United States Patent Application Publication	20250263871
Kind Code	A1
Publication Date	August 21, 2025
Inventor(s)	SAUTER; Jörg et al.

KNITTING TOOL

Abstract

In recent years, development in the field of knitting tools has seen a focus on the reduction of friction and wear. A knitting tool (**1**) and a knitting device (**27**) as described herein are better able to reduce friction in knitting machines and the accumulation of dirt (**23**) than conventional knitting tools. For this purpose, a functional portion (**5**) of the knitting tool (**1**) has subsections (**7**) in which the absolute value of the gradient of a center-of-gravity line (**4**) is greater than zero.

Inventors: **SAUTER; Jörg (Albstadt, DE), SIMMENDINGER; Roland (Albstadt, DE)**

Applicant: **Groz-Beckert KG** (Albstadt, DE)

Family ID: **1000008578237**

Appl. No.: **19/188148**

Filed: **April 24, 2025**

Foreign Application Priority Data

EP	20214742.7	Dec. 16, 2020
DE	10 2021 119 011.8	Jul. 22, 2021

Related U.S. Application Data

parent US continuation 18267934 20230616 parent-grant-document US 12312719 WO continuation PCT/EP2021/081984 20211117 child US 19188148

Publication Classification

Int. Cl.: **D04B35/02** (20060101)

U.S. Cl.:

CPC **D04B35/02** (20130101);

Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 18/267,934, filed Jun. 16, 2023, which is the national phase of PCT/EP2021/081984, filed Nov. 17, 2021, and claims the benefit of European Patent Application No. 20214742.7, filed Dec. 16, 2020, and German Patent Application No. 10 2021 119 011.8, filed Jul. 22, 2021, which are each incorporated herein by reference in their entireties.

TECHNICAL FIELD
[0002] Knitting tools for use in industrial knitting machines have been undergoing further development since the 19th century and continually have to meet new challenges posed by further advances in the field of knitting machines. Recent years have seen a focus on the reduction of friction and wear, particularly against the background of rising energy prices and production costs. Customary knitting tools have a shank, which extends in a longitudinal direction of the tool and which, at least in a functional portion, is designed to be guided in needle slots of knitting machines (both circular and flat knitting machines) and, within a specified operating area, to perform a substantially linear knitting motion in these needle slots in the tool's longitudinal direction. The force for this knitting motion is transmitted to the knitting tool via a butt, which projects above the shank of the knitting tool in an elevational direction that is at right angles to the tool's longitudinal direction. The butt is also acted on by a transverse force in a lateral direction that is at right angles to the tool's longitudinal direction and elevational direction. The transverse force leads to tilting of the knitting tool in the needle slot and is supported by contact with the side walls of the needle slot. On account of the knitting tool's tilt, it only makes linear contact with the needle slot at the top and bottom. The tilt of the knitting tool in a needle slot is shown clearly in FIG. 2 of EP1860219A1: the contact positions are marked there with oval circles.
BACKGROUND
[0003] FR2260262A7 describes a knitting tool with which the intention is to reduce the vibrations of the hook (loop-forming means) generated at high knitting speeds and thus to prevent needle breakage. For this purpose, the needle's rear shank section, which adjoins the butt (FIG. 1, 5), has a wavelike shape (FIGS. 1, 4c and 4d). This wavelike shape is intended to dampen vibrations in the needle's longitudinal direction.
[0004] DE3612316A1 describes a knitting tool intended to have improved shock absorption properties. For this purpose, the knitting tool has at least one elongate groove extending in the shank's longitudinal direction. FIG. 4 shows a special exemplary embodiment of a knitting tool of this type, which has arcuate cut-outs (FIG. 4, 11) along the shank. These cut-outs result in the formation of bridges, which are intended to reduce the weight of the knitting needle and confer a springy resilience on sections thereof.
[0005] DE3213158A1 describes a knitting tool having a hook element (loop-forming means) and a closure element; the hook of the hook element is closable by means of a relative movement between the closure element and the hook element. This kind of knitting tool is also referred to as a compound needle. FIG. 5 shows a special exemplary embodiment of this knitting tool, which has concavities (FIGS. 5, 7 and 9) suitable for receiving a thread. These concavities (FIGS. 5, 7 and 9) directly adjoin the hook element in the longitudinal direction and are not guided in a needle slot.
[0006] EP2927360A1 describes a knitting tool with a meandering shank, which has reduced-thickness portions and thereby reduces the friction between knitting tool and needle slot. The meandering shank has a plurality of shank portions which are mutually offset in the elevational direction and which extend in each case in the tool's longitudinal direction. These shank portions

are interconnected by bridges extending in the elevational direction. The meandering shank of the knitting tool has no sections that are inclined with respect to the tool's longitudinal direction: all the shank sections either point exactly in the tool's longitudinal direction or enclose an angle of 90° with the tool's longitudinal direction.

[0007] The aforementioned EP1860219A1 describes a knitting tool whose shank has a functional portion. In a plane defined by the elevational and lateral directions, the height of the centre of gravity of the knitting tool's cross section varies within the functional portion with the position of the cross section in the tool's longitudinal direction. This is achieved by so-called “floating sections”. These “floating sections” are spaced both from the underside of the knitting tool and from the top side of the knitting tool. The “floating sections”, like the remaining sections of the functional portion, run parallel to the floor of the needle slot of the knitting machine in which the knitting tool is inserted—i.e. they run substantially in the longitudinal direction of the knitting tool. Accordingly, the height of the centre of gravity within the “floating sections” is constant. The “floating sections” are spaced from the top side and the underside of the knitting tool with the intention of reducing the contact surface between knitting tool and needle slot. The “floating sections” are interconnected by shank sections. These extend substantially in the tool's longitudinal direction, are disposed at the top side and underside of the knitting tool and are intended to form a linear contact surface with the needle slot. In a knitting-tool embodiment of this kind, spaces exist above and below the “floating sections”, in which dirt can collect during knitting.

SUMMARY

[0008] One objective of the invention is accordingly to provide a knitting tool and a knitting system with which, compared to conventional knitting tools and knitting systems, friction is reduced and, in addition, less dirt collects.

[0009] A knitting tool having the following features: [0010] a shank, which extends essentially in a tool's longitudinal direction, in which the tool is moved during knitting, [0011] wherein the shank has, at every point along its length, a cross-sectional surface which runs at right angles to the tool's longitudinal direction and is defined by its lateral and elevational directions, [0012] wherein each of these cross-sectional surfaces has a centroid, through which an imaginary centre-of-gravity line runs that interconnects the centroids of all the cross-sectional surfaces along the tool's longitudinal direction, [0013] wherein the shank has at least one functional portion, [0014] in which the centre-of-gravity line varies its height in the elevational direction (i.e. the centre-of-gravity line has no section in which the height of the centre-of-gravity line is constant—i.e. no section which runs substantially in the knitting tool's longitudinal direction. The second derivative of the centre-of-gravity line is accordingly not equal to zero if its gradient is zero), [0015] in which the height of the cross-sectional surface—the cross-sectional-surface height—is less at every point of the length of the functional portion than the shank height within the functional portion (the shank height is the distance, in the elevational direction, between the lowest point of the shank in the elevational direction and the highest point of the shank in elevational direction within its functional portion), [0016] wherein the length of the functional portion is more than 20%, preferably, however, more than 25% of the length of the entire knitting tool,

is characterised in that the functional portion has subsections in which the absolute value of the gradient of the centre-of-gravity line is between 0 and ∞. The absolute value of the gradient of the centre-of-gravity line in the subsections is accordingly greater than zero. The gradient between two points of the centre-of-gravity line corresponds to the quotient of the height difference in elevational direction and the length difference in the tool's longitudinal direction between these two points of the centre-of-gravity line (gradient=height difference/length difference). The areas of the knitting tool for which no gradient can be calculated in this way (e.g. if the length difference between two points of the centre-of-gravity line is zero) are not subsections as defined by this patent application. Advantages are obtained if the absolute value of the gradient of the centre-of-gravity line in the subsections is between 0 and 3. Preferably, however, the absolute value of the gradient of the centre-of-gravity line in the subsections is between 0 and 1. It is advantageous if, for at least 50% of the length of the subsections, the absolute value of the gradient of the centre-of-gravity line is between 0.01 and 0.8, preferably, however, between 0.025 and 0.6. The centre-of-gravity line connects the centroids via the shortest path. In the subsections of the functional portion the centre-of-gravity line varies its height continuously—in other words, the height of the centre-of-gravity line does not remain constant but rises and/or falls in the elevational direction along its course in the tool's longitudinal direction. Advantages are obtained if the centre-of-gravity line varies its height in such a way that, viewed in an x-z plane, it “oscillates”. The shape of the centre-of-gravity line is substantially due to a change relating to the knitting tool's cross section in the x-y plane and not to a change in density or material. Such a change may simply be a displacement of the cross section in elevational direction. It is advantageous if the knitting tool is produced by stamping. It is particularly beneficial if the knitting tool is a monolithic stamped part; the entire knitting tool then consists, as is preferable, of a single material and has essentially the same density throughout. On account of the gradient of the centre-of-gravity line, dirt in the shank area is pushed during the knitting movement of the knitting tool in the tool's longitudinal direction from the shank upwards, in positive elevational direction, and thus out of the knitting tool's operating area. The operating area in this context is the area in which the knitting tool can stay during its knitting movement. The knitting tool moves substantially in the tool's longitudinal direction. Dirt which comes into contact with the functional portion during this movement is acted on by a force directed at right angles to the surface of the knitting tool at the contact point. On account of the shape of the centre-of-gravity line, this force has directional components in the tool's movement direction and in the elevational direction. A self-cleaning effect is thus created in the operating area; dirt is removed and, in consequence, the reliability and service life of the knitting tool increased.

[0017] Further advantages are offered by a knitting tool according to the invention, which has at least one butt. The butt extends substantially in the elevational direction. The butt advantageously projects above the surrounding areas of the knitting tool in elevational direction. Driving forces and driving movements can be transmitted to the knitting tool via the butt. For use in knitting machines, this butt engages a cam with an arcuate cam curve, which, by means of a relative movement between the knitting tool and the stationary cam, transmits a knitting movement in the tool's longitudinal direction to the butt. Additional advantages are offered by a knitting tool having at least two butts. The teaching according to the invention can also be used to advantage with knitting tools comprising more than two butts.

[0018] It is also advantageous if the functional portion consists of at least two sub-portions, each of which has subsections in which the absolute value of the gradient of the centre-of-gravity line is between 0 and ∞, and these sub-portions are spaced apart from each other in the knitting tool's longitudinal direction. What is meant by the functional portion consisting of at least two sub-portions is that between these at least two sub-portions, there is an area of the knitting tool that does not belong to the functional portion. This may, for example, be an area in which the centre of gravity of the knitting tool's cross section does not vary its height, i.e. the height of which is constant. It is especially advantageous if the distance between the at least two sub-portions is at least exactly as large, but preferably 1.5 times as large, as the length of the butt, i.e. the butt length, in the tool's longitudinal direction. It is also to advantage if the butt is located between the at least two sub-portions.

[0019] Further advantages are obtained if the knitting tool has at least one sub-portion of the functional portion that precedes the butt as seen in the tool's longitudinal direction and at least one sub-portion of the functional portion that follows the butt as seen in the tool's longitudinal direction. As the point of force transmission for the driving forces during knitting, the butt is subjected to high loads. The preceding and following sub-portions of the functional portion can distribute and support the driving forces transmitted during knitting.

[0020] It is advantageous if a knitting tool according to the invention, in the case of which at least one sub-portion—preferably, however, two sub-portions—of the functional portion adjoin the butt directly or are spaced apart from the butt only by a distance, in the tool's longitudinal direction, which is less than or equal to 10% of the length of the entire knitting tool. A distance which is less than 5% of the length of the entire knitting tool is particularly advantageous.

[0021] It is advantageous if the functional portion has at least one local elevational extreme—maximum or minimum—of the centre-of-gravity line. At this at least one extreme, the gradient of the centre-of-gravity line is zero. These local extremes are adjoined on each side by the above-described subsections, in which the gradient of the centre-of-gravity line is between 0 and ∞. A transverse force acting on a knitting tool in a needle slot will cause the knitting tool to tilt and come into contact with the side walls of the needle slot in the vicinity of the local minima and maxima. Consequently, the transverse forces are supported there; contact points are created and, as a consequence of a knitting movement by the knitting tool, friction as well. It is particularly advantageous if, in the vicinity of local minima and maxima, the shank is configured in such a way that each of the contact points created here during knitting has a small contact surface.

[0022] Further advantages are obtained if at least two local elevational extremes of the centre-of-gravity line have the same height. It is particularly advantageous if at least two local minima and/or two local maxima have the same height. Additional advantages are obtained if at least two local maxima have the same height and a third local maximum has a lesser height. Similarly, it is to advantage if at least two local minima have the same height and a third local minimum has a greater height. It is particularly advantageous if the at least two local extremes of the centre-of-gravity line that have the same height are global extremes, i.e. the height of the centre-of-gravity line is not greater (global maximum) or smaller (global minimum) at any point.

[0023] It is advantageous if a knitting tool in the case of which the shank surface facing the knitting tool's positive elevational direction, that is, the direction in which the butt projects above the surrounding areas of the tool—from now on the top surface—has the same height at the positions, in the tool's longitudinal direction, of at least two local maxima of the centre-of-gravity line and/or the shank surface facing the knitting tool's negative elevational direction, that is, the direction pointing downwards towards the bed of the needle slot during knitting—from now on the bottom surface—has the same height at the positions of at least two local minima of the centre-of-gravity line. The positive elevational direction and the negative elevational direction are exactly opposite each other. It is particularly beneficial if, at the positions of the global maxima of the centre-of-gravity line, the top surface has the same height and/or, at the positions of the global minima of the centre-of-gravity line, the bottom surface has the same height.

[0024] Advantages are also offered by a knitting tool according to the invention in the case of which at least one local extreme has a surface which is raised laterally relative to the surface of most of the functional portion. As already described, a knitting tool in use in a knitting machine makes contact with a needle slot in the vicinity of the local extremes. If the surface is raised at these positions relative to the rest of the functional portion, a clearly defined contact surface is created at the raised positions and prevents other areas of the knitting tool from forming contact points with parts of the knitting machine—on account of manufacturing inaccuracies, for example. Further advantages are obtained if the surface is raised in such a way that predominantly punctiform contact points are formed with the knitting machine during knitting.

[0025] It is to advantage if, at the positions of local maxima of the centre-of-gravity line, the shank is spaced apart from the minimum shank height of the functional portion and, at the positions of local minima of the centre-of-gravity line, is spaced apart from the maximum shank height of the functional portion. It is particularly advantageous if this distance apart is at least half the magnitude of the maximum shank height of the functional portion.

[0026] Further advantages are obtained if at least one sub-portion of the functional portion comprises, in the x-z plane, at least one triangular recess and/or wavelike recess, which penetrates laterally through the functional portion. It is particularly advantageous if the height of the recess in elevational direction is at least 50%, preferably at least 65%, of the shank height.

[0027] Advantages are offered by a knitting tool according to the invention, in the case of which the shank surface facing the knitting tool's positive elevational direction—the top surface—has a gradient course which, in the tool's positive longitudinal direction, i.e. its extension direction, has a local gradient maximum in front of at least one local height maximum of the centre-of-gravity line and/or the shank surface facing the knitting tool's negative elevational direction-the bottom surface—has a gradient course which, in the tool's positive longitudinal direction, i.e. its extension direction, has a local gradient minimum in front of at least one local height minimum of the centre-of-gravity line. The tool's positive longitudinal direction, or its extension direction, is the tool direction towards the shank end at which the loop-forming element is located. At the positions described, the bottom and top surfaces thus form “dirt catches”, which, on account of the gradient course of the surface, propel dirt preferably in the tool's negative longitudinal direction. The dirt is thus propelled away from the formed loops or knitted textile.

[0028] It is particularly beneficial if the absolute value of the local gradient maximum of the shank surface facing the knitting tool's positive elevational direction—the top surface—and/or of the local gradient minimum of the shank surface facing the knitting tool's negative elevational direction—the bottom surface—has a value between 0.57 and 2.75. Preferably, however, the absolute value of the local gradient maximum of the top surface and/or the local gradient minimum of the bottom surface is between 0.83 and 1.74. Further advantages are obtained if the absolute value of the local gradient minimum of the bottom surface is greater than the absolute value of the local gradient maximum of the top surface.

[0029] Additional advantages are obtained if the shank surface facing the knitting tool's positive elevational direction—the top surface—and the shank surface facing the knitting tool's negative elevational direction—the bottom surface—are substantially parallel to each other in the subsections of the functional portion. The top surface and the bottom surface are parallel to each other at least section-wise. Consequently, material and stress distribution is consistent in these subsections. It is particularly advantageous if the top surface and the bottom surface are substantially parallel in the entire functional portion.

[0030] It is advantageous if the last maximum of the centre-of-gravity line of the functional portion, viewed in the tool's negative longitudinal direction, opposite the extension direction, is a global maximum. Additional advantages are obtained if this last maximum in the tool's longitudinal direction is spaced from the end of the knitting tool, viewed in its negative longitudinal direction, by a maximum of 30 mm, preferably, however, by a maximum of 15 mm. In this way, the knitting tool is prevented from tilting or twisting about an axis running in the lateral direction and good guidance of the knitting tool in knitting machines is achieved.

[0031] The objective is also achieved by means of a knitting device having at least one needle slot, which is configured to receive and, during operation, to guide a knitting tool, and at least one knitting tool having the following features: [0032] a shank, which extends mostly in a tool's longitudinal direction, in which the tool is moved during knitting, [0033] wherein the shank has, at every point along its length, a cross-sectional surface defined by its lateral and elevational directions, [0034] wherein each of these cross-sectional surfaces has a centroid, through which an imaginary centre-of-gravity line runs that interconnects the centroids of all the cross-sectional surfaces along the tool's longitudinal direction, [0035] wherein the shank has at least one functional portion [0036] in which the centre-of-gravity line varies its height [0037] in which the height of the cross-sectional surface is less at every point along the length of the functional portion than the shank height within the functional portion, which is the distance, in the elevational direction, between the lowest point of the shank in the elevational direction and the highest point of the shank in elevational direction within its functional portion, [0038] wherein the length of the functional portion is more than 20%, preferably, however, more than 25% of the length of the entire knitting tool.

The functional portion additionally has subsections, in which the absolute value of the gradient of the centre-of-gravity line is between 0 and ∞. In the subsections, accordingly, the centre-of-gravity line encloses an angle greater than 0° and less than 90° relative to the tool's longitudinal direction. This means, in particular, that in the subsections the centre-of-gravity line is not parallel to the tool's longitudinal direction. This shape of the centre-of-gravity line is due to a change or a “shift” relating to the knitting tool's cross section in the x-y plane and not to a change in density or material.

[0039] Additional advantages are obtained if the length of the needle slot in the knitting tool's longitudinal direction, the reach of the functional portion in the knitting tool's longitudinal direction and the magnitude of the stroke of the knitting tool's knitting movement during knitting are mutually coordinated such that at least 80%, advantageously 90%, but preferably 100% of the reach of the functional portion, in the knitting tool's longitudinal direction, remains within the needle slot during knitting. The reach of the functional portion in the tool's longitudinal direction describes the position of the functional portion in the tool's longitudinal direction relative to other parts of the knitting tool. The reach of the functional portion is the zone, in the tool's longitudinal direction, between the front and rear limits of the functional portion in the tool's longitudinal direction. If a functional portion has a plurality of subsections which are spaced apart from each other in the tool's longitudinal direction, the reach of the functional portion also includes those areas of the knitting tool which are located between these subsections [0040] for example, a butt located between two subsections. The knitting tool is guided in its functional portion by the needle slot, and driving forces are supported in the needle slot. Contact areas exist between the functional portion of the knitting tool and the needle slot. If too great a sub-portion of the functional portion were to exit the needle slot during knitting, the needle would be guided less well as a result. The above-mentioned selection ranges have proved advantageous in order to guarantee good guidance of the knitting tool. Ideally, the guiding portion of the knitting tool remains completely within a needle slot during the entire knitting movement, i.e. does not project out of a needle slot, particularly in the tool's longitudinal direction.

[0041] Further advantages are obtained if the upper edge of the needle slot is spaced in the elevational direction by a maximum of 0.5 mm, preferably, however, by a maximum of 0.3 mm, from the highest point of the shank surface facing the knitting tool's elevational direction, i.e. of the top surface. This distance is referred to from now on as the elevational distance. It is advantageous if the elevational distance is as small as possible. Advantages are obtained if the upper edge of the needle slot is higher or as high as the top surface at its highest point in positive elevational direction. In this way, it is ensured that the knitting tool's functional portion will form a contact area with the needle slot at the position of at least one local maximum and that, in particular, no contact areas are formed with the needle slot in the subsections of the functional portion. It is especially beneficial if the upper edge has substantially the same height in elevational direction as the top surface at its highest point in positive elevational direction.

[0042] It is also to advantage if the knitting tool of the knitting device has a butt, which is raised in the positive elevational direction relative to the functional portion and which engages in a recess of the knitting device—the cam curve—, and if the highest point, in positive elevational direction, of the shank surface facing the positive elevational direction of the knitting tool—the top surface (**10**)—is spaced apart from the cam curve in the tool's longitudinal direction (z). In this way, the top surface of the knitting tool is prevented from accidentally engaging the cam curve at these points. Accidental engagement could cause the knitting tool to jam, with resultant damage to the knitting tool and/or the knitting device. The distance in the tool's longitudinal direction between the highest point, in positive elevational direction, and the cam curve is the safety distance. The safety distance is advantageously greater than zero.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] FIG. **1** shows a knitting tool (**1**), which has a functional portion (**5**).

[0044] FIG. **2** shows the A-A section through the functional portion (**5**) of the knitting tool (**1**) at the position of a local maximum (**14**) in the centre-of-gravity line (**4**).

[0045] FIG. **3** shows the B-B section through the functional portion (**5**) of the knitting tool (**1**) at the position of a local minimum (**15**) in the centre-of-gravity line (**4**).

[0046] FIG. **4** shows a knitting tool (**1**), which has triangular recesses (**19**) in the functional portion (**5**).

[0047] FIG. **5** shows a knitting tool (**1**), which has wavelike recesses (**20**) in the functional portion (**5**).

[0048] FIG. **6** shows a knitting tool (**1**) whose surface in the area of local minima (**15**) and maxima (**14**) in the centre-of-gravity line (**4**) has dirt catches (**21**).

[0049] FIG. **7** shows the three sub-steps in which dirt (**23**) is removed from the operating area (**24**) of the knitting tool (**1**).

[0050] FIG. **8** shows a knitting device (**27**) comprising three needle slots (**28**), one of which is fitted with a knitting tool (**1**).

[0051] FIG. **9** shows four cam elements (**29**) of a knitting device (**27**) and a knitting tool (**1**).

[0052] FIG. **10** shows the top view of a knitting device (**27**) having three needle slots (**28**), each of which is fitted with a knitting tool (**1**).

[0053] FIG. **11** shows the section, in the x-z plane, through a needle slot (**28**) fitted with a knitting tool (**1**).

[0054] FIG. **12** shows a knitting tool (**1**) in the case of which the absolute value of the local gradient maximum (**40**) of the top surface (**10**) is smaller than the absolute value of the local gradient minimum (**41**) of the bottom surface (**13**).

DETAILED DESCRIPTION

[0055] FIG. **1** shows a knitting tool **1** having a shank **2**, which extends predominantly in the tool's longitudinal direction z and has a loop-forming element **3** shaped as a hook at its first end as viewed in the tool's positive longitudinal direction z. The shank **2** has, at every point along its length in the tool's longitudinal direction, a cross-sectional surface **8** which lies in the plane defined by the lateral direction y and the elevational direction x. In the functional portion **5**, the height of this cross-sectional surface **8**, i.e. the cross-sectional-surface height **22**, in the elevational direction x is smaller at every point than the shank height **6**. The shank height **6** is the height between the minimum and maximum extension of the functional portion **5** in the elevational direction x. The cross-sectional surface **8** and the centroid **9** of a cross section are shown by way of example in FIG. **2**. FIG. **1** shows a centre-of-gravity line **4**, which interconnects all the centroids **9** of these cross-sectional surfaces **8** of the shank via the shortest path. In the exemplary embodiment shown in FIG. **1**, this centre-of-gravity line **4** comprises three local maxima **14** and three local minima **15**. Other advantageous embodiments of the knitting tool **1** may, however, have more or fewer local maxima **14** and/or local minima **15**. In the area of the three local maxima **14**, the top surface **10** has the same height. In the area of the three local minima **15**, the bottom surface **13** has the same height in elevational direction x. In the subsections **7** of the functional portion **5**, the centre-of-gravity line **4** has a gradient greater than **0**. In these subsections **7**, therefore, the shank **2** is tilted with respect to the tool's longitudinal direction z and, in particular, does not run parallel to the tool's longitudinal direction z.

[0056] FIG. **2** shows the A-A section, the position of which is shown in FIG. **1** and which goes through the shank **2** in the functional portion **5** at the position of a local maximum **14** in the centre-of-gravity line **4**. Parts of the functional portion **5** are shown, wherein the functional portion **5**, taken as a whole, extends over the entire shank height **6**. The shank height **6** is delimited in positive elevational direction x by the maximum shank height **12** and in negative elevational direction x by the minimum shank height **11**. The cross-sectional surface **8** is shown with hatching and has a centroid **9** which, seen in elevational direction x and lateral direction y, "lies" in the centre of the cross-sectional surface **8**. The cross-sectional surface **8** is delimited downwardly, in negative elevational direction x, by the bottom surface **13** of the knitting tool **1**. The bottom surface **13** is also visible in FIG. **2** in an area that lies outside the sectional plane and continues beneath the cross-sectional surface **8**. The cross-sectional surface **8** is delimited upwardly, in positive elevational direction x, by the top surface **10** of the knitting tool **1**. The top surface **10** is at the level of the maximum shank height **12**. At the position of the cross-sectional surface **8**, the bottom surface **13**—and thus the shank **2**—is, by contrast, spaced apart from the minimum shank height **11** by the bottom distance **16**. In other words, beneath the local maximum **14**, in negative elevational direction x, a "clearance" exists between the shank **2** and the minimum shank height **11**.

[0057] FIG. **3** shows the B-B section, the position of which is also shown in FIG. **1** and which goes through the shank **2** in the functional portion **5** at the position of a local minimum **15** in the centre-of-gravity line **4**. Parts of the functional portion **5** are shown, wherein the functional portion **5**, taken as a whole, extends over the entire shank height **6**. The shank height **6** is delimited in positive elevational direction x by the maximum shank height **12** and in negative elevational direction x by the minimum shank height **11**. The cross-sectional surface **8** is shown with hatching and has a centroid **9** which, seen in elevational direction x and lateral direction y, "lies" in the centre of the cross-sectional surface **8**. The cross-sectional surface **8** is delimited upwardly, in positive elevational direction x, by the top surface **10** of the knitting tool **1**. The top surface **10** is also visible in FIG. **3** in an area that lies outside the sectional plane and continues above the cross-sectional surface **8**. The cross-sectional surface **8** is delimited downwardly, in negative elevational direction, by the bottom surface **13** of the knitting tool **1**. In FIG. **3**, the bottom surface **13** is at the level of the minimum shank height **11**. At the position of the cross-sectional surface **8**, the top surface **10** is, by contrast, spaced apart from the maximum shank height **12** by the top distance **17**. In other words, above the local minimum **15**, in positive elevational direction x, a "clearance" exists between the shank **2** and the maximum shank height **12**.

[0058] FIG. **4** shows a knitting tool **1** according to the invention, having a butt **18**, which, during knitting, is suitable for taking up driving forces and driving movements and transmitting them to the knitting tool **1**. In front of and behind the butt **18**, viewed in the tool's positive longitudinal direction z, are two adjoining sub-portions **33** of the functional portion **5**. Together, the two sub-portions **33** form the functional portion **5**. They are spaced apart from each other in the tool's longitudinal direction z by a functional-portion distance **31**, which is approximately 1.5 times as large as the butt length **32** of the butt **18**. In this exemplary embodiment, the butt **18** is located between the two sub-portions **33** of the functional portion **5**. The shape of the shank **2** in the sub-portions **33** of the functional portion **5** has a plurality of triangular recesses **19**. These triangular recesses **19** have a substantially triangular geometry in the x-z plane and "penetrate" completely through the shank **2** of the knitting tool **1** in the lateral direction. The top surface **10** and the bottom surface **13** of the shank **2** are substantially parallel to each other in the functional portion **5**.

[0059] FIG. **5** shows a knitting tool **1** according to the invention, which also comprises a butt **18** and a functional portion **5** having two sub-portions **33**. Contrary to the shape of the embodiment of FIG. **4**, the shape of the shank **2** in the sub-portions **33** has a plurality of wavelike recesses **20**. These wavelike recesses **20** have a substantially wavelike or arcuate geometry in the x-z plane and "penetrate" completely through the shank **2** of the knitting tool **1** in the lateral direction—One of the two sub-portions **33** is disposed in front of the butt **18** in the tool's longitudinal direction z, the other of the two sub-portions **33** is disposed behind the butt **28** in the tool's longitudinal direction z. The two sub-portions **33** directly adjoin the butt **18**. Accordingly, no space exists between the sub-portions **33** and the butt **18** in the tool's longitudinal direction. The last maximum in the centre-of-gravity line **4** of the functional portion **5**, viewed in the tool's negative longitudinal direction z, opposite the direction of extension, is a global maximum of the functional portion **5**. The knitting tool **1** is supported and guided particularly well by this global maximum in that the knitting tool **1** is prevented from tilting about an axis running in the lateral direction y.

[0060] FIG. **6** shows a knitting tool **1** according to the invention, which comprises a butt **18** and a guiding portion **5**, said guiding portion **5** comprising two sub-portions **33**. In its guiding portion **5**, the shank **2** has subsections **7** in which the shank **2** and the centre-of-gravity line **4** are substantially linear and are tilted at a constant angle with respect to the tool's longitudinal direction z—the absolute value of the gradient of the centre-of-gravity line **4** is accordingly greater than 0. In the area of each local maximum **14**, the top surface **10** of the shank **2** has a dirt catch **21**. In the area of each local minimum **15**, the bottom surface **13** of the shank **2** has a dirt catch **21**. In the case of a dirt catch **21**, which, viewed in the tool's positive longitudinal direction, is located in front of a local maximum **14** in the centre-of-gravity line **4**, the top surface **10** of the shank **2** has a gradient which has a local maximum in front of the local maximum **14** of the centre-of-gravity line **4**. In the case of a dirt catch **21**, which, viewed in the tool's positive longitudinal direction, is located in front of a local minimum **15** in the centre-of-gravity line **4**, the bottom surface **13** of the shank **2** has a gradient which has a local minimum in front of the local minimum **15** of the centre-of-gravity line **4**. The top surface **10** and the bottom surface **13** are thus tilted more strongly with respect to the tool's longitudinal direction—in other words, the absolute value of the gradient is greater than in the adjoining subsection **7** of the shank **2**. During the reverse movement of the knitting tool **1**, in the tool's negative longitudinal direction z, the dirt catches **21** increase dirt transport in the tool's negative longitudinal direction z. In this way, dirt is kept away from the part of the knitting tool **1** that comprises the loop-forming element **3**. Potential soiling of the formed loops and of the textile is reduced.

[0061] FIG. **7** shows the principle according to which the “self cleaning” of the knitting tool works, by way of example in three steps: In the starting position—here step a)—dirt **23** has collected in the operating area **24** of the knitting tool **1**. In this context, dirt **23** may be composed of large numbers of fibres, dust particles and abraded particles. The centre-of-gravity line **4**, which is not shown in this drawing for reasons of better clarity, runs between local maxima **14** and minima **15** and clearly has a gradient which is greater than 0. In step b) of FIG. **7**, the knitting tool **1** is shown during a forward movement **25**. On account of the rising centre-of-gravity line **4** in the subsections **7**, the dirt **23** is pushed during the forward movement **25** of the knitting tool **1** in the tool's positive longitudinal direction z and the elevational direction x. In step c) of FIG. **7**, the knitting tool **1** is shown during a reverse movement **26**. On account of the movement of the knitting tool **1** and the rising centre-of-gravity line **4**, the dirt **23** is pushed in the tool's negative longitudinal direction z and the elevational direction x. In the drawing, the knitting tools **1** are arranged in a knitting machine in such a way that the tool's longitudinal direction z is upright; accordingly, gravitational acceleration g points in the tool's negative longitudinal direction z. Any dirt **23** that protrudes above the knitting tool in the elevational direction because it was pushed out of the operating area **24** will therefore fall out of the knitting machine on account of its weight, which results from the earth's acceleration g. In all embodiments of the teaching according to the invention, dirt **23** protruding from the operating area **24** will additionally be “abraded” by relative movement between the knitting tool **1** and the cam element **29** or a dial (in the case of horizontally disposed knitting tools). Accordingly, soiling of the knitting tool **1** and of the knitting device **27** is reduced.

[0062] FIG. **8** shows part of a knitting device **27** comprising three needle slots **28**. The leftmost of the three needle slots **28** in FIG. **8** is fitted with a knitting tool **1**—in this case a knitting needle whose loop-forming element **3** is a hook. The middle and right-hand needle slots **28** have not been fitted with a knitting tool **1** so that the needle slots **28** can be shown better. Normally, all the needle slots **28** are fitted with a knitting tool **1** during knitting. The knitting tool **1** comprises a butt **18**, which projects above the rest of the knitting tool **1** and the needle slot in elevational direction x.

[0063] FIG. **9** shows a knitting tool **1** and four cam elements **29**, each of which comprises a cam curve **30**. Butts **18** of knitting tools **1** are able to engage in each of the four cam curves and initiate a movement in the tool's longitudinal direction in the respective knitting tool **1**, said movement resulting from a relative movement between the knitting tool **1** and the cam element **29**. In order to depict the position of the cam element **29** relative to the knitting tool **1** and the shape of the cam curves more clearly, the cam element **29** is shown rotated by 90° about the tool's longitudinal axis z. In the correct installation position, the recesses of the cam curves **30** are in fact open in the negative elevational direction x, so that the butt **18** of the knitting tool can engage, in the elevational direction x, in one of the cam curves **30**. The centre-of-gravity line **4** of the knitting tool **1** has two local maxima **14**, at the position of which the highest points, in positive direction x, of the top surface **10** are also located. For purposes of clarity, the drawing does not show the whole centre-of-gravity line **4** but only its two local maxima **14**. These highest points of the top surface **10** are spaced apart, in the tool's longitudinal direction z, from the cam curves **30** by a safety distance **38**, which is greater than zero. In this way, the shank **2** of the knitting tool **1** is prevented from undesirably “hooking into” one of the cam curves **30** and influencing the drive motion of the knitting tool **1** or causing the knitting tool **1** to jam.
[0064] FIG. **10** is a top view of a knitting device **27** comprising three needle slots **28**. In each of the three needle slots **28** is a knitting tool **1** comprising a functional portion **5**, which has two sub-portions **33**. The uppermost and the lowermost of the three knitting tools **1** are shown in an extended state. They show two different variants of an extended state. For one knitting movement there is only one extended state. In FIG. **10**, however, both variants are shown in one drawing. In the extended state, a knitting tool has reached the furthest position of the knitting movement in the tool's positive longitudinal direction z. In the case of the first extended-state variant, shown in FIG. **10** with the uppermost of the three knitting tools **1**, the functional portion **5** of the knitting tool **1** is accommodated completely in the uppermost needle slot **28** and has an edge distance **35** to the front edge of the needle slot **28**. The middle knitting tool **1** of the three is shown in a retracted state. It has reached the furthest position of the knitting movement in the tool's negative longitudinal direction z. The distance, in the tool's longitudinal direction z, between the loop-forming elements **3** of the middle and uppermost knitting tools in FIG. **10** corresponds to the stroke **34** of the knitting movement. The lowermost knitting tool **1** in the drawing is shown in a second variant of the extended state. The magnitude of the stroke **34** is so large in this case that the functional portion **5** exits the needle slot **28** during knitting. At least 80% of the length, in the tool's longitudinal direction z, of the functional portion **5** of the knitting tool **1** always remains within the slot **28** during knitting.
[0065] FIG. **11** shows a sectional view of a knitting device **27**. The section lies in the x-z plane and goes through a needle slot **28** fitted with a knitting tool **1**. The upper edge **36** of the needle slot **28** is spaced apart from the highest point **39** of the top surface **10** of the knitting tool **1**—and accordingly also from the shank **2**—by the elevational distance **37**. In positive elevational direction x, the upper edge **36** is higher than the highest point of the top surface **10**. Also advantageous for all embodiments of the invention is a needle slot **28**, the upper edge **36** of which is at the same height in positive elevational direction x as the highest point of the top surface **10**. In this case the elevational distance **37** would be zero.
[0066] FIG. **12** shows a further exemplary embodiment of a knitting tool **1**, which has essentially the same features as the knitting tool **1** of FIG. **6**. Compared to FIG. **6**, the knitting tool **1** has a top surface **10** with local gradient maxima **40** having absolute values smaller than the local gradient minima **41** of the bottom surface **13**. During knitting, a knitting tool **1** of this kind causes lower frictional forces in the needle slot of a knitting device because the flatter gradient of the top surface **10** makes for better guidance and more fluid motion of the knitting tool **1**. The knitting tool **1** differs additionally from the knitting tool **1** shown in FIG. **6** in that the last maximum **14**, viewed in the tool's negative longitudinal direction z, i.e opposite to the extension direction, of the centre-of-

gravity line **4** of the functional portion **5** is a global maximum **42**. Although this global maximum **42** is spaced, in the tool's longitudinal direction z, from the end of the knitting tool **1** as seen in its negative longitudinal direction z, the distance is selected to be as small as possible. In this way, the knitting tool **1** is prevented from tilting or twisting about an axis running in the lateral direction y. This measure, too, makes for better guidance and fluid movement of the knitting tool **1** during knitting. The above-described features change the shape of the dirt catches **21** formed by the top surface **10** compared to the exemplary embodiment of FIG. **6**, but this form of dirt catch **21** has proved to support the self-cleaning effect already described above with regard to the embodiment of FIG. **7**.

Claims

1. A knitting tool comprising: a shank extending in a longitudinal direction between a proximal end and a distal end comprising a loop forming element, the shank having a length between the proximal and distal ends and having a shank height in an elevational direction orthogonal to the longitudinal direction between a top surface and a bottom surface of the shank; and at least one functional portion of the shank in which the top and bottom surfaces of the shank have a continuously varying height in the elevational direction along a length of the at least one functional portion such that the top surface and the bottom surface each have no portion that extends parallel to the longitudinal direction within the at least one functional portion; wherein the length of the at least one functional portion comprises at least 20% of the length of the shank.
2. The knitting tool of claim 1, wherein the top and bottom surfaces are parallel to one another within the at least one functional portion such that the shank height within the at least one functional portion is uniform.
3. The knitting tool of claim 1, further comprising at least one of: a protuberance at a local height maximum of the top surface within the at least one functional portion configured for shifting dirt or debris proximally when the knitting tool is shifted proximally along the longitudinal direction; and a protuberance at a local height minimum of the bottom surface within the at least one functional portion configured for shifting dirt or debris proximally when the knitting tool is shifted proximally along the longitudinal direction.
4. The knitting tool of claim 3, wherein the protuberance comprises a distal surface portion and a proximal surface portion each having a gradient, wherein an absolute value of the gradient of the proximal surface portion is greater than an absolute value of the gradient of the distal surface portion.
5. The knitting tool of claim 4, wherein an absolute value of the gradient of the proximal surface portion of the protuberance is between 0.57 and 2.75.
6. The knitting tool of claim 1, further comprising a butt raised in a positive elevational direction, wherein the butt is proximal to the at least one functional portion.
7. The knitting tool of claim 1, further comprising a butt raised in a positive elevational direction, wherein the butt is distal to the at least one functional portion
8. The knitting tool of claim 1, further comprising a butt raised in a positive elevational direction, wherein the at least one functional portion comprises a first sub-portion proximal to the butt and a second sub-portion distal to the butt.
9. The knitting tool of claim 1, wherein the at least one functional portion comprises at least 25% of the length of the shank.
10. The knitting tool of claim 1, wherein the shank comprises opposing lateral surfaces extending between the top and bottom surfaces and at least one of the lateral surfaces comprises a surface portion within the at least one functional portion that is raised laterally relative to a majority of the at least one functional portion.
11. The knitting tool of claim 1, wherein within the at least one functional portion, the top surface

comprises at least three local height maxima.

12. The knitting tool of claim 1, wherein within the at least one functional portion, the bottom surface comprises at least three local height minima.

13. The knitting tool of claim 1, wherein the at least one functional portion comprises at least two sub-portions, wherein at least one sub-portion of the at least two sub-portions adjoins at least one butt directly or is spaced apart from the at least one butt by a distance in the longitudinal direction which is less than or equal to 10% of the length of the shank.

14. The knitting tool of claim 1, wherein the at least one functional portion comprises a plurality of triangular-shaped recesses formed by at least one of the top surface and the bottom surface.

15. The knitting tool of claim 1, wherein the at least one functional portion comprises a plurality of wavelike recesses formed by at least one of the top surface and the bottom surface.

16. The knitting tool of claim 1, further comprising a butt raised in a positive elevational direction, wherein a majority of the at least one functional portion is positioned proximal to the butt.

17. The knitting tool of claim 1, wherein the shank has, at every point along its length, a cross-sectional surface which extends orthogonally with respect to the longitudinal direction; wherein each cross-sectional surface has a centroid through which an imaginary center-of-gravity line runs that interconnects the centroids of all the cross-sectional surfaces along the longitudinal direction; wherein in the at least one functional portion, the imaginary center-of-gravity line has a continuously varying height along the length of the at least one functional portion.

18. The knitting tool of claim 17, wherein a height dimension of the cross-sectional surface in the elevational direction is smaller at every point along the length of the at least one functional portion than a maximum height dimension of the shank within the at least one functional portion, wherein the maximum height dimension of the shank within the at least one functional portion is a distance in the elevational direction between a lowest point of the shank in the elevational direction within the at least one functional portion and a highest point of the shank in the elevational direction within the at least one functional portion.

19. The knitting tool of claim 17, wherein a proximal-most maximum of the imaginary center-of-gravity line of the at least one functional portion is a global maximum.

20. The knitting tool of claim 19, wherein the proximal-most maximum of the imaginary center-of-gravity line of the at least one functional portion is spaced from the proximal end of the shank by 15 millimeters or less.
