ADJUSTABLE QUILL HEAD AND INTERLOCKED WIRE ROPE MADE THEREWITH

Fig. 11

Fig. 12

Fig. 13a

Fig. 13b

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ADJUSTABLE QULL HEAD AND INTERLOCKED WIRE ROPE MADE THEREWITH

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ABSTRACT OF THE DISCLOSURE

An inner and an outer section of a quill head each carry one row of quills. The outer section is adjustable longitudinally and rotationally with respect to the inner section to provide precise alignment of the two groups of quills with respect to each other for forming interlocked wire rope.

A final rope having larger outer strands received evenly in the valleys between smaller inner strands and having effectively balanced internal stresses is formed by use of the quill head.

Background of the invention

The present invention relates to the fabrication of interlocked wire rope and apparatus to improve such fabrication.

So-called interlocked rope has assumed great prominence in recent times. This rope is formed by laying the outer strands of a two operation rope upon the inner strands with the same lay as the inner strands so that the outer strands lie in the valleys between the smaller inner strands and the inner and outer layers of strands are therefore "locked" together. While such ropes have superior wear and fatigue resistance because the strand layers do not cross and the rope has increased cross-sectional metal area in a rope of any given diameter, they have been difficult to form because of the precise alignment necessary between the two layers of strands as they are stranded. Fabrication of interlocked ropes in a single operation in particular has not been satisfactory because poor preforming and alignment of the strands as they pass into the standing die may cause large stresses to be built up in the layers of strands over a length of rope. These stresses, which arise primarily because the natural curvature of the preformed strands do not correspond exactly to the natural curvature in the final rope and consequently bear heavily against adjacent wires and strands, have often been sufficient to cause one layer of strands to suddenly rotate with respect to the other layer to relieve the stresses. Such rotation destroys the interlocked nature of the rope. The outer strands then not only tend to cut into the inner strands at the cross over point but also no longer fit compactly around the inner strands because the inner layer of strands has a larger effective diameter with respect to outer strands crossing its lay than to strands lying in the valleys between its strands.

Even when the stresses in the rope are not great enough to cause an actual rotation of the individual layers of the strand with respect to each other, the stresses which are present cause excessive working of the individual strands against each other as the strand is used. The excess friction generated increases internal wear of the rope to such an extent as to greatly decrease the life of the rope and constitutes an even greater problem than that of actual rotation of the strands. The magnitude of this problem has not always been realized and even where it has to some extent been realized, it has been thought to be an inevitable concomitant of forcing the strands into position in the final rope structure with the standing die and whatever preforming means was used, whether a roller head or a quill head.

It was virtually impossible heretofore to fabricate adequately balanced stress-free interlocked strand. The construction of progressively better and better quill heads for any given rope construction was not only impractical because of the expense of making a series of new quill heads for each possible variation in strand characteristics, but the discovery of the best possible head arrangement has for one standard unvarying rope and strand combination was virtually impossible since an examination of a rope section may indicate that a change is needed but it is usually not possible to determine what such change should be, either with respect to the amount of change or the direction in which a change should be made. The present invention of an adjustable quill head eliminates these difficulties by allowing small changes to be made to determine the optimum, and then maintain the optimum, stranding arrangement.

Summary of the invention

We have discovered that the foregoing problems may be eliminated and interlocked ropes having an average useful working life at least double the life of rope made on conventional rope machinery may be easily fabricated by the use of an adjustable quill head wherein the two layers of strands for the interlocked rope pass through two separate concentric sections of the head separately adjustable longitudinally and rotationally with respect to the other such that the two layer strands may be precisely oriented with respect to each other as they pass into the standing die. Each section of the quill head has inclined cylindrical quill orifices, the projected axes of which intersect and is so constructed that the two intersection points may be adjusted to substantially coincide.

The relative radial and axial movements made possible by the two part head aid in preforming so that the wires and strands as they are unloaded after preforming, spring back to assume a curvature corresponding to the exact curvature in a given layer of the final rope, and also in locating the best interlocking point for the strands. Both the statics and dynamic efficiency of the rope is as a consequence greatly increased.

Brief description of the drawings

FIGURE 1 is a side view of the adjustable quill head of the invention in operation.

FIGURE 2 is a rear view of the quill head facing toward the standing die with the quills removed.

FIGURE 3 is a front or face view of the quill head with the quills removed.

FIGURE 4 is a cross section of the quill head along line 4-4 of FIGURE 3.

FIGURE 5 is a partial cross section of the quill head similar to FIGURE 4 but with the two sections of the head opened as far as possible.

FIGURE 6 is a partially cutaway view of the quill head wherein 4a shows in cross section the set screws which control relative rotational movement of the head sections and 6b shows the face of the quill head with the outer head section rotated to extreme position with respect to the inner section.

FIGURE 7 is a front or face view of the outer head section.

FIGURE 8 is a cross section of the outer head section along line 8-8 of FIGURE 7.

FIGURE 9 is a front or face view of the central head section.

FIGURE 10 is a side view of the central head section partially in section along line 10-10 of FIGURE 9.
FIGURE 11 is a side view of the interlocked rope of the invention with the outer strands partially broken away to show the inner strands.

FIGURE 12 is an end view of the rope of FIGURE 11.

FIGURES 13A and 13B show tensile test distribution curves for sections of prior standard interlocked rope and the new interlocked rope of the present invention respectively.

Description of the preferred embodiment

Adjustable quill head 11 is mounted upon the rotatable shaft 13 of a conventional unrolling machine in front of a conventional fixed stranding die 15 in which the smaller inner strands 17 and relatively larger outer strands 19 are stranded around the central strand 21 of an "interlocking" wire rope 20. The adjustable quill head comprises three principal components, central head section 23 mounted upon shaft 13, an outer head section 25 mounted concentrically upon section 23, and a rear mounting section 27 also mounted upon shaft 13. Large quills 29 for preforming outer operation strands 21 are mounted in inclined quill orifices 35 in outer head section 25. Small quills 33 for preforming the inner operation strands 17 are mounted in inclined quill orifices 35 in radial extensions 37 of central head section 23. Radial extensions 37 are accommodated in radial grooves 39 of outer head section 25. Set screws 41 and 43 in screw holes 40a and 40b adjustably secure large quills 29 and small quills 33 in quill orifices 31 and 35 respectively against longitudinal and rotational movement. Index marks 45 and 47 about orifices 31 and 35, respectively, aid in exact positioning of the quills or exact duplication of previous positions. Relatively large orifices 49 in outer head section 25 in line with small quill orifices 35 enable the small inner strands 17 to pass freely through the outer head section 25 to quills 33. The orifices 49 and 35 are oriented in head sections 25 and 23 respectively to orifices 31 so that orifices 31 are positioned between orifices 49 with the inner edges of orifices 31 inside an imaginary circle circumscribed through the outer edges of orifices 49.

As seen in FIGURE 4 the inner surface 51 of outer head section 25 is designed to fit concentrically in a slideable relationship around surface 53 of central head section 23. The sliding movement of outer head section 25 is limited in a forward direction—that is in the direction of movement of the rope strands towards the closing die—by shoulder 55 of central head section 23, against which shoulder 57 of outer head section 25 may abut, and in the rearward direction by the surface 59 of rear mounting section 27, against which the rear face 61 of outer head section 25 may abut. The longitudinal position of outer head section 25 with respect to central head section 23 is determined by set screws 63 bearing against, and tension bolts 65 threaded into, outer head section 25 which cooperate to lock the outer head section in place with respect to rear mounting section 27 as shown in FIGURE 4. Rear mounting section 27 is fixedly secured to central head section 23 by means of machine bolts 67 and key 69. Set screws 63 are threaded into rear mounting section 27. Tension bolts 65 are passed through slots 71 in rear mounting head 27 to enable outer head sections 25 to rotate upon central head section 23 to the extent permitted by slots 71. When the outer head section is in the desired position rotationally with respect to the central head section, set screws 73 are tightened against contact surfaces 74 on central head section 23 to secure the two head sections together. The length of slots 71 as shown in FIG. 2 in rear mounting section 27 is sufficient to allow a full rotational movement of outer head section 25 with respect to central head section 23 which may be allowed by the clearance of the radial extensions 37 of central head section 23 in the radial grooves 39 in outer head section 25 as shown in 60 of FIGURE 6. The rotational position of outer head section 25 with respect to central head section 23 and rear mounting section 27 is indicated by the position of pointer 75 secured on rear mounting section 27 on scale 77 inscribed upon outer head section 25. Rear mounting section 27 is secured to shaft 13 by bolts 79 and may be positioned rotationally on shaft 13 with the aid of scale 81 on rear mounting section 27 and a suitable positioning mark, not shown, on shaft 13.

In the use of the adjustable quill head the smaller inner strands 17 of the interlocked rope are passed through orifices 49 in outer head section 25 and through the spiral preforming grooves of small quills 33 and thereafter through the stranding die 15. The large outer strands 19 of the interlocked rope are likewise passed through the spiral preforming groove of the large quills 29 and through stranding die 15. When all the strands are accurately strung through the stranding apparatus quills 29 and 33 are adjusted to the most advantageous position based on past experience and the central head section 23 and outer head section 25 are adjusted in relation to each other to a more or less intermediate position with respect to longitudinal and rotational position, or alternately to the best position known based on past experience. The stranding machinery is then started and 25 to 50 feet of interlocked wire rope 20 shown in FIGURES 11 and 12 is fabricated and cut off. The cutoff section is then examined for balance and coherence. If the strands are properly preformed and laid into the rope, the rope will be dead and have fleshy feel. Preferably the section of rope is partially unaided to determine if all the strands conform to each other without stress. If the strands are not properly molded into position a displacement from proper position will be evident when the rope structure is unaided. After it is determined what irregularities are in the rope the relative longitudinal and rotational position of the two head sections 23 and 25 are adjusted and the positions of the quills are adjusted in the heads to positions which it is believed will provide fabrication of a balanced rope. A second section of rope is then made, cut off, and examined and adjustments made in the adjustable quill head to components to correct any observed imbalance in the component parts of the rope. This sequence is continued until a substantially perfectly balanced rope structure is obtained. The component parts of the quill head are then locked into final position and production of the rope may continue thereafter as long as necessary.

Four sections of interlocked rope formed in the quill head of the present invention were tested both statically and dynamically and the results compared with the results obtained from tests of four sections of corresponding interlocked rope made by the best prior known practice using a standard quill head. These results are shown below.

The tensile tests were carried out in a standard tensile apparatus and the fatigue tests were carried out in a standard testing machine at a maximum load of 17,500 lb./in.² and a frequency of 150 cycles per minute.

<table>
<thead>
<tr>
<th>1. STANDARD INTERLOCKED ROPE</th>
<th>2. NEW INTERLOCKED ROPE OF INVENTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (lb./in.²)</td>
<td>Cycle to failure on fatigue testing equipment</td>
</tr>
<tr>
<td>Rope No. 1.</td>
<td>84,060</td>
</tr>
<tr>
<td>Rope No. 2.</td>
<td>84,060</td>
</tr>
<tr>
<td>Rope No. 3.</td>
<td>84,060</td>
</tr>
<tr>
<td>Rope No. 4.</td>
<td>84,060</td>
</tr>
<tr>
<td>Mean breaking strength</td>
<td>84,355</td>
</tr>
<tr>
<td>Tensile strength (lb./in.²)</td>
<td>Cycles on fatigue testing machine</td>
</tr>
<tr>
<td>Rope No. 1.</td>
<td>81,410, 2,505,000 cycles to failure.</td>
</tr>
<tr>
<td>Rope No. 2.</td>
<td>81,410, 2,505,000 cycles to failure.</td>
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<td>Rope No. 3.</td>
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</tr>
<tr>
<td>Rope No. 4.</td>
<td>81,410, 2,505,000 cycles to failure.</td>
</tr>
<tr>
<td>Mean breaking strength</td>
<td>81,357</td>
</tr>
</tbody>
</table>
The higher tensile strengths of the standard interlocked rope were found by comparison of tensile tests of all the component wires of the ropes to be the result of several higher strength individual wires which were used in fabrication of these ropes. Comparison of the tensile strengths of the ropes and the tensile strength of the component wires, however, indicated that the rope efficiency, i.e.,

Actual total wire strength

of the standard interlocked and the new interlocked rope of the invention were within ½ of 1% of each other, or for all practical purposes, equal.

The maximum difference between the tensile results on the interlocked rope made in a standard quill head and the interlocked rope of the invention made in the quill head of the invention and the difference from the mean test results are below.

STANDARD INTERLOCKED ROPE

Lb. maximum difference between test results.
83,830
83,440

2,390

Maximum + difference from means:
83,830
84,335

+1,495

Maximum — difference from means:
84,335
83,440

—895

NEW INTERLOCKED ROPE OF INVENTION

Maximum difference between test results:
81,700
80,900

800

Maximum + difference from means:
81,700
81,387

+313

Maximum — difference from means:
81,387
80,900

—487

It will be readily seen in the figures that the spread of the tensile test results is much greater for the standard interlocked rope than for the new interlocked rope. These spreads show a much greater uniformity in the tensile test properties of the new rope and is indicative of a better balanced more stress free internal structure of the new rope.

In addition the results of the fatigue tests above clearly indicate a longer operating life under actual operating conditions for the new rope, in most cases the life of the new interlocked strand being more than twice as long as that of standard interlocked strand. Note that in two of the tests the rope did not fail even after well over two million fatigue testing cycles.

We claim:
1. A quill head, comprising:
(a) a central head section having radial extensions with first cylindrical quill orifices therein;
(b) an outer head section concentric with said central head section having radial grooves for the reception of said radial extensions of said central head section and having second cylindrical quill orifices in said outer head;
(c) the projection of the central axes of said cylindrical quill orifices on each head section extending toward a substantially common intersection;
(d) the radial grooves in said outer head section being wider than said extensions to allow substantial rotational movement of said radial extensions within said grooves;
(e) openings extending through the outer head section from said grooves to the rear of the head section in line with the said first orifices in said radial extensions of said central head section;
(f) said sections being adjustable rotationally and longitudinally with respect to each other; and
(g) means to adjustably secure said concentric head sections together.

2. A quill head according to claim 1 wherein
(h) said grooves of said outer head section are deep enough so that the radial arms of said central head may be nested in said grooves sufficiently closely to bring said intersection points of the projected axes of the said orifices on the two heads into substantial coincident relationship.

3. A quill head according to claim 2 wherein the first orifices in the central head section are smaller than the second orifices in the outer head section to accommodate smaller quills for interlocked rope.

4. A quill head according to claim 3 wherein said first cylindrical orifices in said central head section are positioned between said second cylindrical orifices in said outer head section with the inner edges of said second orifices inside a circumference around the outer edges of all the said first orifices.

5. A method of making an interlocked wire rope by feeding wire strands through a preforming quill head having adjustably secured concentric first and second head sections comprising:
(a) feeding a first layer of smaller wire strands into the first head section having cylindrical inclined smaller orifices for receiving adjusting quills therein,
(b) feeding a second layer of proportionally larger wire strands into the second head section having cylindrical inclined larger orifices for receiving adjustably quills therein,
(c) the projected axes of the orifices on each head section extending toward a substantially common intersection with the larger orifices being oriented with respect to the smaller orifices in substantially the same relationship as the orientation of the wire strands in the completed rope section so that each larger wire strand is received in a valley between two smaller wire strands, and
(d) forming the wire rope in a die after passage of the wire strands through the quill head.

6. A wire rope made according to the method of claim 5.

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JOHN PETRAKES, Primary Examiner.

U.S. Cl. X.R.