METHOD AND APPARATUS FOR PRODUCTION OF TUBULAR STRAND AND ROPE

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ABSTRACT

Wires or strands are led through a die. The wires or strands are centrally supported against inward collapse, by a mandrel coaxial with the die, until the wires or strands are in mutual contact. The wires or strands can be compressed by the die, and the central support of the wires or strands may be maintained during at least the start of compression. Tubular strand can be produced which, in transverse section has a central circular void, and in which adjacent wires abut along interfaces which are straight lines in transverse section.

7 Claims, 23 Drawing Figures
METHOD AND APPARATUS FOR PRODUCTION OF TUBULAR STRAND AND ROPE

The present invention relates to a method and apparatus for the manufacture of tubular wire strand or wire rope or core for wire rope; strand comprises a plurality of parallel or helically laid wires, and rope comprises a plurality of strands laid in helical or parallel relationship.

The employment of tubular rope as a thernce lance is known and is described in British Pat. Specification No. 1,188,079, but the previous methods of manufacture are either slow and time consuming or relatively expensive, and production is confined to comparatively short lengths.

The object of the present invention is to provide a method and apparatus whereby tubular strand or rope, in a wide variety of constructions, may be manufactured as a continuous operation of considerable duration.

The present invention provides a method of forming tubular wire-strand or wire-rope or core for wire-rope, comprising leading a plurality of filaments through a die, and centrally supporting the filaments against inward collapse at least until the filaments are in mutual contact.

The word “filament” includes wire and strand.

The method further comprises, within the die and after mutual contact of the filaments, compressing the filaments inwardly by means of the die, to cause plastic flow at the points of mutual contact of the filaments. The filaments are centrally supported during at least the initial part of the compression, by means of a rigid member of circular transverse section. In general then, the method of forming tubular wire-strand or core for wire rope will comprise leading a plurality of wires through a die; centrally supporting the wires against inward collapse; and, within the die and after mutual contact of the wires, compressing the wires inwardly by means of the die, to cause plastic flow at the points of mutual contact of the wires; the wires being centrally supported during at least the initial part of the compression.

By carrying the compression sufficiently far, while centrally supporting the wires by means of a rigid member of circular transverse section, a wire strand or core can be produced which in transverse section has a central circular void, and in which adjacent wires abut along interfaces which are straight lines in transverse section.

In one particular embodiment, the production of tubular strand is achieved by attaching a circular rod or mandrel to the lay plate of a stranding machine in such a manner that the longitudinal axis of the mandrel lies parallel and concentric with the longitudinal axis of the lay plate and a forming die having a parallel bore, the length of the mandrel being such that, when in operation, its free end projects into the forming die for a distance not less than half the length of the parallel bore of the die.

Similarly, when applying the invention to the manufacture of tubular rope, in one particular embodiment, the mandrel is attached to the “nose” of a pre-forming head on a closing machine so that the longitudinal axis of the mandrel lies parallel and concentric with the common horizontal axis of the pre-forming head and the closing die having a parallel bore, the length of the mandrel being such that the free end projects into the closing die for a distance not less than half the length of the parallel bore of the die.

The function of the mandrel, when operating in either a stranding or closing machine, is that of a continuously retractable central or core element affording support to the overlying wires or strands at the moment of forming, and for a controlled length of time thereafter whilst consolidation by the forming or closing die takes place. From this stage onwards no further internal support is required and the strand or rope emerges from the die in tubular form.

In order that the invention may be more clearly understood various embodiments are given by way of example in conjunction with the accompanying drawings, in which:

FIG. 1 is an isometric view of part of a stranding machine;

FIGS. 2a, and 2b are longitudinal sections of the free end of two types of mandrel which lies within the die;

FIGS. 3 to 8 are cross-sections of a five, seven, eight, nine, and ten wire tubular strand respectively, before compression by the die of the stranding machine of FIG. 1;

FIGS. 9 to 14 show the respective tubular strands of FIGS. 3 to 8 upon emergence from the die of the stranding machine of FIG. 1 used in conjunction with the mandrel shown in FIG. 2b, corresponding to FIGS. 5 to 8 respectively;

FIG. 15 shows the tubular strand of FIG. 4 upon emergence from the forming die of the stranding machine of FIG. 1 used in conjunction with the mandrel shown in FIG. 2b;

FIG. 16 is a 27 round-wire strand formed in three covers 9 × 9 × 9/0; before radial compression;

FIG. 17 shows the consolidated cross-section of the strand of FIG. 16 upon emergence from the forming die of the stranding machine of FIG. 1 used in conjunction with the mandrel shown in FIG. 2a;

FIG. 18 is an 18 round-wire strand before compression formed in two covers 9 × 9/0 incorporating wires of different diameter;

FIG. 19 shows the consolidated cross-section of the strand of FIG. 18 upon emergence from the die of the stranding machine of FIG. 1 used in conjunction with the mandrel shown in FIG. 2a;

FIG. 20 is a tubular steel wire strand is comprised of non-ferrous wires;

FIG. 21 shows the consolidated cross-section of the strand of FIG. 20 upon emergence from the die of the stranding machine of FIG. 1 in conjunction with the mandrel shown in FIG. 2a and;

FIG. 22 is an isometric view of part of a closing machine fitted with rope pre-forming head.

In the production of tubular strand, suitable lengths of round, cold drawn, high tensile carbon steel wire are wound on bobbins 2 and loaded into a stranding machine shown in part in FIG. 1. The number of bobbins is equal to the number of wire desired strand construction.

The wires 1 from the bobbins 2 run along guides in the tube 9 of the strander, and are then threaded through fairleads 3 in the lay plate 4, and then led to a focal or forming point 5 on the horizontal axis A–B of the strander. The individual wires 1, upon reaching the focal point 5, make physical contact with the surface of a mandrel 6 fixed to the lay plate 4 and concen-
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3. The wires traverse into the lead-in, or mouth, of the die making progressive circumferential contact with the working surface or bore of the die. If, at the same time as forward traction is applied to the emergent wires at 10, the tube 9 of the mandrel is rotated clockwise or anti-clockwise, the individual wires adopt a left or right hand helical lay at the forming point 5, thereby forming a coreless or tubular strand. The emergent strand is post-formed by alternately bending in opposite directions.

The formation of a tubular strand, i.e., a strand without a permanent centre or king wire, is made possible by employing the mandrel 6, the free end of which may have the longitudinal profile shown in FIGS. 2a, and 2b. The particular form of mandrel employed depends on the strand construction, wire diameter, and desired bore of the tubular strand.

The effective working portion 12 of the mandrel shown in FIG. 2a commences at a point 11, the diameter at this point being the desired bore of the strand, it is maintained from the point 11 to the extremity 15 of the mandrel.

The effective working portion of the mandrel shown in FIG. 2a commences at the point 11 and progressively tapers to a point 14, the diameter at this point being the desired bore of the finished tubular strand; the remaining portion of the mandrel to its extremity 15 is cylindrical and has the same diameter as the point 14.

The mandrel shown in FIG. 2b is continuously tapered from its starting diameter at the point 11 to its extremity 15, and would be employed in those strand constructions requiring a micro-bore and maximum metal in the wall of the strand. In such instances the mandrel is used to provide internal support to the point at which the consolidated strand is completely stable, and the forming die is used as a reducing means and provides control over the final strand configuration (FIG. 15).

In conjunction with forming the die, the mandrel, irrespective of its design, has an initial function which is to afford temporary support whilst the strand is being formed in the absence of a king wire. It subsequently maintains this support whilst the formed strand is consolidated by radial compression to the stage where the components are capable of sustaining one another in their assigned positions, and the strand becomes resistent to collapse, that is to say when the wires have started to flow plastically at the lines of mutual contact with adjacent wires.

The support offered by the mandrel, particularly to those wires immediately overlying it, is temporary, initially allowing the component wires to make line contact one with another. Its subsequent retention is to provide support whilst the radial pressure induces plastic flow and deformation of the steel at these lines of contact to initiate conjoint plane surfaces. At this stage the internal support afforded by the mandrel can be withdrawn, the uniform inwardly directed radial pressure required to bring the tubular strand to its finished size being exercised by the forming die.

FIG. 3 illustrates a five-wire strand as it would appear in cross-section at the point 11, the radius (r) of the individual wires being greater than the radius (R) of the mandrel 6. FIG. 9 shows the same strand construction upon leaving the extremity 15 of the mandrel the initially round wires 1 (broken line) are transformed to wires which, in section, have an arcuate head 16, radiused at the corners to merge with the plane surfaces 17 between adjacent wires, and leave a central circular void 18. The effect of applying the same treatment to the six-wire tubular strand of FIG. 4 is shown in FIG. 10.

The resulting strands are illustrated in FIGS. 11 to 14. In those instances where it is desired to produce a tubular strand having a very small bore and large radial thickness, the mandrel shown in FIG. 2b is employed. With this type of mandrel the bore of the forming die is also tapered so that, as the strand traverses beyond the tip of the mandrel, the forming die continues to exert a uniform radial pressure which results in further inwardly directed consolidation of the strand. FIG. 15 shows the ultimate very small tubular construction achieved by this means from the six-wire strand shown in FIG. 4.

The apparatus described above is not confined to tubular strands having a one-layer construction; it is equally applicable to such multi-layered constructions as those shown in FIGS. 16, 17, 18, 19, 20, and 21. FIGS. 16, 18, and 20 show the straddles in cross-section as they would be, using the mandrel shown in FIG. 2a at the point 11, whilst FIGS. 17, 19, and 21 illustrate the tubular shape of the respective strands as they would be on emergence from the forming die.

In the manufacture of tubular rope, the desired construction can be built up from a plurality of helically spun round-wire strands having a king wire or from tubular strands.

The rope is produced by winding a plurality of strands, onto bobbins and loading them into a closing machine (FIG. 22). The free end of strand from each bobbin is fed through the machine via fairleads to the lay plate 19 and on through a pre-forming head 20.

The pre-forming head 20 is of orthodox design, except that a mandrel 21, conforming to FIG. 2a, is anchored at the apex 22 of the pre-forming head, its longitudinal axis being concentric and parallel with the longitudinal axis C-D of the pre-forming head. The length of the mandrel 21, from the point of anchorage to its extremity is sufficient to allow its effective working length 12 (FIG. 2a and 2b) to protrude into the closing die 23 for a distance not less than half the length of the parallel portion of the bore of the die.

Having taken the strands along their assigned path through the preforming head, and through the closing die 23, with the tip of the mandrel 21 located centrally, the ends of strand projecting from the exit side of the die 23 are secured to a strap attached to the "take-up" portion (not shown) of the closer, after passing through a set of compression rollers.

The application of a tractive force to the rope on the exit side of the forming die, and rotation of the feed bobbins, lay plate, and preforming head in either a clockwise or anti-clockwise direction, causes the strands 25 to pay-off from their respective bobbins into the preforming head. At this point the individual strands are mechanically set to a helix corresponding to the lay length they will occupy in the finished rope. The fact that the strands, whilst preforming, are progressively converging upon the common axis C-D also as-
The function of the mandrel during the closing of a rope is comparable with that of the mandrel during stranding in that it provides temporary central support until such time as the rope has been consolidated under the influence of the forming die, and becomes self-supporting. At this stage the diameter of the strands is greater than that of the central void and continued support from the mandrel becomes unnecessary as the tubular rope traverse forward.

As such tubular strands and ropes are primarily intended to convey fluid or gaseous media at varying temperatures, the strands or ropes may be circumferentially sheathed, coated, or wrapped with a layer or layers of elastomer, with or without reinforcement, or spirally taped with metal, or covered with composite overlapping layers of metal and elastomer.

We claim:

1. A method of forming a tubular wire-strand or tubular wire-rope or tubular core for wire-rope by leading a plurality of round filaments, all of the same material, onto a rigid member having a circular transverse section with a portion thereof tapering in the direction of movement of the filaments passing through a circular annular die coaxial relative to the rigid member comprising the steps of: centrally supporting the filaments on the rigid member against inward collapse until the filaments are in mutual contact, compressing the filaments radially inwardly by means of the die to cause plastic flow at the points of mutual contact of the filaments; and centrally supporting the filaments, during at least the initial part of the compression, by supporting the filaments on the tapering portion of the rigid member.

2. A method as claimed in claim 1, wherein, during compression, plastic flow of the filaments also occurs at the points of contact between the filaments and the rigid member.

3. A method as claimed in claim 1, wherein the filaments are supported by the rigid member until the compression has ended.

4. A method as claimed in claim 1, wherein, during the compression, the filaments are centrally supported by a rigid cylinder which is a smooth continuation of the rigid member.

5. A method as claimed in claim 1, wherein the filaments are wires.

6. A method as claimed in claim 1, wherein the compressing of filaments radially inwardly is performed uniformly.

7. A tubular wire-strand or core for wire-rope having a plurality of filaments, all of the same material, which in transverse section has a central circular void, and in which adjacent filaments abut along interfaces which are straight lines in transverse section and in which plastic flow has occurred at the interfaces, by leading a plurality of round filaments, all of the same material, onto a rigid member having a circular transverse section with a portion thereof tapering in the direction of the motion of the filaments through a circular annular die comprising the steps of; centrally supporting the filaments on the rigid member against inward collapse until the filaments are in mutual contact, compressing the filaments radially inwardly by means of the die to cause plastic flow at the points of mutual contact of the filaments; and centrally supporting the filaments, during at least the initial part of the compression, by moving the filaments onto the tapering section of the rigid member.