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MANDREL FOR SPINNING METAL

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7 Claims. (Cl. 113—52)

This invention relates to apparatus for spinning metal and has particular relation to closing the open end of a tubular blank for airplane propeller blades, and is a division of my application for Letters Patent of the United States for Improvements in propeller blade and method and apparatus for producing same, filed July 5, 1933, Serial No. 679,133.

Objects of the invention include the provision of an improved apparatus for closing the end of a tubular object by a spinning operation; the provision of an improved mandrel for use internally of a tube during the operation of closing an end of the tube by a spinning operation; the provision of an improved type of mandrel for use internally of a tube the end of which is to be closed by a spinning operation while the tube is in heated condition, and so constructed as to minimize the transfer of heat away from the end of the tube to be closed during the spinning operation; the provision of a mandrel adapted to internally support the end of a propeller blade blank during a spinning operation thereon to close such end; the provision of a mandrel adapted for insertion within the end of a hollow propeller blade blank during a spinning operation to close such end while such end is in a heated condition and so constructed and arranged as to minimize the transfer of heat from such end to the mandrel; the provision of a mandrel for internal use within the end of a hollow propeller blade blank during the operation of spinning the end of the blank closed, the mandrel being formed with a portion to control the internal shape of the spun end portion of the blank and another portion for centering the mandrel in the blank and reinforcing the blank internally against the application of pressure from the outside; and the provision of a mandrel for a spinning operation comprising a main body portion corresponding in size, shape and contour to the interior walls of a portion of a tube to be received thereon, and an additional portion so constructed and formed that it has a relatively limited additional contact with the interior walls of the tube.

The above being among the objects of the present invention, the same consists in certain novel features of construction and combinations of parts to be hereinafter described with reference to the accompanying drawing, and then claimed, having the above and other objects in view.

In the accompanying drawing which illustrates a suitable embodiment of the present invention

and in which like numerals refer to like parts throughout the several different views,

Figure 1 is a partially broken, partially sectioned side elevational view of a blank for an airplane propeller blade.

Fig. 2 is a vertical sectional view taken transversely through the axis of the blank shown in Fig. 1 as on the line 2—2 of Fig. 1.

Fig. 3 is an enlarged fragmentary sectional view of the small end of the blank shown in Fig. 1 and illustrating in part the apparatus employed for closing the small end of the blank and before such apparatus has acted upon such small end.

Fig. 4 is a view similar to Fig. 3 but illustrating in greater detail the apparatus employed in the closing of the small end of the blank and illustrating the small end of the blank after one of the initial closing operations thereon.

Fig. 5 is a view similar to Fig. 3 and illustrating the small end of the blank after a further closing operation thereon.

Fig. 6 is a view similar to Fig. 5 and showing the small end of the blank after it has been completely closed.

In one method of forming airplane propeller blades as brought out in detail in the above referred to application of which the present application is a division, a cylindrical metal tube is acted upon to provide an outwardly projecting annular flange at one end and an inwardly tapered end or nose at the opposite end. The tube is then subjected to suitable machining and/or other operations to predetermine its internal and external size, shape and contour and preferably to reduce the wall thickness thereof from the flanged end toward the small or nose end thereof without changing the cross-sectional shape of the blank. The smaller tapered end of the blank is then closed, and the blank is then placed between suitable dies and suitably acted upon to change its cross-sectional shape to that desired in the finished product. The present invention deals solely with the closing of the small end of such a blank.

Referring now to Figs. 1 and 2, a blank such as that above described is illustrated in a condition where its interior and exterior surfaces have been formed to predetermined size, shape and contour and as comprising a main body portion 112 having at one end thereof a shank portion 104 and flange 106 and the opposite end thereof being gradually tapered as at 124 to form a small end or nose without completely closing such end. The radially extending outwardly projecting annular flange 106 in the particular ex-

ample shown is provided for the purpose of permitting the ultimate blade to be secured to a hub structure. The shank portion 104 varies from a maximum thickness adjacent the flange 106 to a minimum thickness at its opposite end where it merges into the main body portion 112 in a smooth curve and acts to provide added rigidity and strength to this portion of the blade. The wall thickness of the main body portion 112 preferably decreases in thickness from its point of connection with its shank portion 104 to the nose or small end thereof and this feature is shown in the drawing. It will be understood that the entire blank is circular in cross section from end to end as indicated in Fig. 2 and that the small end of the blank is not completely closed initially, in order to permit greater ease in the machining, for instance, of both the interior and exterior surfaces of the blank.

After the blank has reached the stage of completion indicated in Figs. 1 and 2 and as described, the next operation is to close the nose or small end 134 of the blank 112 and this is preferably accomplished by the use of a spinning operation such as is indicated in Figs. 3 to 6, inclusive.

In connection with the closing of the small end of the blank, it has been found desirable, although not necessary in all cases, and particularly where the tip is relatively small, to increase the wall thickness of the blank at the extreme closed end portion thereof and also, although not necessary in all cases, to provide a projecting nipple about the point of closure for the reason that during pressing of the blank to blade shape a considerable amount of bending and stretching of the metal in the extreme end portion occurs, and unless a suitable amount of metal is provided at this point, particularly where the small end of the blank is not relatively small, a crack is liable to develop in the finished article.

In carrying out this spinning operation the blank 112 is placed upon a mandrel indicated at 200 in Figs. 3 to 6, inclusive. This mandrel 200 does not necessarily need to contact with the interior walls of the blank 112 over the full length of the blank but in any case must have an end portion 202 which accurately fits and is properly centered in the inner end portion of the nose 134 of the blank. The extreme end of the portion 202 is rounded as at 204 into exact conformance with that desired for the interior surface of the end of the finished blank. Preferably, the end surface 204 is partially spherical in shape with a center located as at 206. After the mandrel 200 has been thus formed it is preferable to cut it down or relieve it in diameter toward the tip. This relief, which is indicated at 202a, may begin a little over an inch back from the tip and need not be very deep, as little as 5 thousandths of an inch having been found satisfactory. The purpose of this cut is to keep a material area of the end of the blank from actual and thermal contact with the mandrel. It has been found that when the end of the blank is in complete contact with the corresponding portion of the mandrel it is difficult to keep the end of the blank hot enough to be conveniently and properly worked. By cutting out the mandrel as shown the blank is kept from contact therewith except at such locations as are necessary to the proper forming of the interior shape of the end of the blank during the closing operation and for the proper support of the end of the blank without distortion, as will later be brought out, and the

heat is not so readily conducted away from the portion of the blank which is to be spun.

The mandrel 200 with the blank 112 thereon is then mounted in a suitable lathe or other turning machine which may include, as indicated in Fig. 4, a bed 208 upon which is longitudinally movable a main slide 210 upon which is supported a compound slide 212. The nose end of the blank may be suitably supported as by a steady rest 214, care being taken in adjusting it to allow for any subsequent expansion of the blank which may occur due to heating the tip thereof for the spinning operation. The steady rest 214 is preferably located in alignment with that portion of the end 202 of the mandrel which has not been cut out so that undue pressure of the steady rest on the exterior of the blank will not distort the blank. A stop 216, as indicated in Fig. 4, is preferably provided for engagement with the slide 210 so as to limit movement of the carriage 210 and consequently the pivotal axis 218 of the compound slide 212 to the left as viewed in the figure. The stop 216 is preferably adjusted and fixed so that the pivotal center 218 of the compound carriage 212, and consequently the spinning tool 220 carried thereby, may be limited in its approach toward the center 206 of the end surface 204 of the mandrel by a distance indicated in Fig. 3 at 222 equal to the added wall thickness desired for the extreme tip portion of the blank 112.

In operation, and referring now to Fig. 4, the mandrel 200 and blank 112 are rotated in the lathe and flame from a torch such as 224 is played upon the end portion of the blank 112 to bring it to a suitable condition of plasticity as, for instance that indicated by a bright red coloring of the metal at the nose or tip. The carriage 210 is moved to the right until the pivotal axis 218 of the cross slide 212 is spaced a distance such as 226 outwardly from its predetermined final position as determined by the stop 216, and the spinning tool 220 is then brought to a position such that when it is swung about the axis 218 it will engage only the extreme end portion of the nose 134 of the blank 112. As soon as the heat from the flame of the torch 224 has brought the extreme end portion of the blank to a sufficient condition of plasticity, as above described, the compound carriage 212 and the tool 220 carried thereby is swung about the axis 218, preferably in a counter-clockwise direction as viewed in Fig. 4, and the tool 220 thus coming in contact with the extreme end portion of the nose or tip causes it to be spun in as indicated in Fig. 4. The main slide 210 is then moved a short distance to the left, as viewed in the figures, until the distance 226 in Fig. 4 has been reduced, for instance, to a distance indicated at 228 in Fig. 5 at which time the tool 220 is again swung around the pivotal axis 218 to spin the extreme tip of the blade further inwardly as indicated in Fig. 5. This movement of the main slide 210 carrying with it the spinning tool 220 is repeated as many times as is desirable or necessary, taking care that each pass of the tool 220 is an "easy" pass so as to insure a smooth flow of the metal of the tip, and until the carriage 210 has finally been brought up against the stop 216 and the tool 220 has caused the outer surface of the extreme tip of the blank to be spun into a semi-spherical surface merging smoothly with the outer wall of the nose 134 of the blank 112 as indicated in Fig. 6. Toward the end of the operation one of the passes of the tool 220 will go past the center of the blank thus insuring a complete a closure of the end as

possible. An excess of metal is provided in the end of the blank so that the tip wall may be somewhat thicker than the immediately adjoining part. After the tip has been closed the last pass of the tool 220 is restrained from passing center and so manipulated as to raise at the extreme end of the blank a small nipple 230 as clearly indicated in Fig. 6. It is understood, of course, that the flame from the torch 224 continues to play against the tip end of the blank during these operations and may keep such end at such temperature that when the end is finally closed, as indicated in Fig. 6, the metal of the tip may weld itself together at the line or point of closure.

The thickened end portion surmounted by the nipple 230 reinforces the end of the blank so that it may not break open under the stresses produced when the blank is deformed into the blade form in the pressing dies employed in subsequent operations. Upon completion of the closing operations on the end of the blank the newly closed end portion of the blank is preferably polished and buffed so as to bring it to the same condition of finish as the main body portion of the blank.

Formal changes may be made in the specific embodiment of the invention described without departing from the spirit and substance of the broad invention, the scope of which is commensurate with the appended claims.

I claim:

1. A mandrel for supporting a tube to be heated and spun closed at its end comprising a base portion snugly fitting the interior of the tube, a body portion slightly smaller than the interior of the surrounding portion of the tube and adapted to be spaced therefrom throughout the spinning operation to reduce transfer of heat between the tube and the mandrel, and an end of the size and shape desired in the interior of the tip of the closed tube.

2. A mandrel for use internally of a tube during a closing operation upon a heated end thereof comprising a member adapted to fit internally of said tube adjacent said end thereof, an end of said member being shaped to control the internal shape of said end when closed, and said member being radially relieved axially between its ends

to provide spaced zones of contact with the interior walls of said tube.

3. A mandrel for use internally of a tube during a closing operation upon a heated end thereof comprising a member so constructed and arranged as to provide axially spaced contact zones for the interior walls of said tube and an intermediate portion relieved against contact with the tube during the closing operation to reduce transfer of heat between the tube and the mandrel, one of said zones adapted to control the interior shape of said end during said closing operation.

4. A mandrel for use internally of a tube during a closing operation upon a heated end thereof comprising a member having a portion adapted to contact the interior walls of said tube to locate it therein, another portion spaced therefrom providing a form for the internal surfaces of said end when closed thereon, and a portion intermediate the two first mentioned portions adapted to provide a relief between the tube and the mandrel during the spinning operation.

5. A mandrel for use internally of the tapered end of a tube during a closing operation on the end thereof comprising a portion externally conforming in size, shape and contour to the interior surfaces of a portion of said end and an axially spaced portion adapted for initial contact with a limited length only of the interior walls of said end of said tube, the last mentioned portion being shaped to provide a form for said end during the closing operation thereon, and said member being radially relieved between said portions.

6. A mandrel including a pair of axially spaced portions one of which approximates a frustum of a cone and the other of which is provided with a rounded end, said mandrel being radially relieved between said portions.

7. A mandrel for use internally of a tube during a closing operation upon a heated end thereof comprising a member having a portion adapted to contact the interior walls of said tube to locate it therein, and another portion spaced therefrom providing a form for the internal surfaces of said end when closed thereon, the section of said member intermediate said portions being constructed and arranged to remain out of contact with said tube during the spinning operation.

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