MACHINES FOR FORMING FINS WITHIN THE TUBES OF HEAT EXCHANGERS

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Filed Feb. 21, 1961, Ser. No. 90,662

11 Claims. (Cl. 113—42)

This invention relates to machines for forming fins within tubes of heat exchangers.

The co-pending application of J. H. Millington and Samuel Fein, Serial No. 17,995, filed March 28, 1960, discloses how a heat exchange tube can be formed from a series of flat fins having cup-shaped flanges which are fitted together to form the tube, and how the bottoms of the flanges can be cut and bent to form internal fins. The present invention is a machine for forming tapers in such flanges, and for forming internal fins, in a single stroke of a press.

An object of this invention is to reduce the cost of forming fins within tubes of heat exchangers.

Another object of this invention is to reduce the time required for forming fins within tubes of heat exchangers.

This invention will now be described with reference to the annexed drawings, of which:

FIG. 1 is a side view of a press embodying this invention;
FIG. 2 is an end view of the press;
FIG. 3 is a top plan view of the press;
FIG. 4 is a sectional view along the lines 4—4 of FIG. 1;
FIG. 5 is a sectional view along the lines 5—5 of FIG. 1;
FIG. 6 is an enlarged fragmentary sectional view along the lines 6—6 of FIG. 5;
FIG. 7 is an enlarged section along the lines 7—7 of FIG. 6;
FIG. 8 is an enlarged section along the lines 8—8 of FIG. 6;
FIG. 9 is a sectional view showing the sections of FIGS. 7 and 8 superimposed;
FIG. 10 is an enlarged, fragmentary section showing the bottom portions of the outer and inner fingers of one of the upper tools of the press, above the upper ends of the fingers of the corresponding lower tool;
FIG. 11 is an enlarged, fragmentary, side view in section, of an upper and a lower tool ironing a flange of a fin to form a taper in the flange;
FIG. 12 is a view similar to FIG. 11 but showing the knife edges of the fingers of the lower tool penetrating the bottom of the flange;
FIG. 13 is an enlarged, fragmentary, perspective view of a bottom of a flange above the knife edges of the lower tool before they penetrate the flange bottom;
FIG. 14 is a view similar to FIG. 13 but does not show the lower tool, and shows the flange bottom after its penetration by the knife edges of the lower tool;
FIG. 15 is an enlarged, fragmentary view in section, showing the lower portion of the fingers of the upper tool and the upper portion of the fingers of the lower tool bending the cut portions of the flange bottom upwardly in the radial slots shown by FIG. 9;
FIG. 16 is an enlarged, fragmentary section showing a flange bottom after it has been cut, and after its cut portions have been bent upwardly;
FIG. 17 is an enlarged, fragmentary view, partially in section, showing the knife edges on the bottoms of the inner fingers of the upper tool cutting out the central portion of a flange bottom;
FIG. 18 is an enlarged, fragmentary, perspective view of a flange bottom after its central portion has been removed;
FIG. 19 is an enlarged fragmentary view, partially in section, showing the bottoms of the outer fingers of the upper tool bending the peripheral portions of a flange bottom downwardly to the position shown by the dashed lines of FIG. 18;
FIG. 20 is a perspective view of a fin having three cup-shaped flanges without taper as formed for operation on by the press;
FIG. 21 is an enlarged perspective view of one of the flanges of FIG. 20 after having had its flange tapered, and internal fins formed by the press;
FIG. 22 is an enlarged side view of the bottom of one of the upper tools of the press;
FIG. 23 is a bottom plan view of FIG. 22;
FIG. 24 is an enlarged side view of the top of one of the lower tools of the press, and
FIG. 25 is a top plan view of FIG. 24.

A press 30 has a base 31 with a pair of vertically extending shafts 32 near one edge, around which extend sleeves 33 of a movable press member 34, the latter being adapted to be moved by an air cylinder or other suitable source of power which is not shown, acting on drive shaft 35.

An upper tool support plate 36 is attached to the press member 34 by bolts 37. An upper tool guide plate 38 is supported from the press member 34 by bolts 39 around which extend, between the plates 36 and 38, coiled springs 40. Three, spaced-apart, generally cylindrical tools 50 are secured at their upper ends to the plate 36 by screws 43.

A lower tool support plate 45 is attached to the base 31 by bolts 46. A lower tool guide plate 47 is supported from the base 31 by bolts 48 around which extend, between the plates 45 and 47, coiled springs 49. Three, spaced-apart, generally cylindrical tools 59 are secured at their lower ends to the plate 45 by pins 51. The tools 59 are vertically aligned with corresponding tools 42. Stop bars 52 extend vertically from the plate 45 towards the plate 47 and normally are spaced from the plate 47.

Three upper rings 55, one for each of the upper tools 42, are press-fitted within circular openings in the plate 38, and each has three, equally spaced-apart, machine screws 56 slidable vertically therein, the lower ends of the screws 56 being threaded into lower rings 57. Three coiled springs 58 extend vertically within openings in each ring 55 midway between the screws 56. The lower ends of the springs 58 contact the tops of the rings 55, and their upper ends contact the bottoms of screws 59 threaded into the rings 55. The lower portions of the rings 55 have tapered, male ironing members 60 which extend through clearance openings in the rings 55. The lower portions of the tools 42 extend through circular openings in the rings 55, and their lower ends terminate slightly above the lower ends of the ironing members 60.

The lower portion of each upper tool 42 has six, spaced-apart, outer fingers 64 having flat bottoms 66. Supported by a bolt 65 within the upper portion of each tool 42 is an inner tool having six, spaced-apart, inner fingers 67 with flat bottoms 68. The bottoms of the inner fingers 67 extend below the bottoms of the outer fingers 64.

Three rings 70, one for each of the lower tools 59, are press-fitted with circular openings in the plate 47, and each has three, equally spaced-apart, machine screws 71 slidable vertically therein, the upper ends of the screws 71 being threaded into upper rings 72. Three coiled springs 73 extend vertically within circular holes in each ring 70 midway between their screws 71, with their upper ends contacting the bottoms of the rings 72, and their lower ends contacting the tops of screws 75 threaded into the rings 70. Each ring 70 has a passage 79, circular in section, for a tool 50, the top of this passage diverging to form a tapered, female ironing member 76 in the top of the ring.
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70. The ironing members 76 are concentric with corresponding ironing members 69, and have the same tapers except that the members 76 have larger diameters at corresponding sections.

The upper portion of each tool 50 has six, spaced-apart fingers 77 formed as segments of cylinders, having curved tops 83 with knife edges 78 at their upper ends, and have slanted, circular, inner and outer, knife edges 88 along their sides. The edges 78 are normally below the bottoms of the ironing members 76 as shown by FIG. 6.

As shown by FIG. 9, the fingers 64 of the upper tools 42 have spaces therebetween into which the fingers 77 extend, and the fingers 77 have spaces therebetween into which the fingers 64 extend when the upper tools are moved to their lowest positions, there being six radial passages 80 between the fingers 64 and 77 when they are so intermeshed. The circular inner edges 88, if projected onto a horizontal plane, would extend all of the way between adjacent passages 80. This is shown, in effect, by FIG. 9, since the sections of the fingers 77 shown there are on a horizontal plane.

FIG. 20 shows a fin sheet having three, spaced-apart, untapered flanges, and which is performed for operation by the press of this invention, the flanges 90 of this sheet being spaced and dimensioned to line up with the corresponding ironing members and tools described in the foregoing, when the sheet is placed in operating position in the press.

Operation

In operation, a fin sheet similar to the one shown by FIG. 20, is placed in the press with the male sides of its untapered flanges 90 in the diverging upper ends of the passages 79 in the rings 70. The press member 34 is then moved downwardly, and moves through the springs 49, the plate 38 downwardly, and directly moves the upper tools 42 downwardly. The tapered ironing members 60 are moved into the female sides of the flanges, and the bottoms 68 of the inner fingers 67 of the upper tools are moved against the female upper sides of the flange bottoms.

The press continues to move downwardly so that the ironing members 69 press the sides of the flanges against the ironing members 76, providing as shown by FIG. 11 tapers in the flanges. At this time the springs 38 and 73 are compressed, and the rings 57 and 72 are seated against the rings 58 and 70 respectively, with the fin sheet and the flanges in contact with the tops of the rings 72 and the bottoms of the rings 87, as shown by FIG. 11. The top of the lower plate 47 around the rings 72 is in contact with the lower side of the fin sheet, and the bottom of the upper plate 38 around the rings 57 is in contact with the upper side of the fin sheet as shown by FIG. 11.

The press member 34 continues to move downwardly, and to move the flange bottoms downwardly, pressing the male lower sides of the latter against the knife edges 78 on the ends of the fingers 77 of the lower tools 50, which knife edges pierce the peripheral edge portions of the flange bottoms, following which the upper portions of the knife edges 88 on the sides of the fingers 77 cut out upwardly turned tongues 53 as shown by FIG. 14. The bottoms 68 of the inner fingers 67 of the upper tools 42 back up the central portions of the flange bottoms while their peripheral portions are being pierced and cut.

The press member 34 continues to move downwardly and to move the flange bottoms further downwardly so that the curved tops 83 of the lower fingers 77 press the tongues 53 upwardly into the radial slots 80, shown by FIG. 9, between the fingers 67 and 64 as shown by FIG. 15, to the positions shown by FIG. 16, such fingers being meshed at this time.

The press member 34 continues to move downwardly, and to move the bottoms of the flanges further downwardly so that the knife edges on the lower fingers 77 are pressed through the portions of the flange bottoms which connect their remaining peripheral portions with their central portions, severing the central portions from the peripheral portions as shown by FIG. 17, a central cut-out portion 82 being shown by FIG. 17.

As shown by FIGS. 10 and 15, the side knife edges 88 are shown forming contact with the peripheral portions of the cup bottoms as the latter are moved downwardly along the edges 88 until finally, the lengths of the cuts the circular inner edges 88 make are equal to the distances between the bent-up tongues 53 so that the central portions of the cup bottoms are served. FIG. 18 shows a flange bottom with bent up tongues 53, and with its central portion removed. The stop bars 52 at this time are against the bottom of the plate 47, and prevent any further down movement of the plates 38 and 47, and of the flange bottoms.

The press member 34 continues to move downwardly, and to move the upper tools 42 downwardly so that the flat bottoms 63 of the outer fingers 64, which bottoms have substantially the same shapes as the peripheral portions 84 shown by FIG. 18 of the flange bottoms, press downwardly against the peripheral portions 84 turning them as shown by FIG. 19, downwardly through angles of 90° below the bottoms of the flanges to the positions shown by the dashed lines of FIG. 18. At the same time, the tongues 53 are turned radially within the passages 80 and within the spaces between the inner fingers 67 of the upper tools 42. The peripheral portions are now extensions of the sides of the flanges, extending below where the bottoms of the flanges formerly were, and the tongues 53 extend radially inwardly, forming internal fins as shown by FIGS. 18 and 21.

The press member 34 is then moved upwardly, and the springs 49 and 40 restore the plates 38 and 74, respectively, to their original positions. The springs 58 and 73 restore the rings 57 and 72, respectively, to their original positions, forcing the flanges from between the ironing surfaces.

The press, after removal of the worked-on fin sheet, is then ready for operation on another sheet.

The press can be constructed to have as many pairs of ironing, shearing and bending tools as there are tubes in a heat exchanger to be constructed.

The thickness of the fin sheet is much less than that shown for convenience by the drawings. At the start of operation, the sheet may have a thickness in the order of 0.008", too thin to be subjected to the foregoing, the several handlings which would be required if this invention were not used.

In the annexed claims, where it is recited that fingers are formed as segments of cylinders, it is intended that the cylinders have walls of substantially equal thickness. It is recited that the cylinders have diameters, the diameters referred to as outer diameters. Where an inner edge of a tool is referred to in the annexed claims, it is the work contacting end of the tool.

What is claimed is:

1. A fin forming machine comprising a pair of aligned, normally spaced-apart tools, and means for moving one of said tools towards and from the other of said tools, said tools having at their inner ends a plurality of spaced-apart fingers formed as segments of concentric cylinders having the same diameter, said fingers of each of said tools being slidable between said fingers of the other of said tools, one of said tools having at its inner end a plurality of spaced-apart fingers formed as segments of cylinders having a diameter smaller than said diameter.

2. A fin forming machine comprising first and second aligned, normally spaced-apart tools, and means for moving one of said tools towards and from the other of said tools, said tools having at their inner ends, a plurality of spaced-apart fingers formed as segments of concentric cylinders having the same diameter, said fingers of each of said tools being slidable between said fingers of the other of said tools, said first tool also having at its inner end, a plurality of spaced-apart inner fingers formed as segments of a cylinder concentric with said cylinders but having a diameter smaller than said diameter,
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5. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart fingers formed as segments of a cylinder and having flat ends, means for supporting a cup-shaped flange having a circular bottom with the female side of said bottom concentric with and normally spaced from said flat ends, said tool having a plurality of spaced-apart fingers formed as segments of a cylinder having a larger diameter than said first mentioned cylinder and having ends spaced axially outwardly from said flat ends of said inner fingers, means for supporting a cup-shaped flange having a circular bottom with the female side of said bottom concentric with and normally spaced from said flat ends of said inner fingers, said bottom having the same diameter as said second cylinder, a second tool axially aligned with said first tool and normally spaced from the male side of said bottom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp ends and formed as segments of a cylinder having the same diameter as said second cylinder, said fingers of said second tool being aligned with the spaces between said outer fingers but having widths less than the widths of said spaces, said outer fingers being aligned with the spaces between said fingers of said second tool but having widths less than the widths of said last mentioned spaces, so that passages are formed between sides of said fingers of said second tool and adjacent sides of said outer fingers when said outer fingers and said fingers of said second tool are meshed, means for moving said first tool until said flat ends of said inner fingers contact said bottom and for then moving said first tool and said flange supporting means towards said second tool for causing said sharp ends and sides to penetrate said bottom around said flat ends of said inner fingers and to cut tongues from said bottom, to mesh said outer fingers and said fingers of said second tool so as to move said tongues into said passages, and to sever the central portion of said bottom around said flat ends of said inner fingers.

6. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart fingers formed as segments of a cylinder having flat ends, said tool having a plurality of spaced-apart, outer fingers around and spaced from said inner fingers, said outer fingers being formed as segments of a second cylinder having a larger diameter than said cylinder and having flat ends spaced axially outwardly from said flat ends of said inner fingers, means for supporting a cup-shaped flange having a circular bottom with the female side of said bottom concentric with and normally spaced from said flat ends of said inner fingers, said bottom having the same diameter as said second cylinder, a second tool axially aligned with said first tool and normally spaced therefrom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp sides and ends and formed as segments of a cylinder having the same diameter as said second cylinder, said fingers of said second tool being aligned with the spaces between said outer fingers but having widths less than the widths of said last mentioned spaces, so that passages are formed between sides of said fingers of said second tool and adjacent sides of said outer fingers when said outer fingers and said fingers of said second tool are meshed, means for moving said first tool until said flat ends of said inner fingers contact said female side of said bottom and for then moving said first tool and said flange supporting means towards said second tool for causing said sharp ends and sides to penetrate said bottom around said flat ends of said inner fingers and to cut tongues from said bottom, to mesh said outer fingers and said fingers of said second tool so as to move said tongues into said passages, and to sever the central portion of said bottom around said flat ends of said inner fingers.

5. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart, inner fingers formed as segments of a cylinder and having flat ends, said tool having a plurality of spaced-apart, outer fingers around and spaced from said inner fingers, said outer fingers being formed as segments of a second cylinder having a larger diameter than said cylinder and having ends spaced axially outwardly from said flat ends of said inner fingers, means for supporting a cup-shaped flange having a circular bottom with the female side of said bottom concentric with and normally spaced from said flat ends of said inner fingers, said bottom having the same diameter as said second cylinder, a second tool axially aligned with said first tool and normally spaced therefrom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp sides and ends and formed as segments of a cylinder having the same diameter as said second cylinder, said fingers of said second tool being aligned with the spaces between said outer fingers but having widths less than the widths of said spaces, said outer fingers being aligned with the spaces between said fingers of said second tool but having widths less than the widths of said last mentioned spaces, so that passages are formed between sides of said fingers of said second tool and adjacent sides of said outer fingers when said outer fingers and said fingers of said second tool are meshed, means for moving said first tool until said flat ends of said inner fingers contact said male side of said bottom and for then moving said first tool and said flange supporting means towards said second tool for causing said sharp ends and sides to penetrate said bottom around said flat ends of said inner fingers and to cut tongues from said bottom, to mesh said outer fingers and said fingers of said second tool so as to move said tongues into said passages, and to sever the central portion of said bottom around said flat ends of said inner fingers, and means for stopping the movement of said flange supporting means for causing said moving means to move said flat ends of said outer fingers against the remaining peripheral portions of said bottom and to bend said peripheral portions outwardly.

7. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart inner fingers formed as segments of a cylinder and having flat ends; a male ironing member, circular in section, around said fingers, said member being tapered to converge towards said ends of said inner fingers and having its inner end substantially flush with said ends of said fingers; a second tool axially aligned with said first tool and normally spaced therefrom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp ends and formed as segments of a cylinder having a larger diameter than said cylinder; a female ironing member, circular in section, concentric with and normally spaced from said male ironing member, and tapered to correspond with said male ironing member except that it has
larger diameters than said male ironing member, between the inner ends of said tools, said female member having a cylindrical portion around the inner end of said second tool, means for moving said male ironing member and said first tool towards said female ironing member for contacting with said flat ends of said inner fingers, the female side of the circular bottom of an unたuped cup-shaped flange seated in said female ironing member, and for forming a taper in the side wall of said flange, and for then moving said ironing members and said first tool towards said second tool for moving the male side of said bottom against said sharp ends of said fingers of said second tool for causing said sharp ends to penetrate said bottom around said fingers of said first tool.

8. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart inner fingers formed as segments of a cylinder and having flat ends; said tool having a plurality of spaced-apart outer fingers around and spaced from said inner fingers and having ends spaced axially outwardly from said ends of said inner fingers, said outer fingers being formed as segments of a second cylinder having a larger diameter than said cylinder; a male ironing member, circular in section, around said outer fingers, said member being tapered to converge towards said ends of said inner fingers and having its inner end substantially flush with said ends of said inner fingers; a second tool axially aligned with said first tool and normally spaced therefrom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp sides and ends and formed as segments of a cylinder having the same diameter as said second cylinder, said fingers of said second tool being aligned with the spaces between said outer fingers but having widths less than the widths of said spaces, said outer fingers being aligned with the spaces between said fingers of said second tool but having widths less than the widths between said last mentioned spaces, so that passages are formed between sides of said fingers of said second tool and adjacent sides of said outer fingers, a female ironing member, circular in section, concentric with and normally spaced from said male member and tapered to correspond with said male member except that it has larger diameters at corresponding sections, between the inner ends of said tools, said female member having a cylindrical portion around the inner end of said second tool; and means for moving said male member and said first tool towards said female member for contacting with said flat ends of said inner fingers, the female side of the circular bottom having the same diameter as said second cylinder, of a cup-shaped flange seated in said female member and for forming a taper in the side wall of said flange, and for then moving said ironing members and said first tool towards said second tool for causing said sharp ends and to cut tongues from said bottom around said flat ends of said inner fingers, to move said tongues into said passages, and to sever the central portion of said bottom around said flat ends of said inner fingers.

9. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart inner fingers formed as segments of a cylinder and having flat ends, said tool having a plurality of spaced-apart outer fingers around and spaced from said inner fingers and having ends spaced axially outwardly from said flat ends of said inner fingers, said outer fingers being formed as segments of a second cylinder having a larger diameter than said cylinder; a male ironing member, circular in section, around said outer fingers, said member being tapered to converge towards said ends of said inner fingers but having widths less than the widths between said last mentioned spaces, so that passages are formed between sides of said fingers of said second tool and having flat ends spaced axially outwardly from said flat ends of said inner fingers, said outer fingers being formed as segments of a second cylinder having a larger diameter than said cylinder; a male ironing member, circular in section, around said outer fingers, said member being tapered to converge towards said ends of said inner fingers and having its inner end substantially flush with said ends of said inner fingers; a second tool axially aligned with said first tool and normally spaced therefrom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp sides and ends and formed as segments of a cylinder having the same diameter as said second cylinder, of a cup-shaped flange seated in said female member and for forming a taper in the side wall of said flange, and for then moving said ironing members and said first tool towards said second tool for causing said sharp ends and sides to cut tongues from said bottom around said flat ends of said inner fingers, to move said tongues into said passages, and to sever the central portion of said bottom around said flat ends of said inner fingers.

10. A machine for forming fins comprising a first tool having at its inner end, a plurality of spaced-apart inner fingers formed as segments of a cylinder and having flat ends, said tool having a plurality of spaced-apart outer fingers around and spaced from said inner fingers and having flat ends spaced axially outwardly from said flat ends of said inner fingers, said outer fingers being formed as segments of a second cylinder having a larger diameter than said cylinder; a male ironing member, circular in section, around said outer fingers, said member being tapered to converge towards said ends of said inner fingers and having its inner end substantially flush with said ends of said inner fingers; a second tool axially aligned with said first tool and normally spaced therefrom, said second tool having at its inner end, a plurality of spaced-apart fingers having sharp sides and ends and formed as segments of a cylinder having the same diameter as said second cylinder, of a cup-shaped flange seated in said female member and for forming a taper in the side wall of said flange, and for then moving said ironing members and said first tool towards said second tool for causing said sharp ends and sides to cut tongues from said bottom around said flat ends of said inner fingers, to move said tongues into said passages, and to sever the central portion of said bottom around said flat ends of said inner fingers.

11. A machine for forming fins comprising a first press
plate; a first ring having an annular outer end portion within the inner side of said plate, and having an inner end portion formed as a female ironing member, circular in section, tapered to diverge towards said annular portion; a second ring around said inner portion; spring means normally biasing said second ring from said outer end portion; a second press plate extending parallel to and normally spaced from said first plate; a third ring having an annular outer end portion within the inner side of said second plate, and having an inner end portion formed as a female ironing member, circular in section, tapered to converge towards said outer end portion of said third ring and axially aligned with said male member, said female member being tapered similar to said male member except that it has larger diameters at corresponding sections; a fourth ring around said inner end portion of said third ring; spring means normally biasing said fourth ring from said outer end portion of said third ring; a first generally cylindrical tool having its inner end extending through said first and second rings, said inner end having a plurality of spaced-apart inner fingers formed as segments of a cylinder and having flat ends flush with the inner end of said male member, said inner end having a plurality of spaced-apart outer fingers around and spaced from said inner fingers, and formed as segments of a second cylinder having a larger diameter than said second cylinder, and having flat ends spaced axially outwardly from said flat ends of said inner fingers, said third ring having a cylindrical outer portion; a second generally cylindrical tool axially aligned with said first tool and having its inner end extending within said cylindrical portion, said inner end of said second tool having a plurality of spaced-apart fingers formed as segments of a cylinder having the same diameter as said second cylinder and having sharp ends and sides, said fingers of said second tool being aligned with the spaces between said outer fingers but having widths less than the widths of said spaces, said outer fingers being aligned with the spaces between said fingers of said second tool but having widths less than the widths of said spaces; means for moving said first tool towards said second tool until said outer fingers and said fingers of said second tool mesh and including spring means for moving said first plate towards and against said second plate, spring means opposing the movement of said second plate by said first plate, and means for stopping the movement of said second plate by said first plate after a predetermined movement of said second plate by said first plate.

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