WINDING SHAFT FOR A WINDER

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Abstract

The invention relates to a winding shaft for winding a continuous flexible material web into a roll. The winding shaft has means in order to adjust the diameter of the winding shaft surface to be wound between a reduced-diameter unused position and an expanded operating position, and the winding surface in the expanded position is formed jointlessly with a uniform curvature and is supported inward against the operational pressure around said winding surface in a dimensionally stable manner that is substantially uniform. A roll can thereby be wound without disruptions and then stored without a casing until the roll “dies”, said roll remaining stable during storage and not forming any disrupted zones on the inner face of the roll.
WINDING SHAFT FOR A WINDER

[0001] The present invention relates to a winding shaft according to the preamble of claim 1 and a production method for such a winding shaft according to claim 11.

[0002] Such winding shafts are used in winders which are known and described, for example, in EP 2048 100. A usually freshly produced continuous material web of a plastic film is wound in the prior art onto a winding core (a core plugged onto the winding shaft) to form a roll of predetermined size. The material web is then cut and the finished roll is preferably replaced in a flying manner by a new winding core, so that a new roll can be produced without delay and, as far as possible, without material loss.

[0003] Such plastic films are produced with an extraordinary diversity of compositions and accordingly with the most varied properties, which then also influence the winding behaviour and accordingly have to be taken into account during winding. The given production rate and the number of rolls to be produced in a production run are also parameters which have to be taken into account for qualitatively satisfactory production with, at the same time, reasonable costs.

[0004] Typical processing rates range from 2 to 1000 m/min, whilst the finished roll body can have a diameter from 50 to 2000 mm and a width from 10 to 6000 mm. The thicknesses can range from a few pm up to the millimetre range. Mention may be made, by way of example, of films with a thickness from 4 μm to 25 μm, preferably 8 μm to 25 μm, which are wound at a rate of 100 m/min and with a width from approx. 300 mm to 770 mm onto a winding shaft with, nowadays, up to 4-up mode (i.e. four winding cores are plugged onto a winding shaft and four rolls are thus wound beside one another in parallel).

[0005] The formulation of, in particular, plastic films of polyolefins (such as PE polyethylene or PP polypropylene) ranges from the mono-extruded film, comprising a single layer, up to co-extruded film with three, five or more plies, wherein adhesives of the most varied kind can for example be provided in the plies, so that the most varied multi-layer films arise.

[0006] Nowadays, some forty to fifty formulations are known in the area of silage and stretch films, which possess the various properties desired in each case for the application: in northern countries, for example, it is desirable in agriculture for the grass bales wrapped in foil, which can weigh up to 500 kg and are to remain in the field, also to retain their shape when covered in snow, which requires a film of high strength. In other countries, the film is supposed to be black. Alternatively, a film with a specific colour may also be preferred, e.g. green for optical reasons.

[0007] If a grass bale is being wrapped, the adhesive contained between the plastic plies of the films ensures that the individual windings adhere to one another around the grass bale, so that the winding roll possesses stability. Once the grass bale has been formed, a typical scraping noise arises during unwinding of the film, which is loud or quiet depending on the adhesive. Some farmers require films that become detached quietly, which has a corresponding effect on the overall formulation of the film.

[0008] The same applies in the area of stretch films, for example, which are used for the packaging of goods stacked on pallets, as protective films (for example in electronics) or as food-wrapping films. Stretch films must be highly stretchable in order also to cover an irregular surface of the wrapped-round material in the most uniform manner possible, and must also have a very good tear strength in order to hold the material securely, which requires a different formulation from silage films. The food-wrapping film used in the household thus adheres for example at the edge of the plate due to the adhesive excreted at the place where it is wrapped round the edge of the plate on account of the local pressure thus produced. Here too, the formulations are as numerous as the possibilities of use of the films and are adapted to the given use.

[0009] Depending on the requirements, production varies between the production of only a few identical wrapped bales for special applications up to mass production of identical wrapped bales.

[0010] As a result of the different formulations, the films themselves have different properties, which in turn have to be taken into account during winding for fault-free film winding, which makes particular demands on the winder with regard to the parameters such as web tension, winding pressure, winding rate, film thickness, elasticity of the film and adhesiveness of the film in the fresh roll etc.

[0011] The finish-wound film (the winder is usually located directly downstream of the extruder producing the film) is still living, since the various plastic plies are still settling down and the air enclosed between the plies or introduced substances, often the adhesives, are changing and also migrating through the layers. In other words, it is the case that the production process of the films is not yet completed after the winding.

[0012] The finished rolls must therefore be stored in a controlled manner immediately following the winding, which often takes place at a temperature of 30 to 45°C, for up to four days. The internal changes in the film thereby taking place lead to a change in the roll itself: the roll changes chiefly in the roll hardness, which is accompanied by a considerable pressure in the interior of the roll. This pressure then continues to be maintained until the roll is unwound again for use of the film.

[0013] Once again, it is the case that the changes in the roll still living after the winding prove to be different (in severity), depending on the formulation and also depending on the winding parameters, until the roll has died, i.e. is subjected to no further changes and therefore is available ready for sale after the aforementioned storage and can be transported away.

[0014] After use of the films, the cores made of cardboard or, on account of the required stability (considerable internal pressure in the roll), usually of plastic accumulates. A plastic core costs on average 1-2 Euros (whereby costs would also be incurred with recycling of the cores). The use of the film then incurs additional labour costs to collect, store and return the empty cores. This often leads to the empty cores being disposed of in some way or simply being burnt on site, so that the cost of the production of the cores is lost and, in the case of burning, the environment is polluted.

[0015] Accordingly, attempts have been made to produce a core-less roll wherein the film has been wound onto a winding shaft with radially extended segments. After completion of the roll, the segments were retracted so that the living roll could be pulled off axially from the winding shaft and stored. During storage of the roll, its internal diameter then unavoidably caved in, probably due to the increasing internal pressure in the roll, in each case at the points which lay during winding over a gap between the extended segments of the winding shaft. These caved-in points represented in FIG. 1b are ruinous, since the disruption due to caving-in is propagated from...
the inner surface of the roll into its interior and disrupts the correct unwinding of the film. The film often tears at the site of the disruption during unwinding, so that a considerable part of the length of the film is lost for use. Were the torn-off end to be taken up again and further unwound, a new tear would soon be the consequence.

[0016] In the case of some less sensitive stretch films which do not contain adhesive, a stable roll can also be wound on a comparatively thin core, since the roll changes little until it dies. However, this requires winding under low tension and low compressive pressure, because otherwise the thin core could be squashed, whereby the core sticks fast here too on account of the winding in the stable roll and is then unable to be pulled off from the latter. Such rolls are then unavoidably very soft and have large air inclusions between the plies, which is undesirable: folds arise in the wound plies at the site of the air inclusions, so that the film loses transparency (the unwound film is insufficiently transparent at the site of the folds, so that the packaged material can no longer be seen or lettering to identify the material on the latter can no longer be read) and in addition its adhesion is destroyed, since differing pressure prevails in the roll at the site of the folds and the properties of the films have therefore changed locally.

[0017] In other words, it is the case that thinner and therefore cheaper cores, which also reduce the cost of transport, have to be bought at the price of impaired quality of the film.

[0018] Finally, it is conceivable to change the formulation of the film in such a way that the roll can be pulled off from the winding shaft without a core and then remain stable, i.e. does not cave in. According to present-day knowledge, however, it is the case that the film, on account of the formulation that necessarily has to be changed, no longer meets market requirements, i.e. does not suffice in terms of quality.

[0019] Accordingly, the rolls continue to be wound on cores and are brought to the consumer with these cores.

[0020] The problem of the present invention is to make available rolls of plastic films of the aforementioned kind, wherein the previously required circulation of cores is dispensed with.

[0021] This problem is solved by a winding shaft according to the characterising features of claim 1 and by a production method for such a winding shaft according to claim 11.

[0022] Proceeding from the fact that the diameter of the winding shaft surface to be wound can be changed, it is possible to pull off from the latter a finished roll sitting snugly as a result of the winding on the expanded surface to be wound without thereby damaging the roll.

[0023] Due to the fact that the surface of the winding core to be wound in the expanded operating state is formed gapless with a uniform curvature and is supported inwardly all around against the operating pressure in a dimensionally stable manner that is essentially uniform, the roll remains without disruption in its interior region during winding, so that it no longer caves in when it is removed from the winding shaft immediately after the winding and is stored without support by a winding core until it has died. It can thus be transported without a core and can be completely unwound in use without disruption.

[0024] The effect of this is that cores are no longer required in the production of films, i.e. in the winding thereof.

[0025] On the basis of a daily production of 1250 rolls per production line (the average producer having around 8 production lines), the requirement for approx. 3 million cores per year with the corresponding costs is thus removed.

[0026] Preferred examples of embodiment of the winding shaft according to the invention are described in the dependent claims.

[0027] The invention will be explained in detail below with the aid of the figures. In the figures:

[0028] FIG. 1a shows a winding shaft according to the prior art

[0029] FIG. 1b shows a dead core, wound on a shaft according to FIG. 1a

[0030] FIG. 2a shows a winding shaft according to the present invention

[0031] FIG. 2b shows a second embodiment of the winding shaft according to the present invention

[0032] FIG. 2c shows a view of the winding shaft core of the winding shaft according to the invention of FIG. 2b

[0033] FIG. 3 shows in cross-section a roll ready-wound on the winding shaft according to the invention

[0034] FIG. 4 shows the core of FIG. 3 with the winding shaft core in the rest position

[0035] FIG. 5 shows a winding shaft core according to a third embodiment of the invention

[0036] FIG. 6 shows a detail from a winding shaft core of the winding shaft according to the invention with a preferred embodiment of the supporting shells

[0037] FIG. 7a shows a view of a winding shaft according to the invention

[0038] FIG. 7b shows a further winding shaft according to the invention in four-up mode

[0039] FIG. 1a shows a winding shaft 1 of the kind such as that known in the prior art, with ends 2 and 3, which can be clamped into a winder, and with a region 4 to be wound, onto which a continuous, flexible material web is wound to form a roll. Also shown are longitudinally extending segments 5 to 7, which can be extended radially out of the winding shaft and then increase the diameter of region 4. Even when segments 5 to 7 in the retracted state (i.e. with small diameter of the winding shaft) form a closed surface, a gap 8 inevitably arises between respectively adjacent segments 5 to 7 in the extended state, said gap making fault-free winding of a film to be wound directly onto such a winding shaft impossible, as described above, and therefore imposes the use of cores for the vast majority of formulations. (In FIG. 1a, only three segments 5 to 7 can be seen, whilst the other three of the total of six segments cannot, so that segments 5 to 7 are mentioned below as being representative of all the segments of winding shaft 1.)

[0040] If winding takes place without a core, roll 10 shown in FIG. 1b, after being pulled off from the winding shaft, already shows (depending on the formulation of the film) scarcely discernible or more marked pressure traces: adjacent segment edges stand out on the innermost winding ply of roll 10, but the curvature of internal region 11 of roll 10 is as a rule not disrupted.

[0041] After storage, the picture shown in the figure emerges: the roll has caved in its internal region 11 at the site of the previously only slight pressure traces. Corresponding disruption zone 12 extends, depending on the formulation, to a differing extent into roll 10 and subsequently prevents the proper unwinding of the wound-up material web or film. On account of the selected detail of the picture, the figure shows only one of the three disruption zones present in the case of three winding shaft segments. The wound film is indicated by the lines on the end face of roll 10, as also the caved-in windings in the interior of roll 10 at the site of disruption zone
12. A raised portion can thus be seen in internal region 11, said raised portion having approximately a triangular cross-section.

[0042] FIG. 2a shows a winding shaft according to the invention with a winding shaft core 20 as a preferred embodiment of means of adjusting the diameter of the surface of winding shaft 1 to be wound between a diameter-reduced rest state and an expanded operating state, the surface to be wound in the expanded state being formed gapless with a uniform curvature.

[0043] Winding shaft core 20 comprises an elastic base body 21, outer side 22 whereof the surface to be wound of winding shaft 1. The effect of the elasticity of base body 21 is that winding shaft core 20 can be widened from its rest state to an expanded operating state when segments 5 to 7 of winding shaft 1 are extended. Winding shaft core 20 is represented in the figure in its expanded state, segments 5 to 7 and the interior of the winding shaft body being indicated only schematically, since the structure of a winding shaft is known to the person skilled in the art without the winding shaft core according to the invention. In particular, a conventional winding shaft, onto which a rigid core is plugged in the conventional method (which then remains in the roll until it is unwound), can subsequently be retrofitted according to the production method according to the invention to form the winding shaft according to the invention. In other words, the expandability of the winding shaft core permits the change in its circumferential length between the rest state and the operating state.

[0044] Supporting elements constituted here as shells 24 are formed at inner side 23 of base body 21, said supporting elements also running longitudinally along winding shaft 1 and thus also winding shaft core 20. In the shown expanded state of the winding shaft according to the invention, shells 24 lie by side with a predetermined spacing from one another, determined by the increase in the circumference of winding shaft core 20 due to its increase in diameter. The spacing is dimensioned and predetermined by the person skilled in the art in such a way that, in the rest state of the winding shaft and therefore of winding shaft core 20, its diameter can be reduced to an extent such that a roll can be reliably pulled off from it. The inner surfaces of shells 24 form, in the configuration shown here, sections of inner surface 25 of winding shaft core 20.

[0045] Located between shells 24 are webs 25 of base body 21 which, again determined by the aforementioned increase in the circumference in the expanded state, are somewhat spaced apart from shells 24, so that small intermediate spaces 26 have formed.

[0046] FIG. 2b shows a further embodiment of a winding shaft according to the invention with a winding shaft core 30, which in contrast with the embodiment of FIG. 2a has only three shells 34, i.e. is designed to be plugged onto a winding shaft with only three radially extendable segments 5 to 7. Outer side 32 of base body 31, with winding shaft core 30 plugged on a corresponding winding shaft, again forms its windable surface, shells 34 are also positioned with a predetermined spacing, and small intermediate spaces 36 have also formed between webs 35 and shells 34. The interior of the winding shaft body is again omitted to make the figure easier to read. Only segments 5 to 7 and their direction of rotation corresponding to the drawn double arrow are indicated.

[0047] The function of winding shaft core 20, 30 is described in greater detail below in connection with FIGS. 3 and 4.

[0048] FIG. 2c shows winding shaft core 30 according to FIG. 2b in a view wherein the winding shaft body and segments 5 to 7 (FIGS. 2a and 2b) are completely omitted to make the figure easier to read. It is clear that, whilst shells 34 indicated by the dotted lines run longitudinally at the inner side of winding shaft core 30, they do not run straight, but rather along a helical line, which is not essential, but it is advantageous, as will also be described below.

[0049] In the expanded state of the winding shaft, however, the supporting shells always lie side by side with a spacing from one another and are disposed with respect to radially extendable segments 5 to 7 in such a way that each intermediate space between radially extendable segments 5 to 7 is overlapped by an associated supporting shell.

[0050] FIG. 3 shows a just completed roll 40, which is still sitting on winding shaft 41 and has to be pulled off from the latter.

[0051] Winding shaft 41 comprises here a winding shaft core 20 according to FIG. 2a. It is shown that the film is wound on outer side 22 of elastic base body 21 of winding shaft core 20, outer side 22 thus forming the surface to be wound of winding shaft 41. Also shown are segments 45 to 50 of winding shaft 41, which are extended radially corresponding to the shown double arrows, with the result that the winding shaft core is in the expanded operating state in which roll 40 has been wound. In order to make the figure easier to read, the mechanics for extending and retracting segments 45 to 50 are omitted, said mechanics being known from the prior art to the person skilled in the art as mentioned above and being able to be easily designed for the specific case.

[0052] Winding shaft core 20 is positioned on segments 45 to 50 in such a way that webs 25 lie on the latter (intermediate spaces 26 are omitted to make the figure easier to read), wherein shells 24 then overlap gaps 28 between adjacent shells 24, with the result that elastic base body 21 is supported perfectly by shells 24 at the site of gaps 28. As a result of the supporting effect of webs 25, base body 21 is also supported there. It thus follows that outer side 21 in the expanded state is formed gapless with a uniform curvature and is supported inwardly against the operating pressure all round in a dimensionally stable manner that is essentially uniformly. The uniform curvature is ensured by supporting shells 24, which are each curved identically and which here all have an identical cross-section, as well as by the, in each case, identical curvature of segments 45 to 50, which corresponds to the curvature of the supporting shells. The operating pressure arises on the one hand due to the winding tension and on the other hand due to the contact pressure if a contact roller of the winder is placed against the winder during winding, which is usually the case with difficult formulations. Elastic base body 21 is thus supported inwardly at every point of its circumference in a dimensionally stable manner that is uniform, either directly at respective segment 45 or indirectly via supporting shells 24 to 50.

[0053] The uniformity of the dimensional stability of base body 21 thus obtained over its circumference appears to be important, which must not be completely hard for perfect winding, but uniformly hard over its circumference, so that the roll does not cave in without a core during storage. Accordingly, the person skilled in the art will design the supporting shells preferably as thin as possible, so that the
base body is approximately of equal thickness over supporting shells 24 and between the latter (webs), which assists uniform dimensional stability.

As mentioned above in connection with FIG. 2c, shells 24 disposed longitudinally in winding shaft core 20 preferably run along a helical line. Especially in the case of a contact-pressure roller, which has contact with emerging roll 40 during winding and the continuously wound-up film presses against the latter, a pressure loading of the roll arises along a lateral surface line, i.e. where the contact roller makes contact with roll 40. At the site of webs 25, the contact-pressure roller would be able, on account of the web formed from elastic material, to sink somewhat more into the latter than is the case at the site of shells 24, which in turn could lead to a local irregularity in the winding of the film and thus a quality problem in roll 40. Such sinking-in is only possible if webs 25 also lie on a lateral surface line, but not when the latter lie on a helical line (which is the case when shells 24 follow a helical line). It is then the case that the contact-pressure roller always runs, apart from on web 25, also on a shell 24, is then supported in a harder manner there and thus cannot sink into web 25.

In turn, it follows from this that the helical line should be matched to the width of segments 45 to 50; if a web 25 does not lie completely on a segment 45 to 50, it projects into a gap 28 where any support would be absent, which would have an unfavourable effect. In the case of two segments, the helical line therefore reaches less than a half, in the case of three segments less than a third, in the case of four segments less than a fourth and for example in the case of six segments less than a sixth of a full rotation.

As an alternative to (i.e. in the case of straight-running shells) or in addition to shells running in the form of a helical line, elastic base body 21 can be constituted in such a way that, in the rest state, webs 25 are somewhat overdimensioned in the width and/or the height, so that, in the state extended by the expanded operating state, intermediate spaces 26 (FIG. 2a) are minimised and the height of webs 25 is such that, under the pressure of the winding, they do not diverge from the height of outer side beyond shells 24. A thickening of webs 25 possibly appearing in the rest state does not cause a disruption.

FIG. 4 shows roll 40, which can now be pulled off from the winding shaft, since the latter is in the diameter-reduced rest state. Segments 45 to 50 are retracted in the arrow direction, elastic base body 21 is relaxed, and thus it is contracted and accordingly reduced in diameter. A free space 51 lies between inner side 50 of roll 40 and outer side 22 of winding shaft core 20 and therefore winding shaft 41, said free space enabling roll 40 to be pulled off and stored until it has died. Roll 40 will no longer form any disruption zones 12 even in the case of the most sensitive formulations, since the winding has taken place over a uniformly hard, gapless winding shaft surface to be wound and the pulling-off from the winding shaft has taken place without contact (i.e. the innermost plies of the winding have not been disrupted).

The supporting elements constituted here as shells comprise a material which is harder than the expandable material of the winding shaft core and its base body and preferably comprise a sheet metal or glass fibre-reinforced or carbon fibre-reinforced plastic. The supporting elements can be cast in a known manner into the winding shaft core or, if the latter is made of rubber, can be vulcanised into the latter.

FIG. 5 shows a cross-section through a further embodiment of winding shaft 60 according to the invention in the expanded state with a winding shaft core 61 elastically expandable in the circumference, outer surface 62 whereof forms the surface to be wound of winding shaft 60. Winding shaft core 61 comprises, as in FIGS. 2a and 2b, supporting elements 63, which in the shown expanded state lie in a predetermined arrangement with respect to one another, i.e. here have an identical spacing at the sides and are disposed over the intermediate spaces of radially adjustable segments 65. Once again, small intermediate spaces 66 in base body 67 of winding shaft core 61 arise on account of the expansion. This arrangement offers the advantage that supporting shells 63 lying in the interior of base body 67 are firmly anchored in the latter and therefore are particularly suitable for the embodiment of a supporting shell 70 shown in FIG. 6 (FIG. 6). As in FIGS. 2a and 2b, the structure of the body of winding shaft 60 is omitted to make the figure easier to read. The preferred embodiment shown in FIG. 5 can also comprise only three segments 65 and supporting shells 63 or four or five thereof or more than six thereof.

In other words, the arrangement of supporting shells 70 in the embodiment shown is such that the latter run in the interior of winding shaft core 61 on a common diameter between surface 62 to be wound and inner surface 68.

Finally, it emerges from the preferred embodiments represented in the figures that the winding shaft according to the invention comprises radically movable segments for the adjustment between the rest state and the operating state, and means comprising a winding shaft core elastically expandable in the circumference, the outer surface whereof forms the surface to be wound of the winding core, and into which supporting elements running over at least the length of the surface to be wound are moulded, said supporting elements in the expanded operating state lying in a predetermined configuration in respect of one another (here with a predetermined spacing).

FIG. 6 shows a particularly preferred embodiment of supporting shells 70, which are disposed in a base body 67 according to FIG. 5. A detail of the base body is represented with one of supporting shells 70 in the expanded state. The other elements of the associated winding shaft preferably correspond to those of FIG. 5 and are omitted to make the figure easier to read. Supporting shells 70 comprise a central region 71, which lies between longitudinal edges 72, 73 of supporting shells 70 and has the greatest thickness, whilst the supporting shells taper off towards longitudinal edges 72, 73. Once again, intermediate spaces 74, 75 are present, which have arisen due to the expansion of base body 67. This tapering-off of supporting shells 70 produces a particularly gentle and uniform transition between the zones without supporting shells 70 of base body 67 and the zones in which supporting shells 70 are present, with the result that the winding takes place particularly uniformly.

FIG. 7a shows a winding shaft 80 according to the invention with a winding shaft core 81, the configuration whereof corresponds to that of FIG. 2c. Elastic base body 82 of winding shaft core 81 is represented transparent with a dashed line, so that the three supporting elements constituted here as shells 83 to 85 can be seen. FIG. 7b, on the other hand, shows a winding shaft 90 in four-up mode, i.e. for winding shaft cores 91 to 94 disposed behind one another (the dashed line base body is omitted in each case to make the figure easier to read), the structure whereof corresponds for example to
that of winding shaft core 81 of FIG. 7a. Such an arrangement permits four rolls to be wound simultaneously.

A method for the production of a winding shaft with supporting elements according for example to FIG. 5 comprises the following process steps:

In the retracted state of the radially movable segments, an elastic material is cast over the length on the rotating winding shaft until the latter is covered with a layer of the material all round at least over the entire surface to be wound, after which the supporting elements are brought onto this layer and a further layer of the material is cast onto the rotating winding shaft until the intended thickness of the winding shaft core has been reached, and wherein the winding shaft core expands after the hardening of the cast elastic material and is worked in the expanded state into a round shape with respect to the axis of rotation of the winding shaft, until the surface to be wound is constituted cylindrical and coaxial with respect to the axis of rotation.

The body of the winding shaft to be produced is preferably clamped in a lathe and rotates thereon, a nozzle for the elastic material positioned above being disposed so as to be traversable along the length of the winding shaft to be produced. During the rotation of the winding shaft to be produced, the nozzle is activated and suitably traversed, so that a layer of elastic material builds up in a region which corresponds at least to the intended surface to be wound. The rotation is then stopped, the supporting shells are pressed onto the cast compound, and the rotation is continued, as well as the casting process, until such time as the supporting shells are covered with a sufficiently thick material layer. The hardening process of the finish-cast winding core then takes place.

Preferably, the winding shaft is subsequently expanded, the rotation again being continued so that the outer side of the winding core can be worked into a round shape, for example by means of a blade in the lathe. A cylindrical windable surface of the winding core thus results, which is precisely concentric with the axis of rotation of the winding shaft. The surface to be wound is thus constituted gapless particularly precisely with a uniform curvature.

For a particularly preferred embodiment, the surface to be wound, which has been turned until round, is then ground, also preferably to surface quality N6 or even N7, which prevents the winding with film from being disrupted by any inevitable subsequent surface to be wound. Surprisingly, it has been shown that, especially in the case of films of 4 µm to 25 µm, the grinding of the surface to be wound to a higher surface quality can raise the quality of the winding depending on the formulation of the film.

As mentioned above, the material to be cast preferably comprises polyurethane with an admixture of rubber in order to ensure the required elasticity.

It emerges that, with the winding shaft according to the invention, the winding quality, achievable in itself, can be disrupted if the bearing of the winder on which the winding shaft is inserted is not sufficiently rigid to prevent vibrations due to the rotation of the winding shaft (which does not usually cause disruptions with a conventional core, since the winding is delivered on the core). Accordingly, the winding shaft according to the invention is preferably dynamically counterbalanced, in such a way that its mass in the expanded state is counterbalanced dynamically towards its axis of rotation.

The embodiments represented above are based on a conventional winding shaft with radially movable segments, on which a conventional core is clamped for the winding process according to the prior art. The present invention, however, is not limited to such designs known to the person skilled in the art which are then improved according to the invention. Although it is particularly suitable for the latter, the winding shaft according to the invention can be provided with arbitrarily constituted expansion elements.

Accordingly, the present invention also comprises a winding shaft core for a winding shaft constituted so as to be diameter-adjustable between the rest state and the operating state, with the following features:

A winding shaft core for the winding of a continuous, flexible plastic film to form a roll, wherein the winding shaft core comprises a surface to be wound, characterised in that the winding shaft core also comprises means for adjusting the diameter of its surface to be wound between a diameter-reduced rest state and an expanded operating state, wherein the surface to be wound in the expanded state is constituted gapless with a uniform curvature and is constituted so as to be supportable inwardly all round against the operating pressure in a dimensionally stable manner that is essentially uniform.

A winding shaft core, wherein the means comprise a winding shaft core elastically expandable in the circumference, the outer surface whereof forms the surface to be wound of the winding core, and into which supporting elements running over at least the length of the surface to be wound are moulded, said supporting elements in the expanded operating state lying with a predetermined spacing from one another.

A winding shaft core, wherein the supporting elements are constituted as supporting shells, which in the interior of the winding shaft core run on a common diameter between the surface to be wound and its inner surface and lie side by side with a spacing from one another in the expanded state of the winding shaft core.

A winding shaft core, wherein the supporting elements are constituted as supporting shells, the inner surfaces whereof form sections of the inner surface of the winding shaft core.

A winding shaft core, wherein the supporting elements run in the form of a helical line along the length of the winding shaft core and the helical line extends over the length of the windable surface less than a half, preferably less than a third, particularly preferably less than a quarter of a full revolution.

A winding shaft core, wherein the winding shaft core comprises an elastically expandable material, preferably a plastic such as polyurethane with an admixture of rubber, the expandability whereof permits the change in the circumferential length between the rest state and the operating state.

A winding shaft core, wherein the supporting elements comprise a material which is harder than the expandable material of the winding shaft core, and are preferably made of a sheet metal or glass fibre-reinforced or carbon fibre-reinforced plastic.

A winding shaft core, wherein the supporting shells taper from a central region between the longitudinal edges towards the latter.

1. A winding shaft for a winder for the winding of a continuous, flexible plastic film to form a roll, which comprises a surface to be wound on, characterised in that it comprises means for adjusting the diameter of its surface to be wound on between a diameter-reduced rest state and an expanded operating state, wherein the surface to be wound on in the expanded state is constituted gapless with a uniform curva-
ture and is supported inwardly all round against the operating pressure in a dimensionally stable manner that is essentially uniform.

2. The winding shaft according to claim 1, with radially movable segments for the adjustment between the rest state and the operating state, wherein the means comprise a winding shaft core elastically expandable in the circumference, the outer surface whereof forms the surface to be wound of the winding core, and into which supporting elements running over at least the length of the surface to be wound are moulded, said supporting elements in the expanded operating state lying with a predetermined spacing from one another.

3. The winding shaft according to claim 2, wherein the supporting elements are constituted as supporting shells, which in the interior of the winding shaft core run on a common diameter between the surface to be wound and the inner surface whereof form sections of the inner surface of the winding shaft core.

4. The winding shaft according to claim 2, wherein the supporting elements are constituted as supporting shells, the inner surfaces whereof form sections of the inner surface of the winding shaft core.

5. The winding shaft according to claim 3 or 4, wherein the supporting shells run in the form of a helical line along the length of the winding shaft core and the helical line extends over the length of the windable surface less than a half, preferably less than a third, particularly preferably less than a quarter of a full revolution.

6. The winding shaft according to any one of claims 2 to 5, wherein the winding shaft core comprises an elastically expandable material, preferably a plastic such as polyurethane with an admixture of rubber, the expandability whereof permits the change in the circumferential length between the rest state and the operating state.

7. The winding shaft according to any one of claims 2 to 6, wherein the supporting elements comprise a material which is harder than the expandable material of the winding shaft core, and are preferably made of a sheet metal or glass fibre-reinforced or carbon fibre-reinforced plastic.

8. The winding shaft according to claim 3 or 4, wherein the supporting shells taper from a central region between the longitudinal edges towards the latter.

9. The winding shaft according to any one of the preceding claims, with radially movable segments for the adjustment between the rest state and the operating state, wherein the segments are disposed over the length of the windable surface in the form of a helical line on the winding shaft and the helical line is preferably less than a half, preferably less than a third, particularly preferably less than a quarter of a full revolution.

10. The winding shaft according to any one of the preceding claims, wherein its mass in the expanded state is counterbalanced dynamically towards its axis of rotation.

11. A method for producing a winding shaft according to claim 2, wherein, in the retracted state of the radially movable segments, an elastic material is cast over the length on the rotating winding shaft until the latter is covered with a layer of the material all round at least over the length of the surface to be wound on, after which the supporting elements are brought onto this layer and a further layer of the material is cast onto the rotating winding shaft until the intended thickness of the winding shaft core has been reached, and wherein the winding shaft core expands after the hardening of the cast elastic material and is worked in the expanded state into a round shape with respect to the axis of rotation of the winding shaft, until the surface to be wound on is constituted cylindrical and coaxial with respect to the axis of rotation.

12. The method according to claim 5, wherein the surface to be wound, after being worked into a round shape, is subsequently ground, up to quality N6, preferably N7.

13. A winding shaft core for a winding shaft constituted so as to be diameter-adjustable between the rest state and the operating state, for the winding of a continuous, flexible plastic film to form a roll, wherein the winding shaft core comprises a surface to be wound, characterised in that the winding shaft core also comprises means for adjusting the diameter of its surface to be wound between a diameter-reduced rest state and an expanded operating state, wherein the surface to be wound in the expanded state is constituted gapless with a uniform curvature and is supported inwardly all round against the operating pressure in a dimensionally stable manner that is essentially uniform.

14. The winding shaft core according to claim 13, wherein the means comprise a winding shaft core elastically expandable in the circumference, the outer surface whereof forms the surface to be wound of the winding shaft, and into which supporting elements running over at least the length of the surface to be wound are moulded, said supporting elements in the expanded operating state lying with a predetermined spacing from one another.

15. The winding shaft core according to claim 14, wherein the supporting elements are constituted as supporting shells, which in the interior of the winding shaft core run on a common diameter between the surface to be wound and its inner surface and lie side by side with a spacing from one another in the expanded state of the winding shaft core.

16. The winding shaft core according to claim 14, wherein the supporting elements are constituted as supporting shells, the inner surfaces whereof form sections of the inner surface of the winding shaft core.

17. The winding shaft core according to claim 14 or 15, wherein the supporting shells run in the form of a helical line along the length of the winding shaft core and the helical line extends over the length of the windable surface less than a half, preferably less than a third, particularly preferably less than a quarter of a full revolution.

18. The winding shaft core according to any one of claims 14 to 16, wherein the winding shaft core comprises an elastically expandable material, preferably a plastic such as polyurethane with an admixture of rubber, the expandability whereof permits the change in the circumferential length between the rest state and the operating state.

19. The winding shaft core according to any one of claims 14 to 17, wherein the supporting elements comprise a material which is harder than the expandable material of the winding shaft core, and are preferably made of a sheet metal or glass fibre-reinforced or carbon fibre-reinforced plastic.

20. The winding shaft core according to claims 14 to 19, wherein the supporting shells taper from a central region between the longitudinal edges towards the latter.

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