is possible in one working step, wherein positioning of the anchorage means at the ends of the steel fibres is particularly effective.

15 In accordance with a first embodiment of the invention the method is performed in such a way that the steel fibre veins are shaped transversely to the longitudinal direction of the sheet metal strip.

20 In that respect in a further advantageous configuration there is the possibility that the steel fibre vein strip which is provided with anchorage means after the notching operation and which extends over the entire width of the sheet metal strip is divided by separating blades forming two or more steel fibre strips.

In that respect it is further advantageous if the division operation to form a plurality of steel fibre strips is effected prior to the flexing process.

25 In a further procedure it is recommended that the steel fibre strips after the flexing process pass through a shaping roller for shaping the steel fibres (cranked ends, upset ends, wave shape and so forth) to correspond to the purpose of use.

30 Finally this procedure involves the possibility of the steel fibre strips being wound up after complete manufacture thereof. When the steel fibre strip is in the form of a reel a large amount of steel fibres which are present

in ordered relationship and which can be easily and quickly separated is available in a compact and readily transportable fashion for transport to the position of use thereof. Therefore the invention further provides that separation of the steel fibre strips to afford steel fibres is effected at the
5 location of concrete preparation. In that way it is possible to dispense with equipment and measures with which nowadays 'hedgehog formation' (lump formation of steel fibres in the concrete) is to be avoided. It will be appreciated that it is also possible for the separation operation to be already performed in the production line if that is desirable or necessary.

10 In an alternative configuration of the invention however the steel fibre veins can also be shaped in the longitudinal direction of the sheet metal strip.

In that respect after the flexing process optionally the top side and/or the underside of the strip can be easily roughened in the manner of
15 knurling, in which case however that is also possible in comparable fashion in respect of the above-described alternative with steel fibre veins arranged transversely to the longitudinal direction of the sheet metal strip. That makes it possible to achieve better adhesion in the concrete.

After those method steps the steel fibre strip could optionally be
20 wound layer upon layer and the subsequent method steps could then be implemented at the location of concrete preparation with a suitable piece of equipment.

In that respect the method further provides that then the steel fibre veins oriented in the longitudinal direction of the strip are separated from
25 each other.

In the further course of the method it is provided that after their separation the steel fibre veins are subjected by a shaping tool to a shaping operation corresponding to the purpose of use. That can involve producing a cranked configuration for the steel fibre ends, a wave-shaped
30 configuration extending in the longitudinal direction, or the like.

Finally in this procedure the steel fibre veins after shaping thereof are cut to length to the desired measure so that the individual steel fibres are ready for use for the further application thereof.

5 Notching of the sheet metal strip is advantageously effected in a V-shape, wherein the notch tip angle W should be between 30° and 120° . In that respect a notch tip angle W of about 60° has proven to be particularly advantageous.

The thickness of the limb should advantageously be 20% to 95% of the thickness of the strip.

10 In accordance with the invention the depth of the V-shaped notches is advantageously so selected that it corresponds to the strength of the sheet metal strip and the purpose of use of the steel fibres.

In addition it has proven to be advantageous in accordance with the invention if the flexing process includes multiple bending deformation at one side in relation to the plane of the steel fibre strip, until fatigue fracture incipient cracks occur in the region of the limbs at the notch bottom. Alternatively the flexing process can also include multiple bending deformation at both sides in relation to the plane of the steel fibre strip, until fatigue fracture incipient cracks occur in the region of the limbs at the notch bottom.

20 In that respect the flexing process can take place in such a way that multiple bending deformation of the limbs is effected through equal angular amounts in each case. Depending on the respective situation of use and material nature instead however it may also be more advantageous if the multiple bending deformation of the limbs is effected at one or both sides through respectively increasing or also decreasing angular amounts.

Desirably multiple bending deformation of the limbs should be effected at an angle less than the notch angle.

30 To completely separate the steel fibre veins from each other the separation limb can be broken by slight, oppositely directed deflection of mutually juxtaposed steel fibre veins. More specifically in the case of the

steel fibres which are disposed transversely to the strip direction, the separation limb can be severed in a separation apparatus on the zip fastener principle and thus the steel fibres can be individually separated while in the case of the steel fibre veins which are disposed longitudinally relative to the strip direction the separation operation is effected by shaping rollers by slight, oppositely directed deflection of mutually juxtaposed steel fibre veins and thereafter the steel fibre is shaped and cut to length.

Preferably semifinished material of metal in strip form is used as the starting material.

In respect of apparatus the object of the invention is attained by a steel fibre strip of metal which comprises a plurality of mutually parallel steel fibre veins connected together by way of limbs and which is produced in accordance with at least one of the preceding method claims, which is characterised by semifinished material in strip form which is used as starting material and which for forming the steel fibre veins is notched on one side or on both sides and in the notching operation is provided with anchorage means, wherein the limbs are converted by multiple bending deformations by means of a flexing process to provide thin, easily mutually separable separation limbs which form low-burring and fracture-rough separation surfaces upon separation and which have a fatigue fracture or fatigue fracture incipient cracks and the steel fibre veins and the steel fibre strips are subjected to a shaping operation, wherein steel fibres suitable as an additive to concrete are formed in the individual separation operation of the steel fibre strips or the steel fibre vein strips.

Fatigue fracture incipient cracks are produced on the notch bottoms by the flexing process whereby the limbs are weakened. The remaining limb residues – referred to as separation limbs – can be very thin because they are in the region of the neutral fibre of the bending operation; the steel fibre veins can thus be later easily separated from each other and reliably singled off.

Here high-quality steel-based or iron-based materials in all strength states which are usual on the market are provided as the metallic material. If the purpose of use requires it, the metallic material can also be coated in the form of metal strips, in particular galvanised or copper-plated steel strip. It is desirable in that respect in particular that the metallic material involved is materials with which – if required – particularly high strength values can also be achieved by rolling, for the respective group of materials.

Finally the invention concerns a steel fibre produced in accordance with the above-described method. It is characterised in that it is formed from semifinished material in strip form which is used as the starting material and which for forming steel fibre veins which are initially still connected together by limbs is notched on one side or on both sides and is provided with anchorage means in the notching operation, wherein the limbs are converted by multiple bending deformations by means of a flexing process to provide thin separation limbs which form easily mutually separable separation surfaces which have low burring and are fracture-rough upon separation, and which have a fatigue fracture. In that way that steel fibre forms a completely novel type of steel fibre.

In that respect it is desirable if the steel fibre is of a shape suitable for addition to concrete.

The invention is described in greater detail hereinafter by means of embodiments by way of example illustrated in the drawing in which:

Figure 1 shows a diagrammatic view of the procedure according to the invention in a first embodiment with a steel fibre vein disposed transversely relative to the strip direction,

Figure 2 shows a view corresponding to Figure 1 of the procedure in an alternative configuration, with a steel fibre vein disposed longitudinally relative to the strip direction,

Figure 3 shows a detail view of the notching roller, shown in unrolled form,

Figure 4 shows a view in cross-section of a notched strip of which only part is shown and which is intended for the production of the steel fibre strip or steel fibre vein strip, with notching already implemented,

Figure 5 shows the notched strip which is subjected to the flexing process and which is intended for the production of the steel fibre strip or the steel fibre vein strip in the condition of bending deformation, in Figure a) for steel fibre veins disposed longitudinally relative to the strip direction and in Figure b) for steel fibre veins disposed transversely relative to the strip direction,

Figure 6 shows an arrangement for severing the separation limbs of the steel fibre strip or steel fibre vein strip,

Figure 7 shows an only partial view in section through the wire strip in the region of a notch,

Figure 8 shows a separation apparatus for singling off the steel fibres,

Figure 9 shows different views of an individual steel fibre,

Figure 10 shows a different configuration of individual steel fibres, and

Figure 11 shows a steel fibre with an end cross-sectional enlargement in comparison with the cross-section of the steel fibre.

The method diagrammatically shown in the drawing, in particular in Figures 1 and 2, serves for the production of steel fibres 2 which are preferably used as a concrete additive. For that purpose, for forming the steel fibres 2, firstly a sheet metal strip 1 is notched either on one side or on both sides between rollers 3, thereby providing the steel fibre veins 4 having anchorage means 7. In this situation the steel fibre veins 4 are firstly still connected together by limbs 5, as can be seen from Figure 4.

For subsequently converting the limbs 5 to afford thin, easily mutually separable separation limbs which upon separation form low-burring and fracture-rough separation surfaces the steel fibre strip formed by the steel fibre veins 4 is subjected to a flexing process in which each

limb 5 is subjected to multiple flexing deformation about its longitudinal axis as is indicated in the drawing by reference 6. In that way formed in the region of the limbs 5 are incipient cracks, due to fatigue fracture, whereby the separation limb is produced. Moreover, incipient scratching of the surface is effected between the notches so that fatigue fracture is also triggered there to prolong the bottom of the notches.

Upon notching thereof the steel fibre veins 4 can additionally be provided with anchorage means 7 in the form of cross-sectional enlargements in comparison with the steel fibre cross-section, as can be seen from Figures 3 and 9. They serve for better anchorage of the steel fibres 2 in the concrete and can be positioned at the appropriate location, corresponding to the purpose of use. In Figure 9 the flexing fracture surface is also denoted by reference 15.

In the configuration of the invention shown in Figure 1 the steel fibre veins 4 are shaped transversely to the longitudinal direction of the sheet metal strip 1. Depending on the desired length of the steel fibres 2 they can either extend over the entire width of the sheet metal strip 1; it is however also possible to provide separating blades 8 by which the steel fibre vein strip 1 is subdivided into two or more steel fibre strips. That division of the steel fibre vein strip is desirably effected prior to the flexing process.

After the flexing process the steel fibre vein strip or the steel fibre strips passes or pass through a shaping roller 9 which imparts to the steel fibres 4 a shaping corresponding to the later purpose of use. As shown in Figure 10 the ends of the steel fibres 2 can be for example of a cranked configuration; equally the steel fibres 2 can be converted into a wave-shaped configuration or shaped in some other suitable fashion. In particular the shape of the steel fibre ends can be altered, more specifically in the nature of an enlargement, as indicated in Figure 11. That enlargement or thickening leads to particularly effective anchoring in the concrete.

After complete production the steel fibre strips are wound layer upon layer whereby they can be transported to the later position of use easily and in a space-saving fashion.

5 The operation of individually separating the steel fibre strips to afford steel fibres 2 is thus effected only at the location of concrete preparation, and for that purpose an individual separation device as shown in Figure 8 can be used. This involves a high-speed toothed wheel 10 which separates off the individual steel fibres 2. That further affords the advantage that, when the operation of individually separating the steel fibres is effected at
10 the concrete preparation location, the individual steel fibres 2 can be more homogeneously introduced into the concrete while otherwise – if the steel fibres 2 are supplied in already individually separated form – they have a tendency to 'hedgehog formation' and thus involve possibly irregular distribution in the concrete.

15 There is however also the possibility of the steel fibre veins 4 being shaped in the longitudinal direction of the sheet metal strip 1, as shown in the diagrammatic view in Figure 2. In principle the procedure here is very similar; in addition here there is a further pair of rollers 11 which, after the flexing procedure, optionally roughens up the top side and/or the underside
20 of the strip 1 in the manner of knurling. That however is in principle also possible in the first variant of the operating procedure, in a similar form.

Here however, following the flexing process, the steel fibre veins 4 oriented in the longitudinal direction of the strip are separated from each other at 12. After that separation the shaping operation is then again
25 effected by means of a special shaping tool 13 which imparts to the steel fibres 2 the shaping required for the later purpose of use.

After that shaping operation the steel fibre veins 4 are cut to the desired length for example by rotary shears 14 so that the steel fibres 2 can already be packaged in the individually separated condition and taken
30 to the later location of use. The steel fibre vein strip can also be wound up layer upon layer after the flexing process and the operation of individually

separating the steel fibres can then be effected with a suitable item of equipment which separates, shapes and cuts them to length, at the location of concrete preparation.

Notching of the sheet metal strip 1 is effected in a V-shape, wherein
5 the notch angle W can be between 30° and 120° ; a notch angle W of about 60° is preferred.

The thickness of the initially remaining limb 5 is in this case usually 20% to 95% of the thickness of the strip 1.

In accordance with the invention the depth of the V-shaped notches
10 is advantageously so selected that it corresponds to the strength and purpose of use of the steel fibres.

The flexing process can take place in different ways; thus it is firstly conceivable that only multiple flexing deformation at one side in relation to the plane of the steel fibre strip 1 is effected, until fatigue fracture occurs in
15 the region of the limbs 5. Equally however the flexing process can also experience multiple flexing deformation at both sides with respect to the plane of the steel fibre strip, in which case the multiple flexing deformation of the limbs 5 can either be effected through respectively identical angular amounts or however through respectively increasing or decreasing angular
20 amounts. Details in that respect are also to be found in particular in Figures 5a and 5b.

At any event multiple flexing deformation of the limbs 5 should be at an angle which is less than the notch angle W .

The separation limbs in the case of the longitudinally oriented steel
25 fibres are then broken locally transversely relative to the strip 1 by slight, oppositely directed deflection of mutually juxtaposed steel fibre veins, which can be effected by suitable shaping rollers and is shown in Figure 6. In the case of the transversely oriented steel fibres the individual separation operation is effected in the separation device (Figure 8) as the
30 last method step.

Usually the starting material used is semifinished material in strip form of metal, in which case in particular high-quality steel-based or iron-based materials in all strength states which are usual on the market are recommended. Insofar as particular purposes of use make it necessary it is
5 also possible for that purpose to use coated metal strips, in particular galvanised or copper-plated steel strip. At any event it is desirable if the metallic material involves materials with which particularly high strength values can also be achieved by rolling, for the respective material group.

Finally a steel fibre produced in accordance with the above-described
10 method is also subject-matter of the invention. It is formed from semifinished material in strip form, used as the starting material, which to produce steel fibre veins 4 which are firstly still connected together by limbs 5, is notched at one or both sides. In the notching operation they are provided with anchorage means. The anchorage means are larger cross-
15 sectional regions of the steel fibres, which have remained in the notching operation by virtue of a suitable tool configuration and which are even still somewhat upset in the notching operation. The anchorage means are preferably positioned on the steel fibre ends, wherein in that respect there is also the possibility with the steel fibre being transverse of also notching
20 the steel fibre end transversely and in so doing also upsetting it somewhat.

The limbs 5 are subjected to incipient cracking at both sides due to fatigue fracture by virtue of multiple bending deformations by means of a flexing process and the limb residue – the separation limb – is later separated practically without deformation so that the separation surfaces
25 have a low degree of burring and are fracture-rough.

The top side and the underside of the steel fibres can also be knurled and in addition the steel fibre can be provided with a shape suitable for addition to concrete and the purpose of use.

CLAIMS

1. A method of producing steel fibres, suitable for use as concrete additive, and for the supply thereof in the production of steel fibre concrete, in which to form the steel fibres firstly a sheet metal strip is notched either on one side or
5 both sides, whereby steel fibre veins are formed, which are initially still connected together by limbs, that further for subsequently converting the limbs into thin easily mutually separable separation limbs forming separation surfaces which are fracture-rough and low in burring upon separation the steel fibre strip is subjected to a flexing process in which each limb is subjected to multiple
10 bending deformation about its longitudinal axis in such a way that incipient cracks are produced in the region of the limbs due to fatigue fracture and thus the separation limb is produced, whereupon in the notching operation the steel fibre veins are provided with anchorage means formed by interruptions in the notching operation.
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2. A method according to claim 1 characterised in that the steel fibre veins are shaped transversely to the longitudinal direction of the sheet metal strip.
3. A method according to claim 1 or claim 2 characterised in that the steel
20 fibre vein strip which after the notching operation extends over the entire width of the sheet metal strip is divided by separation blades forming two or more steel fibre strips.
4. A method according to claim 3 characterised in that division of the steel
25 fibre vein strip is effected prior to the flexing process.

5. A method according to any one of claims 1 to 4 characterised in that after the flexing process the steel fibre strips pass through a shaping roller for shaping the steel fibre veins in accordance with the purpose of use.
- 5 6. A method according to any one of claims 1 to 5 characterised in that after complete production the steel fibre strips are wound layer upon layer.
7. A method according to any one of claims 1 to 6 characterised in that the operation of individually separating the steel fibre strips to afford steel fibres is
10 effected at the location of concrete preparation.
8. A method according to claim 1 characterised in that the steel fibre veins are formed in the longitudinal direction of the sheet metal strip.
- 15 9. A method according to claim 1 or claim 8 characterised in that after the flexing process the top side and/or the underside of the strip is optionally roughened up in the manner of knurling.
10. A method according to any one of claims 1, 8 or 9 characterised in that
20 then the steel fibre veins (4) oriented in the longitudinal direction of the strip are separated from each other.
11. A method according to any one of claims 1, 8, 9 or 10 characterised in that after their separation the steel fibre veins are subjected by a shaping tool to
25 a shaping operation corresponding to the purpose of use.

12. A method according to any one of claims 1, 8, 9, 10 or 11 characterised in that after their shaping the steel fibre veins are cut to length to the desired measurement of the steel fibre.
- 5 13. A method according to any one of claims 1 to 12 characterised in that the notching is effected in a V-shape.
14. A method according to claim 13 characterised in that the notch angle W is between 30° and 120°.
- 10 15. A method according to claim 13 characterised in that the notch angle W is about 60°.
16. A method according to any one of claims 1 to 15 characterised in that the 15 thickness of the limb is 20% to 95% of the thickness of the strip.
17. A method according to any one of claims 1 to 15 characterised in that the depth of the V-shaped notches is so selected corresponding to the strength of the starting material and the purpose of use of the steel fibre, that the fatigue 20 fracture is achieved.
18. A method according to any one of claims 1 to 17 characterised in that the flexing process includes multiple bending deformation at one side with respect to the plane of the steel fibre strip until incipient fatigue fracture in the region of 25 the limbs.

19. A method according to any one of claims 1 to 17 characterised in that the flexing process includes multiple bending deformation at both sides with respect to the plane of the steel fibre strip until incipient fatigue fracture cracks occur in the region of the limbs.

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20. A method according to any one of claims 1 to 19 characterised in that the multiple bending deformation of the limbs is effected through respectively identical angular amounts.

10 21. A method according to any one of claims 1 to 19 characterised in that the multiple bending deformation of the limbs is effected through respectively increasing or decreasing angular amounts.

15 22. A method according to any one of claims 1 to 21 characterised in that the multiple bending deformation of the limbs is through an angle less than the notch angle W .

20 23. A method according to any one of claims 1 to 22 characterised in that the separation limbs are locally broken by slight oppositely directed deflection of mutually juxtaposed steel fibre veins.

24. A method according to any one of claims 1 to 23 characterised in that semi-finished material in strip form of metal is used as the starting material.

25 25. A steel fibre strip or steel fibre vein strip of metal which comprises a plurality of mutually parallel steel fibre veins connected together by way of limbs and which is produced by a method in accordance with any one of claims 1 to 24,

composed of semi-finished material in strip form which is used as starting material and which for forming steel fibre veins which are initially still connected together by limbs is notched on one side or on both sides and in the notching operation is provided with anchorage means, wherein the limbs are converted
5 by multiple bending deformations by means of a flexing process to provide thin, easily mutually separable separation limbs which form low-burring and fracture-rough separation surfaces upon separation and which have a fatigue fracture and the steel fibre veins and the steel fibre strips are subjected to a shaping operation whereby steel fibres suitable as an additive to concrete are formed in
10 the individual separation operation of the steel fibres from the steel fibre strip or the steel fibre vein strip.

26. A steel fibre strip or steel fibre vein strip according to claim 25 characterised in that high-quality steel-based or iron-based materials are
15 provided as the metallic material.

27. A steel fibre strip or steel fibre vein strip according to claim 25 characterised in that coated metal strips, in particular galvanised or copper-plated steel strip, are provided as the metallic material.

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28. A steel fibre produced in accordance with a method of any one of claims 1 to 24, formed from semi-finished material in strip form which is used as the starting material and which for forming steel fibre veins which are initially still connected together by limbs is notched on one side or on both sides and is
25 provided with anchorage means in the notching operation, wherein the limbs are converted by multiple bending deformations by means of a flexing process to provide thin separation limbs which form easily mutually separable separation

surfaces which have low burring and are fracture-rough upon separation, and which have a fatigue fracture.

29. A steel fibre according to claim 28 characterised in that it is of a shape
5 suitable for addition to concrete, creating anchors therein.