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Dohmann

[11] **3,887,978**

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[54] **MANUFACTURING OF BEVEL GEAR BY COLD FORMING OF BLANKS IN A PRESS DIE**

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[52] **U.S. Cl.** **29/159.2;** 72/354

[51] **Int. Cl.** **B21j 5/12**

[58] **Field of Search** 29/159.2; 72/352, 359, 72/377, 358, 354; 74/431, 432, 459.5, 460

[56] **References Cited**

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[57] **ABSTRACT**

Bevel gear is made by cold forming of a cylindrical blank in a die, using a press punch and a counter punch, and wherein the die cavity is extended cylindrically with gear like cross-section corresponding to the smallest gear diameter portion of the bevel gear. The counter punch is initially in a receded disposition so that some material of the blank is extruded into the tooth - impressions of the die cavity extension. The die is resiliently supported in relation to the counter punch so that in the last phases of press forming, the counter punch pushes the material from the cavity extension into the cavity proper for completely filling the tooth impressions in the die wherein the small diameter portion of the bevel gear is formed.

6 Claims, 2 Drawing Figures

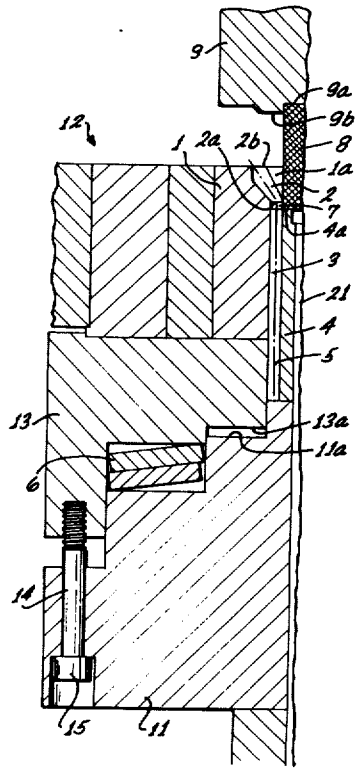

Fig. 1

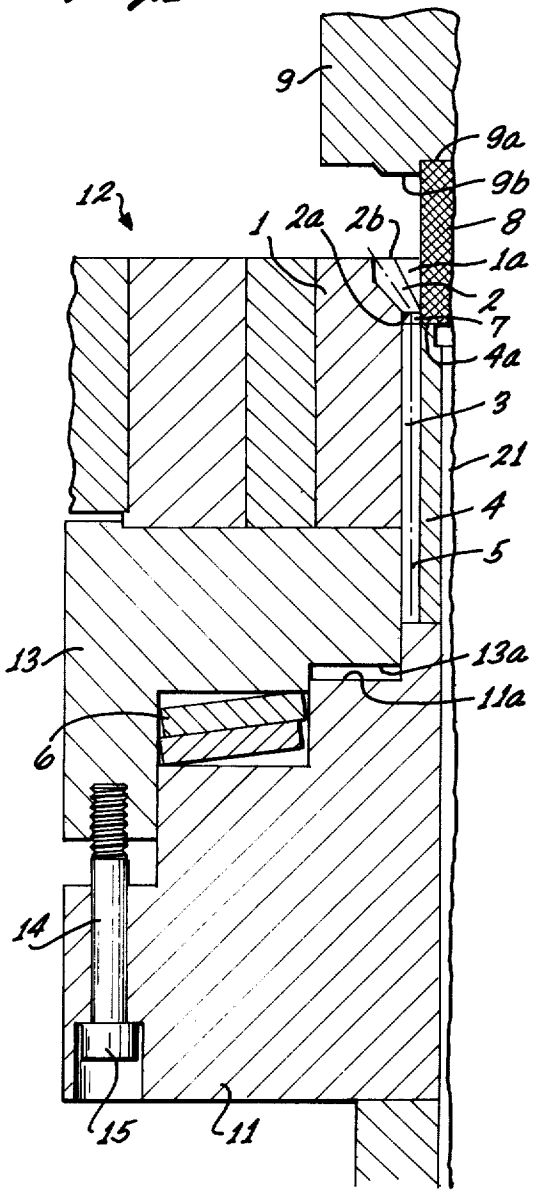
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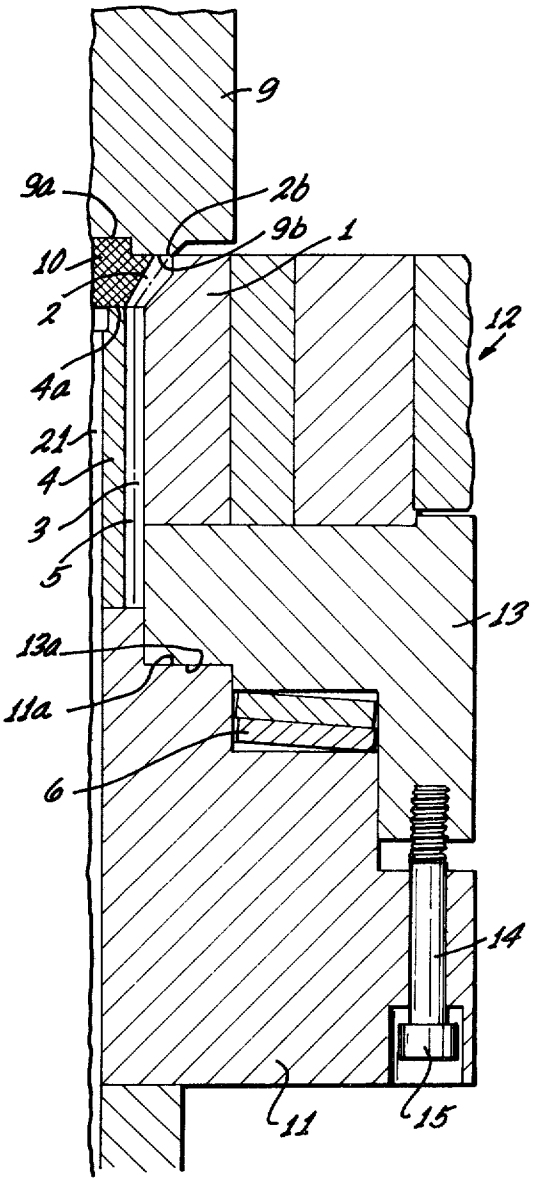
Fig. 2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MANUFACTURING OF BEVEL GEAR BY COLD FORMING OF BLANKS IN A PRESS DIE

BACKGROUND OF THE INVENTION

The present invention relates to the making of bevel gear without cutting or other kinds of machining, and more particularly the invention relates to improvements in the making of such bevel gear from steel blanks using a press die, a punch and a counter punch.

It is known to make bevel gears by means of warm forging or cold extrusion using a die, a punch and a counter punch. Frequently such bevel gears are not sufficiently accurate with regard to the contour of the teeth. Moreover, the problem has been encountered frequently that the die cavity is not filled completely with material when the cold extrusion and press forming is to be carried out in one step. Particularly the flow of material into those portions of the die cavity which are provided for forming the teeth, is impeded significantly by friction on the flanks of those teeth forming portions of the die. This is particularly prevalent if the teeth to be formed are small; the small diameter portion of the gear to be made is quite difficult to fill completely with flowing material. Under such circumstances relatively large changes in cross-sectional dimensions occur locally in the deformed and flowing blank under increasing frictional resistance from the die.

As a consequence of the inherent deficiencies in this method of bevel gear making, it has been tried to provide for a second press working operation, which has to be conducted at room temperature, for filling all parts of the die cavity completely.

The problem should be considered in some detail and from a certain point of view. During the press forming of a blank, the die has the tendency to changes in shape, contour and dimensions as a result of resilient reaction against the forcing-in of the cold-flowing material. In order to obtain accurate dimensions for the bevel gear that is being made, such changes are to be avoided, so that the forces exerted here should be as low as possible.

On the other hand, the die cavity and all extremities thereof must be filled completely. As far as the filling of the teeth defining cavity impressions is concerned, the forces needed here are well above those deemed desirable for preventing undue changes in contour of the die itself. In order to balance the situation it was found necessary to press form bevel gears in three steps which renders the process quite expensive. It can readily be seen that an economical way of making bevel gears depends to a considerable extent on the utilization of a one-step press forming process.

Several different steps have been taken here to control the flow of material of and in the blank as it is being deformed so as to minimize the overall forces exerted while ensuring complete filling of all portions of the cavity. The German Pat. No. 1,048,766, for example, has proposed a combination of warm forging with local heating of the blank.

Another approach has been taken in accordance with my U.S. Pat. No. 3,675,459. The method suggested here uses a blank which has been given particular contour, i.e. the blank has a bulging convex contour. It was found that upon using such a blank one can indeed fill all impressions in a bevel gear die cavity with material in a one step press forming process. From a technical

point of view, the problem was solved therewith. The local deforming actions of and in the blank, the temperature, the local friction on the teeth forming flanks of the die, the arrangement of the tools and the forming speed all can well be balanced when using such blanks. Unfortunately, this process does require preforming of the blank to have the needed bulging contour. There remains therefor, the problem of providing for bevel gear making when using cylindrical blanks, i.e., blanks which do not require the individualized preparation.

DESCRIPTION OF THE INVENTION

It is an object of the present invention to provide for making of bevel gears using cylindrical metal blanks filling the various portions of the die cavity completely.

It is another object of the present invention to cold press form bevel gears wherein the press die is filled completely without exertion of excessive, die deforming press working pressure, and as it has been practiced with blanks of bulging contour except that cylindrical blanks are to be used.

It is a further object of the present invention to provide for press tool for forming a cylindrical blank or work into a complete bevel gear without requiring further preparation of the blank.

It is still a further object of the present invention to improve tooling for making bevel gears, as comprised of a die, a punch and a counter-punch.

In accordance with the preferred embodiment of the invention it is suggested to provide the die cavity with an axial extension corresponding to the smallest bevel gear diameter and with similar cross-sectional contour and impressions; the counter punch has a corresponding contour and moves in this cavity extension. The counter punch is, receded initially from the plane in the die cavity defining the smallest diameter of the bevel gear to be made so that some material flows and is made available above the counter punch; this material is subsequently pushed by the counter punch into the small diameter portions of the die impression. Specifically, the cylindrical blank is placed onto the counter punch, and in the beginning of the deforming process some material flows into teeth defining cavities of the die cavity extension. That material is pushed up in the last phases of the process to fill the small diameter portions of the bevel teeth defining impressions of the die proper.

In furtherance of the invention, the press die is resiliently supported relative to the counter punch, so that in the last phases of press punch advance, when the resistance of the deforming blank becomes quite large, the resilient support will be overcome forcing the die down on the counter punch support so that the counter punch advances in the die cavity to obtain the filling of the small diameter cavity zone as far as the teeth defining extremities in the die cavity are concerned.

The resilient support is preferably established by cup springs but hydraulic cylinders with pressure dependent displacement of pistons can be used. The resilient reaction must be such that the counter punch is advanced only in the final phases of forming process.

DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the in-

vention and further objects, features and advantages thereof will be better understood from the following description taken in connection with the accompanying drawings in which:

FIG. 1 shows a section through a die with punch and counter punch, to one side of the center axis through those tools, and prior to the beginning of forming a bevel gear in accordance with the preferred embodiment of the invention; and

FIG. 2 shows a similar section in complementary fashion, to the other side of the center axis, with the tool parts shown in the end of the bevel gear forming process, the Figures being drawn in horizontal alignment.

The Figures show a press die **1** with a mold cavity **1***a* having tapering ridges **2** for establishing the bevel gear impression, forming in particular the grooves between the teeth of the bevel gear to be made by the die between the ridges **2**. The line **2***a* denotes the bottom of the die cavity proper. This bottom is situated in the plane in which the smallest diameter of the bevel gear is going to be formed and established.

The die cavity is continued below plane **2***b* in a second cavity **3** of star shaped cross-section corresponding to the smallest tooth circle of the bevel gear. One can also say that the cross-section of cavity **3** corresponds to an axial projection of the smallest gear dimensions of the cavity **1***a*. In any event, the cavity **3** continues the smallest gear forming impressions of the bevel gear die.

The cavity or space **3** has cross-section of a gear but is uniform in axial direction, i.e., it is cylindrical in the general sense and receives the counter punch **4** having gear shaped cross-section with teeth **5** running in the longitudinal grooves of the cavity **3**. Counter punch **4** has slide fit in cavity **3** and sits on a thrust block or support **11**. The die **1** is received in a die holder **12** which in turn sits on a support **13**. An ejector **21** is slidably disposed inside of counter punch **4** and traverses also block **11** for external operation at the end of a forming step.

The assembly **1, 12, 13** and particularly support **13** does not sit directly on block **11**, but resilient elements **6** such as plate or cup springs are interposed. Connecting bolts **14** are threaded in support **13** and run in corresponding bores in the block **11**. A collar **15** on each bolt restricts upward displacement of the assembly **1, 12, 13**. The spring elements **6** may be biased so that the assembly is indeed tightened to some extent.

The particular disposition of the arrangement as shown in FIG. **1** shows the upper end-face **4***a* of counter punch **4** below plane **2***a*, which separates cavity **1***a* from cavity **3**. A cylindrical work or blank **8** has been inserted and rests on the counter punch. Thus, the lower end of blank **8** extends below bottom plane **2***a* of die cavity **1***a*. On the other hand, the grooves of cavity **3** above the upper end of the teeth **5** of counter punch **4** are empty, the space is denoted by **7** and actually consists of individual groove portions along the upper periphery of cavity **3**, above punch **4** and bounded and separated from each other by the outer, lower periphery of cylindrical blank **8**.

The press punch **9** is disposed above the blank. Blank **8** is inserted in a recess **9***a* bounded by an annular shoulder **9***b* having outer dimension to cover the largest diameter of the bevel gear defining cavity **1***a*.

For forming a bevel gear, press punch **9** is lowered and blank **8** is deformed and begins cold extrusion flow into available flow space. Since the upper end-face **4***a* is the only surface offering resistance (in addition to the punch itself) the metal of the blank flows radially outwardly.

One can readily see that the upper portions of the die cavity are available for receiving radially outwardly spreading material, offering no flow resistance during the first phases of punch advance. Moreover, as the punch **9** is advanced further, the upper part of die cavity **1***a*, including the large diameter portion of the tooth defining peripheral extremities in the die cavity, are filled with flowing material from above as well as through radial flow.

The situation is different in the lower portion of the die cavity. Material flows also into the teeth defining cavity extremities as well as into spaces **7**, but very soon resistance from the die wall cavity and of the grooves defining tooth flanks are encountered so that the flow is impeded, particularly when compared with rather unimpeded flow conditions in the upper portion of the die cavity. Thus, the peripheral die grooves in the lower portion and the spaces **7** contiguous therewith are not being filled completely.

As the punch **9** progresses further metal fills the wider portions of cavity **1***a* and by transmission of force upon the die the assembly **1, 12** and **13** is forced down. Particularly, the resistance of the material of the blank against plastic deformation, when in abutment with the oblique impressions of the die, is larger than the resilient reaction of elements **6**, so that assembly **1, 12, 13** is forced down until a shoulder **13***a* of support **13** sits on a shoulder **11***a* of block **11**. As a consequence, the material which flowed into spaces **7** is forced up, and that operation of the counter punch ensures complete filling of the tooth defining impressions of smallest diameter in the die cavity **1***a*, particularly, in and above plane **2***a*.

The end state of press forming as shown in FIG. **2** finds front end **4***a* of counter punch **4** situated in plane **2***a*. The material that had flown previously into spaces **7** has been completely removed therefrom into the small diameter zone of die cavity **1***a*. The dimensions of the blank **8** have been chosen so that the annular end-face **9***b* of punch **9** can rest (or almost rest) on the projections **2***b* in the upper part of die **1** which establish the bevel gear grooves. The forming process is then completed.

The spaces **7** have been selected so that the amount of blank material that will flow into them by cold extrusion corresponds to the material needed in the region of smallest bevel gear diameter. The development of excess material should be avoided as such material could flow into the gap between die and counter punch and bind the latter (not necessarily during the current run, but for the next one in preparation of which counter punch **4** must be receded). The axial dimensions of spaces **7** can be accurately adjusted as bolts **14** may have the function of adjustment spindles due to their threading into support **13**.

After the end phase of press forming the bevel gear, punch **9** is retracted, and ejector **21** pushes the bevel gear out of the die cavity.

The invention is not limited to the embodiments described above but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be included.

I claim:

1. In an apparatus for forming bevel gear, including a die with bevel gear forming die cavity, a punch acting from the side of largest diameter of the die cavity and a counter punch acting from the side of smallest diameter, the improvement, comprising:

a continuation portion of the die cavity having gear shaped cross-sectional contour corresponding to the smallest, bevel-gear-defining cavity portion, and having longitudinally cylindrical configuration;

the counter punch positioned in said continuation portion of the die cavity and having correspondingly gear like cross-section; and

means for advancing the counter punch during the last phase of the relative advance of the punch.

2. In an apparatus as in claim 1, including means for resiliently supporting the die with respect to the counter punch, to obtain counter punch movement towards the die cavity during the last phase of forming, when the press force as transmitted by the punch via blank onto the die overcomes resilient resistance by the means for supporting.

3. In an apparatus as in claim 2 wherein the front end of the counter punch is held in receded disposition from the die cavity prior to press forming.

4. The method of forming bevel gear by means of a die with bevel gear forming die cavity, punch and counter punch, comprising the steps of using a die with a cavity continuation at the end of smallest bevel gear diameter and axially continuing the dimensions thereof.

using a counter punch with gear shaped outer contour for slidable displacement in the cavity continuation and establishing a temporary bottom for the die cavity;

positioning the counter punch in receded disposition relative to the bevel gear defining die cavity;

placing a cylindrical blank into the cavity so that it rests on the counter punch;

forcing the punch against the blank for causing the blank to deform and flow radially outwardly to fill the contour of the die cavity; and

causing the counter punch to advance toward the punch during the last phases of bevel gear forming by forcing material from the blank which flowed radially from the blank where resting on the counter punch, into the teeth defining cavities of smallest diameter for filling same completely.

5. In the method as in claim 4, wherein the counter punch has disposition below the plane in the die cavity defining the small diameter end of the bevel gear to be made so that the material flowing into the grooves of the die cavity extensions when forced and displaced axially upon advance of the counter punch will fill the tooth defining portions of the die cavity completely.

6. The method as in claim 4, wherein the support for the counter punch bears resiliently against die, the resiliency being overcome during advance of the punch as forcing the blank into peripheral grooves of the die to thereby causing the counter punch to advance toward the punch.

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