APPARATUS FOR MANUFACTURING INTEGRAL FINNED TUBING

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This invention relates generally to an improved method and apparatus for manufacturing integral finned tubing.

Tubing having integral fins has been produced in the past by subjecting a length of tubular stock to the action of a plurality of forming rolls. More particularly, three forming rolls are ordinarily respectively mounted on rear fortes in which are barely spaced equal distances from one another around a straight length of tubular stock and which are supported on a head for movement into and out of engagement with the stock. Each forming roll has a plurality of axially spaced annular portions which co-operate with one another during the rolling operation to extrude or roll up material from the outer surface of the stock in a manner to provide the stock with integral fins. In the event it is desired to form the length of tubular stock with a continuous helically extending fin, the axes of the arbors are crossed with respect to the axis of the stock at an angle depending on the specified helix angle of the fin to be formed.

When manufacturing certain types of integral finned tubing with apparatus of the general character noted above, difficulty has been encountered in producing a uniformly satisfactory product on a commercial basis. For example, when manufacturing tubing having a large number of fins per unit of length and having a relatively thin wall thickness, it is not unusual to build up such high stresses in the material during the rolling operation that fracture or severe damage to the tubing results.

It is an object of the present invention to provide a method and apparatus rendering it possible to manufacture integral finned tubing having a relatively thin wall and having a multiplicity of closely spaced fins per unit of length without the danger of fracturing or otherwise damaging the tubing. The above result is obtained in accordance with this invention by distributing the stress over a greater length of the stock during the rolling operation and by relieving the stress at a mid-point during the rolling operation so that the stress is not accumulative throughout the length of the forming rolls.

It is another object of this invention to provide a fin forming roll having a first group of axially spaced annular forming portions and having a second group of axially spaced annular forming portions separated from the first group by a distance which exceeds a multiple of the pitch of the annular forming portions by an amount approximating the extent of elongation of the stock resulting from the forming operation of the first group of annular portions.

As a result of the spacing between the two groups of annular fin forming portions, relatively free elongation of the tubular stock is permitted between the initial and final stages of the rolling operation. Also, torsional stresses imparted to the stock is relieved between the two rolling stages and, hence, the over-all torsional stress applied to the stock by the rolls is reduced to such an extent that it has no detrimental effect on the completed finned tube.

The foregoing as well as other objects will be made more apparent as this description proceeds especially when considered in connection with the accompanying drawings, wherein:

Figure 1 is a semi-diagrammatic cross sectional view of a part of the apparatus forming the subject matter of this invention;

Figure 2 is an enlarged elevational view of one of the forming rolls shown in Figure 1 and illustrating the relationship between the axes of the forming rolls shown in Figure 1 and the axis of a length of tubular stock; and

Figure 3 is an enlarged fragmentary longitudinal sectional view of the forming roll shown in Figure 2.

For reasons which will become apparent as this description proceeds, the present invention is especially advantageous when used in the manufacture of relatively thin walled tubes having two or more continuous helically extending fins formed integral with the tube. However, the invention should not be considered as limited to the production of tubes of the above type since in actual practice it has been found that the features of this invention also greatly improve the manufacture of integral finned tubes having widely varying wall thicknesses and having one or more continuous helically extending fins.

With the above in view, reference is made to Figure 1 of the drawings wherein the numeral 11 designates a length of tubular stock supported in a manner to be presently described for movement in the direction of its axis and formed of a material rendering it possible to roll up fins from the outer surface thereof. Suitably supported on a head (not shown) are three slides 12 spaced equal distances from one another about the axis of the stock 11 and movable radially with respect to the latter axis. Journalled on each slide 12 is an arbor 13 having its axis extending in the direction of the axis of the tubular stock 11 and having an enlargement 14 intermediate the ends thereof. The axes of the arbors 13 are spaced equal distances from one another circumferentially of the stock 11 and are arranged to cross the axis of the stock 11 at an angle depending on the helix angle of the fin or fins to be formed on the length of stock 11.

Mounted on each arbor 13 is a fin forming roll 15 having the inner end abutting a spacer 16 mounted on the arbor 13 at the outer side of the enlargement 14 and having the outer end engaged by a clamp 17. The clamps 17 are respectively secured to the outer ends of the arbors 13 by studs 18 having threaded shank portions threadably engageable in bores formed in the outer ends of the arbors 13 and having heads 19 engageable with the clamps 17.

The forming rolls 15 are identical in construction and a description of one will suffice for all of the rolls. The forming roll 15 shown in Figures 2 and 3 comprises a first group of annular discs 20, a second group of annular discs 21, and a spacer 22 separating the two groups of discs. The individual discs of each group are keyed or otherwise secured to the associated arbor 13 for rotation as a unit with the latter and the space 22 is mounted on the arbor between the adjacent end discs of the two groups. The number of discs in each group may be varied considerably, depending to some extent on the number of fins per unit of length it is desired to form on the length of stock 11. By way of example, each fin forming roll 15 shown herein has four discs in the first group 20 and eight discs in the second group 21. The discs in the second group are designated by the numerals 23–30 inclusive and the discs in the first group are designated by the numerals 31–34 inclusive.
Forming rolls having the specific number of discs noted above and arranged to cross the axis of the stock 11 in the manner shown have been found highly satisfactory in the production of finned tubes having 19 fins per inch formed by two interposed continuous helical fins. It is to be understood that the above specific values are merely given by way of example and that the total number of discs as well as the number of discs in each group may be varied depending upon the particular type of finned tube required. Also, it will be apparent that the angle at which the arbors 13 cross the axis of the stock 11 may be varied depending on the helix angle of the fins to be formed.

The discs in each group are of uniform thickness and are clamped together in face to face contact by the cooperation of the clamp 17 with the spacers 16 and 22. The outside diameter of the discs in both groups decrease successively from the outermost disc 23 in the second group 21 to the innermost disc 34 in the first group 20. The opposite side walls of the discs at the periphery of the latter converge toward the median planes of the respective discs to provide the discs with tips 35 and form annular spaces 36 between adjacent discs. The median or pitch planes of the respective discs are indicated by the numeral 37 and it will be noted that these planes respectively bisect the tips 35 of the discs. Hence, for the purpose of this disclosure, it is considered that the discs in both groups have a uniform pitch. The angle of inclination of the opposite side walls at the peripheral portions of the discs varies in such a manner that the annular spaces 36 gradually decrease in width from the inner end of the forming roll 15 to the outer end of the latter.

In order to more clearly illustrate the above, one specific example of forming roll is described and illustrated herein. In detail, the angular relationship of the converging walls at the peripheral portions of the discs is determined from a reference line 38 which extends parallel to the axis of the roll 15, as shown in Figure 3 of the drawings. The opposite converging sides of the discs 23, 24, 25, 26, and 27 are inclined at an angle of approximately 15° with reference to a plane perpendicular to the gage line 38, and the opposite converging sides of the discs 28, 29, and 30 are inclined with respect to a plane perpendicular to the gage line 38 at an angle of approximately 9°. The opposite converging sides of the discs 31 and 32 are inclined at an angle of 18° with reference to a plane perpendicular to the gage line 38 and the opposite converging sides of the discs 33 and 34 are inclined at an angle of 10° with reference to a plane perpendicular to the gage line 38. Although it will be apparent from the above that the angle of convergence of the side walls of a number of the discs with reference to the gage line 38 is the same, nevertheless, it will be noted that the diameters of the discs decrease from the disc 23 to the disc 34 so that the portions of the annular spaces 36 into which material flows during the rolling operation or, in other words, the effective widths of said spaces is such that the fin being formed is gradually reduced in thickness as it approaches the annular space 36 between the discs 23 and 24.

The length of tubular stock 11 extending between the forming rolls 15 is slidable supported on a mandrel 39 having a diameter less than the inside diameter of the stock 11 and predetermined to provide the completed tube with the specified inside diameter. The rolls 15 are adjusted radially with respect to tubular stock 11 so that the discs in both groups apply a circumferential rolling pressure in a radially inward direction on axially spaced helically aligned portions of the outer surface of stock 11 during rotation of the rolls 15 by the arbors 13. As a result, material from the outer surface of the length of stock 11 between the tips 35 of the discs is extruded or displaced in a radially outward direction into the spaces 36 to form ribs or fins. It is to be noted that the length of tubular stock is fed in the direction of its axis on the mandrel 39 by the axial thrust applied to the stock during the rolling operation.

As stated above, the diameters of the discs in both groups increase from the inner disc 34 of the first group to the outer disc 23 of the second group, and this arrangement together with the shape of the peripheral portions of the discs previously described provides for progressively increasing the height as well as decreasing the width of the fins rolled up from the tubular stock 11 by the rolls 15. In practice the discs in the first group 20 cooperate with one another to not only partially form the fins but, in addition, to reduce the diameter of the length of stock 11 sufficiently to engage the inner surface of the stock with the mandrel 39. Thus, the tubular stock 11 is in firm supporting relationship with the mandrel 39 when engaged by the discs in the second group 21 and in practice this feature has been found to reduce the tendency for the tube to become out of round during the rolling operation. Also, it is believed that reducing the tube 11 against the mandrel 39 by the first group of discs 20 causes the major portion of elongation of the tube 11 to take place in the space provided between the two groups of discs by the spacer 22.

In any event, the tube 11 elongates during the rolling operation and the space between the two groups of discs provides a relief zone which permits elongation of the tube caused by the rolling action of the first group of discs without unduly stressing the tube. Also since the tube 11 is free to rotate, the space between the two groups of discs relieves the torsional stresses applied to the tube 11 by the first group of discs and prevents such stresses from becoming cumulative over the full length of the 15.

The length of the spacer 22 is at least equal to the elongation of tube 11 caused by the rolling action of the first group of discs and in actual practice exceeds the amount of elongation by an amount sufficient to also materially reduce twisting of the tube by torsional stresses. The extent of elongation of the tube 11 by the first group of discs and the degree of twisting of the tube during the rolling operation will depend on the material from which the tube 11 is formed, the wall thickness of the tube 11, and to some extent on the helix angle of the fin or fins being formed. Thus, the length of the spacer 22 will vary but, in actual tests, best results have been obtained with a spacer having a length at least equal to a multiple of the pitch of the tips 35 plus the amount of elongation of the tube 11 caused by the rolling action of the first group of discs 20.

Particularly satisfactory results have been obtained with a spacer 22 having a length at least five times the pitch between adjacent tips or the thickness of the individual discs plus the elongation of the particular tube 11 being rolled by the first group of discs 20. Assuming that the tube 11 being rolled has a wall thickness of .058 inch and is formed of a nonferrous material, such as copper, within .004/.008 grain size in temper, the elongation resulting from the rolling action of the first group of discs will approximate .010 inch. Now assuming that the thickness of the individual discs or the pitch between adjacent tips 35 is .0505 inch, the minimum length of the spacer 22 should be five times .0505 or .252 inch plus .010 inch or, in other words, .262 inch.

In the event the tube 11 is formed of a ferrous material such as steel and a wall thickness noted above, the extent of elongation is reduced about one half. If the minimum length of the spacer should be about .257 inch in cases where steel tubing having a .058 inch wall is being rolled. The above specific values are of course given by way of example and are subject to change in accordance with different types of tubing to be formed. The maximum length of the spacer 22 is limited by practical considerations. Ordinarily it is preferred to keep the spacer 22 as short as is consistent with obtaining the
desired results so that the load on the bearings for the arbors 13 may be kept within practical limits and flexing of the arbors prevented. Also, spacers of greater length than required would have the tendency to space the final discs in the second group 21 so far from the tube that the rolling action of these discs would be affected. Moreover, spacers of excessive length have a tendency to interfere with proper operation of the rolls in cases where skip finning is required. In this connection, it will be noted that the rolls 15 may be moved radially outwardly when it is desired to provide a tube with plain cylindrical portions by merely actuating the slides 12 carrying the arbors 13. In the event the spacer 22 is too long there is a tendency for the final discs in the second group to shave the tube and thereby interfere with proper finning of the tube when the rolls are reengaged with the tube.

While the minimum length of the spacer 22 is important in order to obtain the most satisfactory finning operation, nevertheless, the invention is not limited to the specific values noted above. In other words, the specific values previously noted should be considered typical for two different materials and merely serve to illustrate that the space between the two groups of discs divides the rolling operation into at least two stages in a manner such that the stresses on the tube 11 is relieved between said stages. As a result, thin walled tubes having a large number of fins per unit of length may be produced on a production basis with a minimum amount of scrap and with less wear on the discs of the rolls.

What I claim as my invention is:

1. A forming roll for rolling up fins from tubular stock comprising a rotary support arbor, a first group of coaxial annular fin-forming members, a second group of coaxial annular fin-forming members, rigidly assembled together on said arbor, the radially inner portions of said annular members of each group being of uniform thickness, and in which the diameters of said members progressively varies from the first member of the first group to the last member of said second group, the peripheral portions of the members of each group being spaced axially of the arbor to provide annular grooves therebetween, the peripheral portions of the members of each group having uniform pitch, a spacer between said groups, said spacer having a thickness which exceeds a multiple of the pitch of the peripheral portions of the annular members in adjacent groups by an amount approximately equal to the elongation of the stock caused by the rolling action of the group of annular members ahead of the spacer.

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