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Old extrusion process for internal helical gear teeth.

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EP-A- 0 088 867
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Description

The invention relates according to the precharacterising part of claim 1 to a process for cold extruding internal gear teeth.

The invention comprises improvements of an earlier application comprising a method for forming internal teeth for a ring gear by advancing an annular workpiece across external die teeth of a floating mandrel that is surrounded by a die ring.

The workpiece of the earlier invention is extruded through the die teeth by a punch that is actuated by a ram, the punch entering the annular space between the mandrel and the die ring. As the punch is advanced, the workpiece is extruded throughout a major portion of its axial length. The punch then is withdrawn to permit entry of a second workpiece in registry with the first workpiece in end-to-end relationship. The second workpiece is received over a pilot portion of the mandrel. Subsequent movement of the punch advances the second workpiece, which in turn advances the partially extruded workpiece until the latter is fully extruded and moved beyond the location of the external die teeth of the mandrel.

During the extrusion of a workpiece using the above mentioned process relatively large friction forces occur because of the necessity of the workpiece, during the extrusion process, to slide along the annular inner surface of the die ring. If the workpiece is made of steel -- for example, SAE 5130 steel -- a relatively large and costly extrusion press is required. This is due partly to the high friction forces that are established during the extrusion process. In a typical embodiment the extrusion forces may be 2.18 x 10^3 kg (240 tons) or more.

DE-B-2,325,837 comprising the closest prior art discloses a process for cold extruding internal teeth on a workpiece comprising mounting an annular workpiece over a mandrel, said mandrel having external teeth with a metal forming portion, mounting a die ring around said mandrel and workpiece, mounting a further work piece over said mandrel and moving an annular punch between said die ring and said mandrel whereby said first mentioned workpiece is extruded.

In the extrusion process of the earlier application as well as in the present invention, the workpiece is caused to enter the entrance portion of the die teeth of the mandrel as the extrusion of metal begins. The entry of the workpiece is facilitated by a ramp portion on the leading edge of the die teeth adjacent to the pilot portion of the mandrel. The actual internal tooth formation region of the external teeth is only a fraction of the total die tooth length of the mandrel teeth. The trailing edge portions of the teeth are recessed to provide a progressively decreasing outer diameter. They also are formed with a progressively decreasing tooth thickness. This permits the die teeth of the mandrel to guide the workpiece during the extrusion process, but it avoids excessive friction forces between the teeth of the mandrel and the metal that is being extruded on the inside diameter region of the workpiece.

According to the present invention there is provided a process for cold extruding internal ring gear teeth comprising the steps of machining an annular ring gear work piece with precision inside and outside diameters, mounting said gear work piece over a mandrel arranged coaxially with respect to said work piece, said mandrel having external die teeth with metal forming portions, mounting a die ring around said mandrel and workpiece, said die ring having an inside diameter equal to the desired outside diameter of the finished ring gear, moving an annular punch between said die ring and said mandrel whereby said workpiece is extruded partially through said die teeth, mounting a subsequent workpiece over said mandrel adjacent the aforesaid workpiece in abutting relationship with respect to the latter, characterised in that the process further comprises providing said mandrel with a relief portion of pitch diameter and tooth thickness less than the corresponding dimensions of the metal forming portions, and moving said die ring in unison with the workpiece being extruded thereby reducing the total extrusion force required and eliminating the possibility of scoring of the workpiece and die ring at the surface-to-surface interface.

In the process embodying the invention the friction forces that are required during the extrusion process are substantially reduced. This is done by making provision for movement of the die ring in unison or synchronism with the movement of the workpiece as the latter is extruded through the die teeth. After the die teeth fully extrude the internal teeth of the workpiece, the workpiece that is inserted in end-to-end relationship with respect to the extruded workpiece as well as the mandrel are raised without any relative motion occurring between the workpiece and the die ring. As the ring, the mandrel and the workpiece are raised, the extruded workpiece is stripped and ejected from the press. As the mandrel, the die ring and the partially extruded workpiece then are returned to a lower level, a subsequent workpiece can be inserted above the mandrel pilot portion and the foregoing method steps are repeated in the same sequence.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a view showing a finished ring gear made by the process of the invention.
Figure 2 is a view showing the external tooth mandrel used in the extrusion of the ring gear of Figure 1.

Figure 3 is a view showing the elements of the extrusion press employed in our extrusion process.

Figures 4A through 4E show the structure of Figure 3 in its various operating positions for the steps used in the extrusion process.

In Figure 1 the ring gear is designated generally by reference character 10. It includes an annular shell 12 of precise diameter and internal helical gear teeth 14 which are extruded during the process. The workpiece from which the ring gear 10 is formed during the extrusion process is an annular ring with precision machined outside and inside diameters. It is fitted over a pilot portion 16 of the mandrel shown generally at 18 in Figure 2. Mandrel 18 is a cylindrical member on which are formed external die teeth 20, the shape of which will be described with respect to Figure 2. The mandrel includes also a support portion 22 which is adapted to be seated on a press bed capable of accommodating the considerable gear tooth extrusion forces.

The ring gear 10 may be extruded from an aluminium alloy material if the gear forces that would act on the teeth are relatively small. If higher gear forces are required, the ring gear stock should be steel, such as SAE 5130 steel. In either case, the metal of the workpiece is extruded through the die teeth 20 as metal is displaced. This, of course, increases the axial length of the workpiece, and that axial growth is taken into account in the precision machining of the blank.

In Figure 3 the hydraulic press is generally designated by reference numeral 24. It has secured thereto an annular punch 26 having a lead end portion 28 with radial dimensions equal to the radial dimensions of a workpiece 30.

Mandrel 18, as well as the workpiece 30, are received in a die ring 32 having a precision machined inside diameter that matches the outside diameter of the workpiece 30. Die ring 32 is supported by cylinder rods, one of which is shown at 34.

Die teeth 20 on the mandrel include a lead in tapered portion 36, a metal extruding portion 38 and a relief portion 40. Relief portion 40 is formed with a progressively decreasing outside diameter, and the teeth of the relief portion 40 are formed with a progressively decreasing width in comparison with the corresponding dimensions of the gear extruding portion 38.

When the punch 26 is withdrawn, a second workpiece 42 is inserted over the pilot portion 16 in end-to-end, juxtaposed relationship with respect to the workpiece 30. As the punch 26 then is advanced, workpiece 42 advances the workpiece 30 through the extrusion die teeth 20 until it is ejected at the lower portion of the assembly as shown at 44. When the workpiece 30 is being extruded through the die teeth 20, the die ring 32 moves in unison with the workpiece thereby preventing relative sliding movement of the workpiece with respect to the inner surface of the die ring 32. This eliminates any frictional forces that normally would be accompanied by such sliding motion. The total extrusion forces that are required then are reduced in magnitude.

In Figures 4A through 4E we have illustrated the sequence of the various steps during the extrusion process. In Figure 4A the die punch is in the upper or retracted position. At that time a workpiece 42 is inserted over the pilot portion 16 of the mandrel. The die ring 32 is moved to an upward position by hydraulic cylinder rods 34. The preceding workpiece 30 is shown in Figure 4A assembled over the pilot portion 16.

In Figure 4B the punch 26 advances, thereby forcing the workpiece 42 against the workpiece 30 and extruding the latter through the teeth 20. When the positions of the workpieces assume that illustrated in Figure 4B, the die ring 32 begins to move in unison with workpiece 30 until the movable parts assume the position shown in Figure 4C. At that time the workpiece 30 is fully extruded, and the workpiece 42 is only partially extruded. In the next step the die ring 32, together with the partially extruded workpiece, are moved upwardly by the hydraulic piston rods as the extruded workpiece is stripped from the teeth. Continued movement of the die ring upwardly is accompanied by vertical movement of the mandrel until the parts assume the position shown in Figure 4E. Continued movement of the punch ring 26 allows the loading of another workpiece as illustrated in Figure 4A, and the cycle is repeated.

It is thus seen that with the ram and the punch in the upward position the blank may be initially preloaded over the pilot diameter of the mandrel into the cavity defined by the mandrel and the surrounding ring. During downward travel and in timed motion with the die ring, the punch axially forces the blank material into the entrance ramp and the tooth area of the mandrel. It stops movement when the workpiece is about .15 cm (.06 inches) short of contact of the teeth of the mandrel. At that time the blank is maintained with high frictional contact between the mandrel and the die ring. As the punch and the die ring retract to the upward position the blank is partially stripped from the ring and a subsequent blank then is loaded in end-to-end relationship with respect to the preceding blank. Downward motion of the punch then forces the second blank into engagement with the
partially extruded blank until the latter is fully extruded through the mandrel teeth. At that time the extruded workpiece drops free into the recess cavity where it can be ejected as shown in Figure 4E.

As the punch retracts, the cylinder rods rise in unison with the other movable portions of the system into the position shown in Figure 4E. At that time access is provided for a robotic arm, for example, to slide the extruded workpiece from the confines of the tooling. After ejection, the cylinders return the assembly to the original position.

The mandrel is a floating mandrel, and because of it is self-centring. The blanks are precision machined because any eccentricity that might be built into the blank in the pre-extruded state would result in a corresponding eccentricity of the extruded part.

The hole diameter of the pre-extruded workpiece blank must correspond to the minor diameter of the gear teeth. This ensures that the space between the teeth will be completely filled by the blank material during the extrusion process. Concentricity of the extruded pitch diameter is determined by the concentricity of the pre-extruded blank.

The tapered relief of the teeth and the progressively decreasing tooth thickness of the mandrel teeth discourage metal build-up and galling while serving the function of helical guidance in the case of the extrusion of helical teeth. We contemplate, however, that our improved process may be used to form spur gear teeth as well.

Claims

1. A process for cold extruding internal ring gear teeth comprising the steps of machining an annular ring gear work piece (30) with precision inside and outside diameters, mounting said gear work piece (30) over a mandrel (18) arranged coaxially with respect to said work piece, said mandrel having external die teeth (20) with a metal forming portions and, mounting a die ring (32) around said mandrel (18) and workpiece, said die ring having an inside diameter equal to the desired outside diameter of the finished ring gear, moving an annular punch (26) between said die ring (32) and said mandrel (18) whereby said workpiece is extruded partially through said teeth, mounting a subsequent workpiece (42) over said mandrel (18) adjacent the aforesaid workpiece (30) in abutting relationship with respect to the latter, characterised in that the process further comprises providing said mandrel (18) with a relief portion (40) of pitch diameter and tooth thickness less than the corresponding dimensions of the metal forming portions, and moving said die ring (32) in unison with the workpiece being extruded thereby reducing the total extrusion force required and eliminating the possibility of scoring of the workpiece and die ring at the surface-to-surface interface.

2. A process as claimed in claim 1, further comprising retracting the die ring, the partially extruded workpiece and the punch to permit stripping of the extruded workpiece from the die ring.

3. A process as claimed in claim 2, further comprising retracting the die ring and the partially extruded workpiece further together with said mandrel to permit ejection of the extruded workpiece from the tooling.

4. A process as claimed in any one of claims 1 to 3, wherein said mandrel is mounted on a die bed with a free floating characteristic whereby the extruding motion of said workpiece is accompanied by rotary movement of said mandrel to accommodate any lead angle for helical teeth for the ring gear.

Patentansprüche

1. Verfahren zur Kaltextrusion von Innenringgetriebezähnen, welches Schritte zur Bearbeitung eines ringförmigen Zahnkrankwerkstückes (30) mit Präzisionsinnen- und -außendurchmesser, zur Aufspannung des genannten Kranzwerkstückes (30) über einen Dorn (18), der im Verhältnis zu dem genannten Werkstück koaxial angeordnet ist, wobei der genannte Dorn Außenformzähne (20) mit einem Metallformungsteil hat, und zur Montage eines Formrings (32) um den genannten Dorn (18) und das Werkstück herum, wobei der genannte Formring einen Innendurchmesser hat, der gleich dem gewünschten Außendurchmesser des fertigen Zahnkrankes ist, zur Anbringung eines ringförmigen Stempels (26) zwischen dem genannten Formring (32) und dem genannten Dorn (18), wobei das genannte Werkstück teilweise durch die genannten Formzahne hindurch extrudiert wird, und zur Aufspannung eines nachfolgenden Werkstückes (42) auf den genannten Dorn (18) angrenzend an das oben genannte Werkstück (30), das an das letztere anstößt, beinhaltet, dadurch gekennzeichnet, dass das Verfahren ferner beinhaltet, dar der genannte Dorn (18) mit einer Aussparung (40), mit einem Rollkreisdurchmesser und einer Zahndicke, die geringer sind als die entsprechenden Abmessungen der Metallformungsteile, versehen ist, und daß der genannt-
te Formring (32) in Übereinstimmung mit dem zu extrudierenden Werkstück bewegt wird, und dadurch die benötigte Gesamtextrusionskraft reduziert wird und die Möglichkeit der Rillenbildung an dem Werkstück und dem Formring an den Grenzflächen der beiden Oberflächen entfällt.

2. Verfahren nach Anspruch 1, das ferner das Zurückziehen des Formrings, des teilweise extrudierten Werkstückes und des Stempels enthält, um das Abstreifen des extrudierten Werkstückes vom Formring zu ermöglichen.


Revendications

1. Procédé pour filer à la presse, à froid, des dentures annulaires intérieures, comprenant les étapes qui consistent à usiner une ébauche annulaire de couronne dentée (30) pour lui donner des diamètres intérieur et extérieur de précision, à enfiler cette ébauche de couronne (30) sur un mandrin (18) disposé coaxialement par rapport à cette ébauche, le mandrin portant des dents extérieures de filière (20) avec des parties de formage du métal, et à monter un anneau de filière (32) autour du mandrin (18) et de l'ébauche, l'anneau de filière ayant un diamètre extérieur égal au diamètre extérieur désiré de la couronne dentée finie, à faire avancer un poinçon annulaire (26) entre l'anneau de filière (32) et le mandrin (18), de manière que l'ébauche soit filée partiellement à travers les cotes des dents de filière, ainsi qu'à enfiler une ébauche suivante (42) sur le mandrin (18) pour qu'elle soit adjacente à l'ébauche (30) mentionnée en premier et disposée bout à bout avec celle-ci, caractérisée en ce qu'il comprend en outre les étapes consistant à doter le mandrin (18) d'une partie en dépouille (40) dont le diamètre du cercle primitif et l'épaisseur des dents sont inférieurs aux dimensions correspondantes des parties de formage du métal, et à déplacer l'anneau de filière (32) conjointement avec l'ébauche en cours de filage, en réduisant ainsi la force totale de filage nécessaire et en éliminant la possibilité de striage de l'ébauche et de l'anneau de filière à l'interface où leurs surfaces sont mutuellement en contact.

2. Procédé selon la revendication 1, comprenant en outre la rétraction de l'anneau de filière, de l'ébauche partiellement filée et du poinçon afin de permettre que la pièce filée soit détachée de l'anneau de filière.

3. Procédé selon la revendication 2, comprenant en outre la rétraction de l'anneau de filière et de l'ébauche partiellement filée sur une plus grande distance, ensemble avec le mandrin, afin que la pièce filée puisse être éjectée de l'outilage.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel le mandrin est monté sur une table de filière de manière qu'il puisse flotter librement, le mouvement de filage de l'ébauche étant accompagné d'un mouvement de rotation du mandrin afin de permettre l'obtention d'un angle d'attaque quelconque nécessaire en vue de la réalisation d'une couronne à denture hélicoïdale.