

A Segmented Drawing Die with A Binding Collar

Field of Invention

[0001] The present invention relates to sheet metal drawing dies. In particular, this invention relates to drawing die assemblies with each die being formed in segments in a binding collar to avoid die cracking.

Background

[0002] Deep drawing of a sheet metal to form a hollow article of manufacture involves drawing the sheet metal into a drawing member (or female die) with a punch (or male die) with an aid of a press. Often, deep drawing is carried out in progressive steps through a series of progressive dies.

[0003] Typically, the clearance between the drawing member and punch is determined and fixed when each set of progressive die is designed. The thickness tolerance of the sheet metal must, then, be controlled. If the thickness of the sheet metal is too thin, wrinkling may result; if the thickness of the sheet metal is too thick, the sheet metal may tear or the progressive die may crack before more serious problems occur to the press.

[0004] In addition, if the thickness of the sheet metal is out of tolerance, the deep drawn article may not satisfy the dimensional requirements specified for its function; if the thickness tolerance is marginally thicker than specified, the deep drawn article may satisfy the dimensional requirements but it may exhibit drawing streaks/scratches due to excessive drawing stresses; a deep drawn article thus manufactured may be rejected on the basis of the surface finish instead of the dimensional requirements. When excessive drawing stresses occur in a die during deep drawing, the life of the die is invariably shortened.

[0005] The problems associated with deep drawing are exacerbated when the article of manufacture has a polygonal cross-section. For example, FIG. 1 shows a prior art drawing die 10 for forming a hexagonal hollow article. Unavoidably, the corners of the polygon on the drawing member experience tremendous amount of stress concentrations. The corners of the drawing die tend to crack. As shown in FIG. 1, cracks 15 often form at the corners of the polygonal drawing die 10, often due to fatigue of the die material. As a result, the entire prior art drawing die need to be replaced and the costs of replacement increase.

[0006] It can thus be seen that there exists a need for a simple and robust method of forming a deep drawing die, which can overcome some of the limitations of prior art drawing dies.

Summary

[0007] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a simplified form as a prelude to the detailed description that is to follow.

[0008] In one embodiment, the present invention provides a drawing die assembly. The drawing die assembly comprises a drawing member having two or more segments; and a collar operable to bind the two or more segments together with a pre-tension force; wherein the pre-tension force allows the two or more die segments to expand when a drawing force exceeds the pre-tension force.

[0009] In one embodiment of the drawing die assembly, the pre-tension force is generated by shrink fitting the collar onto the drawing member by thermal expansion and contraction. In another embodiment, the pre-tension force is generated by narrowing a gap between cut ends of the collar.

[0010] In one embodiment of the drawing member, the drawing member has a polygonal drawing edge and the two or more segments are segmented at two or more corners of the polygon. In another embodiment, the drawing member has a circular drawing edge.

[0011] In one embodiment of the collar, the collar is polygonal. In another embodiment, the collar is substantially circular. Preferably, the collar is more elastic than the drawing member, and it may be hardened and tempered.

[0012] In another embodiment, the present invention provides a method of forming a drawing die assembly with reduced frequency of die cracking. The method comprises forming a drawing member in two or more segment; and binding the two or more segments of the drawing member in a collar with a pre-tension force.

Brief Description of the Drawings

[0013] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0014] FIG. 1 shows a prior art drawing die for drawing a hexagonal hollow article;

[0015] FIG.2A illustrates a plan view of a die assembly in accordance with an embodiment of the present invention; and FIG. 2B shows a sectional view B-B of the die assembly;

[0016] FIG. 3A shows a plan view of a die insert forming part of a drawing member shown in FIG. 2A; and FIG. 3B shows a sectional view C-C of the die insert shown in FIG. 3A.

[0017] FIG. 4A shows a plan view of a collar shown in FIG. 2A; and FIG. 2B shows a sectional view D-D of the collar shown in FIG. 4A.

[0018] FIG. 5 illustrates another embodiment of the die assembly according to a second embodiment of the present invention;

[0019] FIG. 6 illustrates another embodiment of the present invention according to a third embodiment of the present invention;

[0020] FIG. 7 illustrates yet another embodiment of the present invention according to a fourth embodiment of the present invention

Detailed Description

[0021] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0022] FIG. 2A shows a plan view of a die assembly 100 according to a first embodiment of the present invention. FIG. 2B shows a section view B-B of the die assembly 100 mounted in a die holder 106 in addition to a punch 108. The die assembly 100 is for deep drawing of a sheet metal 110 to form a hollow article 120 having a hexagonal shape. As can be seen in FIG. 2A, the die assembly 100 is made up a drawing member 130 and a collar 140.

[0023] As shown in FIG. 3A, the drawing member 130, formed in the shape of a regular hexagonal ring 132, is made up of six inserts 134. Each insert 134 forms a segment of the hexagonal ring 132 by a radial cut through each corner of the hexagon. Each outside corner of the hexagonal ring 132 has a radius R1. FIG. 3B shows a cross section C-C of the insert 134. As can be seen in FIGs. 2B and 3B, a drawing radius R2 is formed on a drawing edge on an upper surface 136 of the drawing member 130. In addition, as can be seen in FIG. 3A and 3B, each insert 134 has an elongate projection 139 of rectangular cross-section substantially extending along a straight portion of an outer surface 138 of the hexagonal ring 132. The projection 139 is continuous with a lower surface of the hexagonal ring 132. Also as shown in FIG. 3B, each insert 134 has a thickness T.

[0024] Each insert 134 is formed from iron carbide, for example, with a tradename CD 337 supplied by Fine Carbide. The surfaces of each insert 134 are profile ground to a roughness of about 5 micron so that six inserts 134 are placed together to form the hexagonal ring 132. After forming the hexagonal ring 132, the six inserts 134 are integrally ground in a gang. In addition, radius R2 is polished to a roughness of about 2 micron.

[0025] FIG. 4A shows a plan view of the collar 140, while FIG. 4B shows a cross-section E-E of the collar 140. As show in FIGs. 2A, 4A and 4B, the collar 140 is in the form of a hexagonal ring 141. The collar has an upper surface 142 and a lower surface

144. Along an inside hexagonal surface 146 of the collar 140 is formed a recess 148, which is contiguous with the lower surface 144. On the upper surface 142 are formed partially circular steps 149 at four locations on the upper surface 142. Each partially circular step 149 has a depth D. The collar 140 is made of a softer and more elastic material than the drawing member 130. For example, collar 140 is made of tool steel, such as SW 42 supplied by Assab Steel, and is hardened and tempered to a Rockwell harness of Rc 50.

[0026] During machining of the inserts 134 and collar 140, the dimensional tolerance of the inside surface 146 of the hexagonal ring 141 is controlled such that the hexagonal surface 146 and the drawing member's hexagonal surface 138 formed by the six inserts 134 are shrink fit. To assemble the die assembly 100, the collar 140 is heated on a hot plate, for example, to a temperature of about 100 degree C so that the distance of a hexagonal surface 146 with an opposite hexagonal surface is expanded by about 100 micron. While the collar 140 is still hot, the top surface 142 of the collar is placed on a flat datum and six inserts 134 are inserted into the collar 140 with the projection 139 in the recess 148. After allowing the collar 140 and inserts 134 to cool, typically to room temperature, the hexagonal surface 146 contracts on the drawing member's hexagonal surface 138 to create a shrink fit between the inserts 134 and the collar 140. This shrink fitting of the inserts 134 in the collar 140 creates a collar pre-tension force F to bind the inserts 134 snugly in the die assembly 100.

[0027] In use, the die assembly 100 is slide fit into a die holder 106. The die assembly 100 and the die holder 106 are secured together with screws 104 and associated die buttons 102 so that a head of each die button 102 engages a partially circular step 149 on the collar 140. The die assembly 100 is, in turn, located on a platen of a press. During deep drawing of the article 120, the punch 108 draws the sheet metal 110 into the hollow centre of the die assembly 100 and drawing member 130. As the punch 108 draws into the die assembly 100, the sheet metal 110 is made to plastically flow over

the drawing edge R2 of the drawing member 130. The collar pre-tension force F provides the reaction force at the drawing edge R2 to form the article 120 into its shape with the required dimensional tolerances. During withdrawal of the punch 108, the projection 139 on each insert 134 of the drawing member 130 engages the recess 148 on the collar 140 to prevent the drawing member 130 from being drawn out with the article 120 and punch 108.

[0028] In a manufacturing facility, the sheet metal 110 is typically supplied in the form of coils. The coiled sheet metal 110 has portions that are inherently inconsistent in its thickness tolerance. When a portion of the sheet metal thickness exceeds the designed clearance between the drawing member 130 and the punch 108, the drawing edge R2 experience a drawing force larger than its designed force. With the present invention, the collar pre-tension force F accommodates the higher drawing force by elastic expansion of the collar 140. This is only possible with the drawing member 130 formed by discrete inserts 134. If the drawing member 130 were formed from a solid piece, the corners of the hexagonal drawing surface would experience tremendous amount of stress; with repeated use, the stress concentrations result in the drawing member failing by fatigue. This is evidenced by premature die failure encountered in the prior art die, as shown in FIG. 1. With the present invention, the collar 140 is allowed to expand elastically during each deep drawing operation yet providing sufficient reaction force at the drawing edge R2 to form the article 120. An advantage of the present invention is to extend the life to the die assembly 100.

[0029] Another advantage of the present invention is that the inserts 134 can be individually replaced. This leads to lower costs in replacing the inserts 134, instead of replacing the entire drawing member 130.

[0030] FIG. 5 shows another die assembly 200 according to a second embodiment of the present invention. Instead of a hexagonal collar 140 in the first embodiment, the die

assembly 200 has a collar 240 with a circular outline. In addition, as shown in FIG. 5, the die assembly 200 has a drawing member 230 formed with three inserts 234. Each insert 234 takes the outline and dimensions of two adjacent inserts 134 described in the previous embodiment. In another embodiment, two parallel flat surfaces (as shown by the dotted line in FIG. 5) may be provided, for example, for orientation of the drawn article 120 with respect to the feeding direction of the sheet metal 110.

[0031] FIG. 6 shows another die assembly 300 according to a third embodiment of the present invention. As shown in FIG. 6, the die assembly has a collar 340 with a circular outline but the collar 340 is formed with two substantially semicircular segments 342a, 342b. The ends of the two semicircular collar segments 342a, 342b before assembly are spaced apart by a radial gap S. As shown in FIG. 6, each end of the semicircular segment 342a is counter-bored to accommodate a screw 350, while a corresponding end of the collar segment 342b is threaded. In use, the screw 350 tightens each of the two ends of the substantially semicircular segments 342a, 342b together to create a collar pre-tension force F against inserts 334 forming a drawing member 330. In a variation of this embodiment, the collar 340 is made up of radial gap S and one screw 350. In yet a further embodiment, the collar 340 is made up of three or more segments.

[0032] FIG. 7 shows yet another die assembly 400 according to a fourth embodiment of the present invention. As shown in FIG. 6, a collar 440 is formed in two substantially semicircular segments 440a, 440b just like that in the third embodiment but with an addition peripheral groove 444. Inside the peripheral groove 444 is a screw and band assembly 448. The screw and band assembly 448 has a screw 450 for opening and closing the semicircular segments 440a, 440b. In a variation of this embodiment, the collar 440 is made up of a single collar but with a cut end such that there is a gap between the cut ends of the collar. In another variation, the collar 440 is made up of a single collar with a cut end and additional one or more partially radial cuts, either on the inside or outside circumference. The partially radial cuts are to increase the elasticity of

the collar. In another variation, the partial cuts are non-radial. In yet another variation, the radial cuts are through the collar ring such that the collar is made up of three or more segments.

[0033] Other variations of the above embodiment are also possible. For example, instead of using hardened and tempered steel for the collar, other materials with more elastic property than the drawing member, such as, precipitate hardened and tempered aluminium alloy may be used.

[0034] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention. For example, the present invention is not limited to deep drawing of a hexagon-shaped article. The principle of the invention can be applied to forming a drawing die into segments and binding the segmented die components with an elastic collar, even for die drawing of a round or circular article.

CLAIMS:

1. A drawing die assembly comprising:
a drawing member having two or more die segments; and
a collar operable to bind the two or more die segments together with a pre-tension force;
wherein the pre-tension force allows the two or more die segments to expand when a drawing force exceeds the pre-tension force.
2. A die assembly according to claim 1, wherein the collar pre-tension force is generated by shrink-fitting the collar onto to the drawing member by thermal expansion and contraction.
3. A die assembly according to claim 1, wherein the collar pre-tension force is generated by narrowing a gap between cut ends of the collar.
4. A die assembly according to claim 3, wherein narrowing of the gap is operable by a screw in one cut end and an engaging thread in an adjoining cut end.
5. A die assembly according to claim 3, wherein narrowing of the gap is operable by a screw and band assembly.
6. A die assembly according to any one of claims 3-5, wherein the gap comprises two or more spaced apart gaps.
7. A die assembly according to any one of claims 3-6, further comprising one or more partial cuts on the inside or outside circumference of the collar.

8. A die assembly according to claim 7, wherein the one or more partial cuts are radial.
9. A die assembly according to claim 7, wherein the one or more partial cuts are non-radial.
10. A die assembly according to any one of the preceding claims, wherein the drawing member has a polygonal drawing edge.
11. A die assembly according to claim 10, wherein the two or more segments are segmented at two or more corners of the polygon.
12. A die assembly according to claim 10 or 11, wherein the collar is also polygonal.
13. A die assembly according to claim 10 or 11, wherein the collar is substantially circular.
14. A die assembly according to any one of claims 1-9, wherein the drawing member has a circular drawing edge.
15. A die assembly according to claim 14, wherein the collar is substantially circular.
16. A die assembly according to any one of the preceding claims, wherein the collar is more elastic than the drawing member.
17. A die assembly according to claim 16, wherein the collar is hardened and tempered.

18. A method of forming a drawing die assembly with reduced frequency of die cracking, the method comprising:

forming a drawing member in two or more die segments; and

binding the two or more die segments of the drawing member in a collar with a pre-tension force;

wherein the pre-tension force allows the two or more die segments to expand, thereby reducing the frequency of cracking of the drawing member.

19. A method according to claim 18, wherein the pre-tension force is generated by shrink-fitting of the collar onto the drawing member by thermal expansion and contraction.

20. A method according to claim 18, wherein the pre-tension is generated by narrowing a gap between cut ends of the collar.

21. A method according to any one of claims 18-20, wherein the drawing member has a polygonal drawing edge.

22. A method according to claim 21, wherein the two or more segments of the drawing member are segmented at two or more corners of the polygon.

23. A method according to claim 21 or 22, wherein the collar is also polygonal.

24. A method according to any one of claims 18-22, wherein the collar is circular.

25. A method of manufacturing a drawing die assembly according to any one of claims 1-24.