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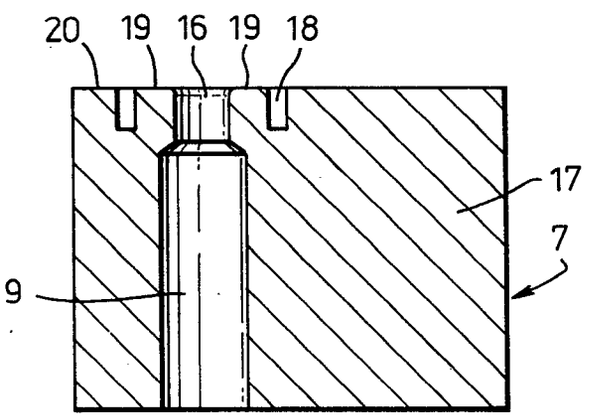
(54) Extrusion of Metal.

(57) A die unit for radial Conform extrusion machinery has a surface (21) round the entrance to the die (16) which is isolated from any other surface in contact with the material being extruded to the extent that strain induced in that surface by the drag of material entering the die is substantially independent of strain induced in any other surface, said surface having major dimensions from the die orifice to its periphery which differ from one another by no more than ±25%.



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EXTRUSION

This invention relates to a die unit and machinery for extrusion of metal. More particularly it relates to machinery of the kind in which a passageway is formed between an arcuate first member and a second member in the form of a wheel having a circumferential groove formed in its peripheral surface into which groove the first member projects, the wheel being rotatable to urge material in the passageway towards one end (the exit end) thereof, an abutment member extending across the passageway at the exit end thereof and at least one die orifice through a part of the arcuate first member adjacent the abutment member.

The abutment member may be large enough to block the end of the passageway completely (as described in the specification of UK Patent 1370894) but especially when the material to be extruded is a relatively hard metal, such as copper, we prefer that the abutment member is of substantially smaller cross-section than the passageway and leaves a substantial gap between the abutment member and the groove surface and that the material being extruded is allowed to adhere to the groove surface, whereby a substantial proportion of the metal (as distinct from the inevitable leakage of flash through a working clearance) extends through the clearance and remains as a lining in the groove to re-enter the passageway while the remainder of the metal extrudes through the die orifice(s), as described in our UK Patent No. 2069389B.

Such machinery is commonly known as radial "Conform" machinery, and will be referred to as such

hereinafter.

No doubt because of the extreme assymetry of the die area, we have found that the product of radial Conform extrusion may differ significantly in shape from the die through which it was produced; for example a round die produces wire of appreciably oval cross-section. It is the object of this invention to eliminate or at least reduce this effect.

In accordance with one aspect of the invention, radial Conform machinery comprises a surface round the entrance to the die which is isolated from any other surface in contact with the material being extruded to the extent that strain induced in that surface by the drag of material entering the die is substantially independent of strain induced in any other surface, said surface having major dimensions from the die orifice to its periphery which differ from one another by no more than $\pm$ 25%.

In accordance with a further aspect of the invention, a die unit for radial Conform extrusion machinery comprises a die member having an orifice which forms a die or will mount an insert die and formed with a surface round the entrance to the die which is isolated from any other surface in contact with the material being extruded to the extent that strain induced in that surface by the drag of material entering the die is substantially independent of strain induced in any other surface, said surface having major dimensions from the die orifice to its periphery which differ from one another by no more than $\pm$ 25%.

The benefits of the invention are greatest when

the die is formed integrally with the die holder, but it may be used with advantage with an insert die.

The die unit is most suitably employed as a separate insert, but if desired the die unit could be directly formed in the arcuate first member of the machine or made in one piece with the abutment.

The periphery of the isolated surface may be defined by a boundary between two (or more) separate members or by one or more than one recess of sufficient depth and extent to provide the required isolation.

Preferably, at least part of the periphery is defined by at least one recess.

Ideally, all the radial dimensions of the surface, from the die orifice to the periphery, would be equal. In this case we prefer the surface periphery to be defined by an annular groove in the front face of the die member or die-holder having its centre at the die orifice.

However, we have found that acceptable and useful results can be achieved more easily with an isolated surface which approximates to a square, especially a square with a side equal to the width of the extrusion passageway. Such a square isolated surface can be formed using a straight groove extending across the die member or die holder or a circular depression of sufficient diameter cut into it and approximately spaced from the die entrance on the side of the die remote from the abutment. Both these alternatives are easier to form than an annular groove, using a milling cutter (or a saw) and a drill respectively.

The invention also includes methods of Conform

extrusion in which the machinery or the die unit described is used and products of these methods.

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

Figure 1 is a cross-section of part of a radial Conform machine (in accordance with our UK Patent No. 2069389B);

Figures 2 and 3, 4 and 5, and 6 and 7 are mutually perpendicular views of alternative die units in accordance with the invention.

In the Conform machine shown in Figure 1, a wheel 1 (the curvature of which is too slight to be visible in this section) is formed with a rectangular groove 2, that forms three walls of the working passageway 3. The fourth wall is formed by an assembly comprising a shoe 4 (a small portion of which is shown), and an abutment 5 projects into the passageway.

A radial extrusion die 6 is formed in a die member 7 (which is preferably a separate component as shown, though it might be integral with either the abutment or the shoe).

The shoe, abutment and die area are of high-strength materials and are held in position by heavy-duty support members (not shown), and cooling means is provided.

Figures 2 and 3 are mutually perpendicular views of an ideal die unit in accordance with the invention. A die 16 is formed in the die holder 7 and is relieved by a counterbore 9 to provide a clearance around the extruded

product. In accordance with the invention, the die orifice is surrounded by an annular groove 18 deep enough (say 2-3 mm deep) to isolate the enclosed surface 19 from the surrounding surface 20 in the sense that any deformation of the surface 20 induced by the drag of the material extruded will not be transmitted to the enclosed surface 19 but will be dissipated into the body of the die member.

Figures 4 and 5 are mutually perpendicular views of a more practical die unit in accordance with the invention in which the isolated surface 21 is substantially square and is defined on three sides by the edges of the die member 7 and on the upstream side by a groove 15 milled or otherwise cut across the face of the die member. The groove may be, for example, 1 mm wide by 2 mm deep.

Figures 6 and 7 are mutually perpendicular views of a further practical embodiment of a die unit in accordance with the invention which is similar to that of Figures 4 and 5 except that the front side of the isolated surface is defined, somewhat imprecisely, by a shallow circular depression 12 formed, for instance, by drilling, suitable dimensions for a 9 mm wheel groove being 6 mm diameter by 2.5 mm deep (at the edges). Because, under the extreme stresses present under conditions of use, the narrow portions 13, 13 are relatively flexible, the area 14 around the die is effectively isolated. Compared with Figures 4 and 5, this design has the merit that there is no adverse effect on the risk of flash leakage at the sides of the die member.

In a particular example, the die unit for use in a 9 mm groove is of the alloy Inconel, registered under the trade mark "Inconel Alloy 718", fully described in our British Patent Application Serial No. 2102321A and is of the form shown in Figures 6 and 7. The circular die is 2.500 mm in diameter and the circular depression is 6.0 mm in diameter and 2.500mm deep. The copper wire extruded has a substantially circular cross-section with a diameter of 2.460 mm $\pm$ 0.007 mm whereas, under the same conditions, wire produced using a known die unit of Figures 2 and 3 with the same size die aperture had a seriously non-circular cross-section with diameter ranging from 2.432 mm to 2.465 mm.

Similar results were obtained using a die unit of the form shown in Figures 4 and 5, wherein the die is 2.500 mm in diameter and the straight groove is 1.0 mm wide and 2.0 mm deep.

CLAIMS

1. Radial Conform extrusion machinery characterised in that a surface round the entrance to the die is isolated from any other surface in contact with the material being extruded to the extent that strain induced in that surface by the drag of material entering the die is substantially independent of strain induced in any other surface, said surface having major dimensions from the die orifice to its periphery which differ from one another by no more than $\pm$ 25%.

2. Radial Conform extrusion machinery as claimed in Claim 1, characterised in that at least part of the periphery round the isolated surface is defined by at least one recess.

3. Radial Conform extrusion machinery as claimed in Claim 1, characterised in that the periphery of the isolated surface is defined by an annular groove having its centre at the die orifice.

4. Radial Conform extrusion machinery as claimed in Claim 1, characterised in that the isolated surface is substantially square and is defined by three edges of the die member and a straight groove extending across the die member.

5. Radial Conform extrusion machinery as claimed in Claim 1 characterised in that the isolated surface is defined by three edges of the die member and a circular depression cut into the face of the die member and spaced from the die entrance on the side of the die remote from the abutment.

6. A die unit for the radial Conform extrusion machinery claimed in Claim 1 comprising a die member having an orifice which forms a die or will mount an insert die characterised in that it is formed with a surface round the entrance to the die which is isolated from any other surface in contact with the material being extruded to the extent that strain induced in that surface by the drag of material entering the die is substantially independent of strain induced in any other surface, said surface having major dimensions from the die orifice to its periphery which differ from one another by no more than $\pm$ 25%.

7. A die unit as claimed in Claim 6, characterised in that at least part of the periphery round the isolated surface is defined by at least one recess.

8. A die unit as claimed in Claim 6, characterised in that the periphery of the isolated surface is defined by a circular groove having its centre at the die orifice.

9. A die unit as claimed in Claim 6, characterised in that the isolated surface is defined by three edges of the die unit and a straight groove extending across the die unit.

10. A die unit as claimed in Claim 6, characterised in that the isolated surface is defined by three edges of the die unit and a circular depression cut into the face of the die unit and spaced from the die entrance on the side of the die remote from the abutment.

Fig. 1.

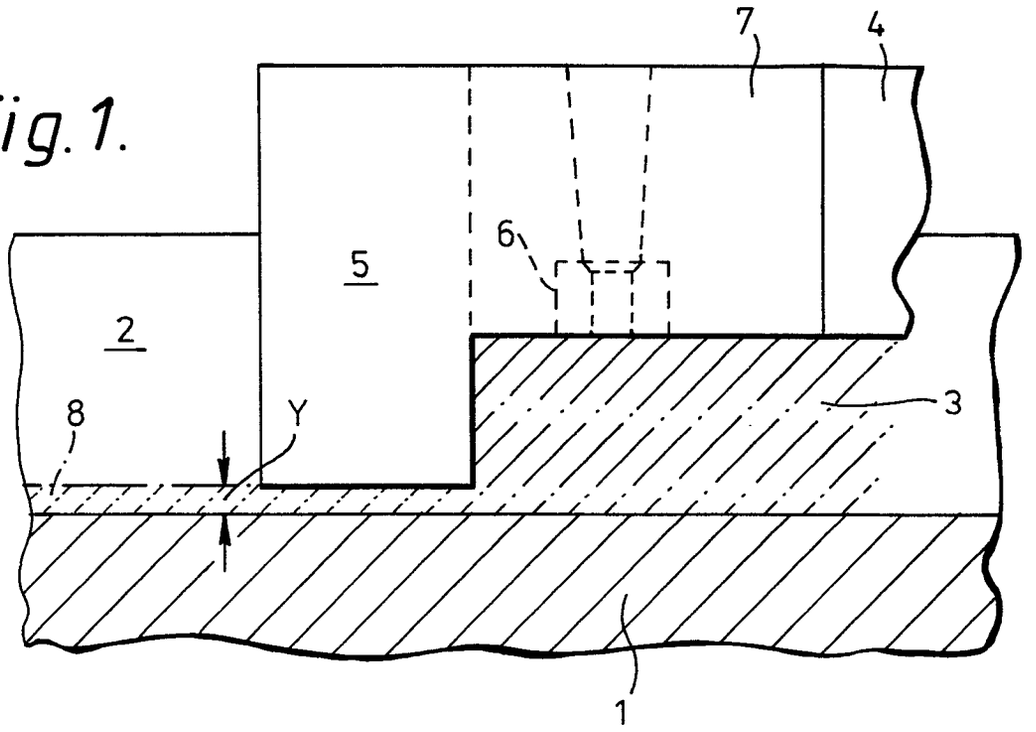


Fig. 2.

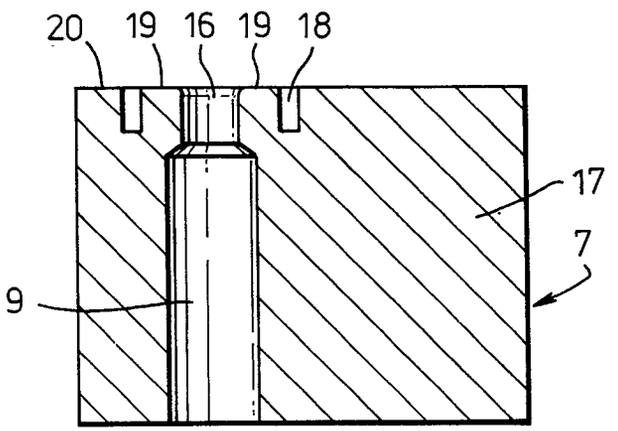
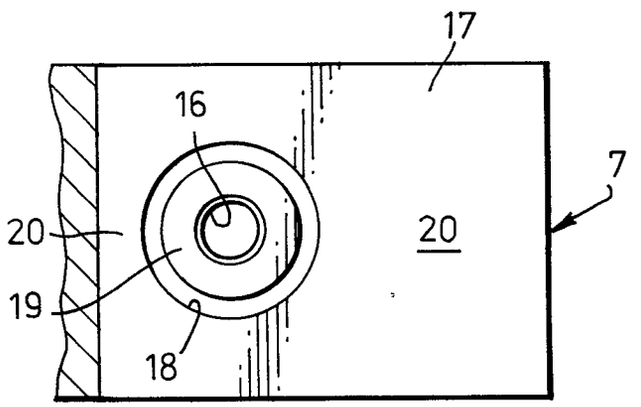


Fig. 3.



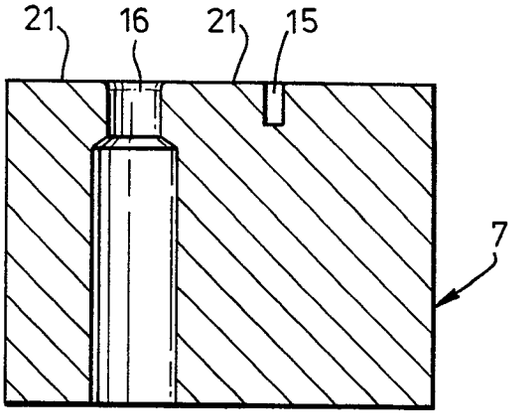


Fig. 4.

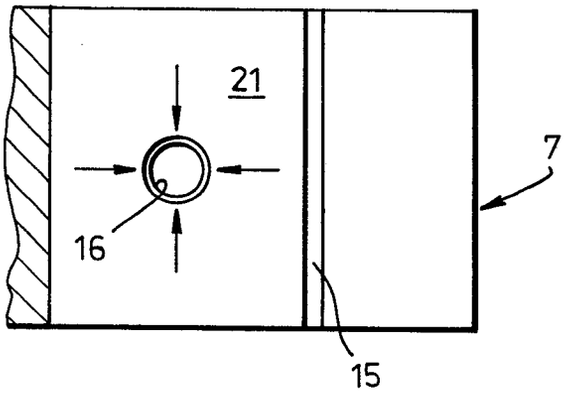


Fig. 5.

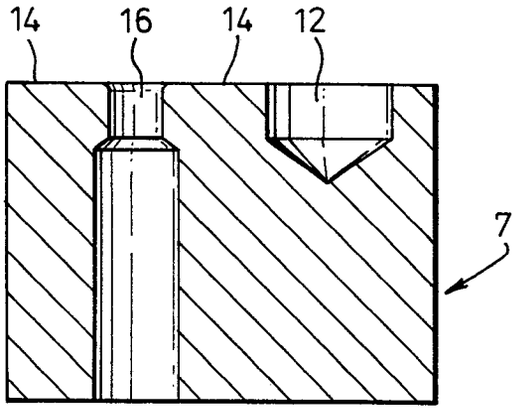


Fig. 6.

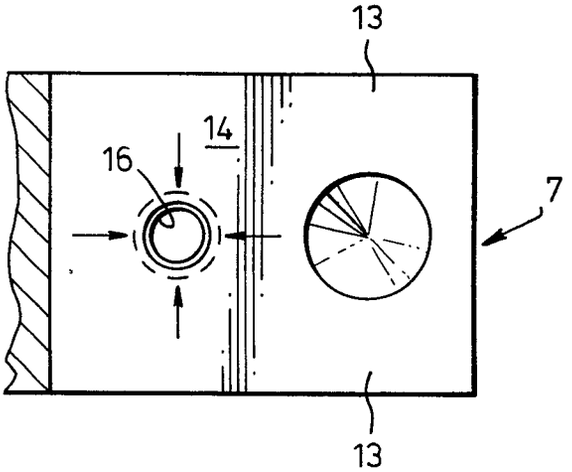


Fig. 7.