March 9, 1954 W. ROSENKRANZ 2,671,559

PROCESS OF PRESS FORGING METAL ALLOYS

Filed Jan. 6, 1950

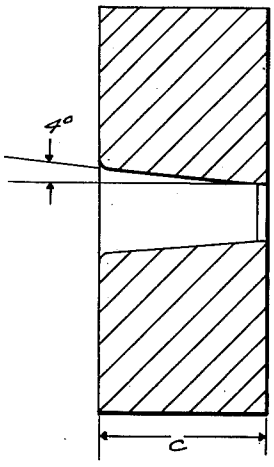


FIG. 3.

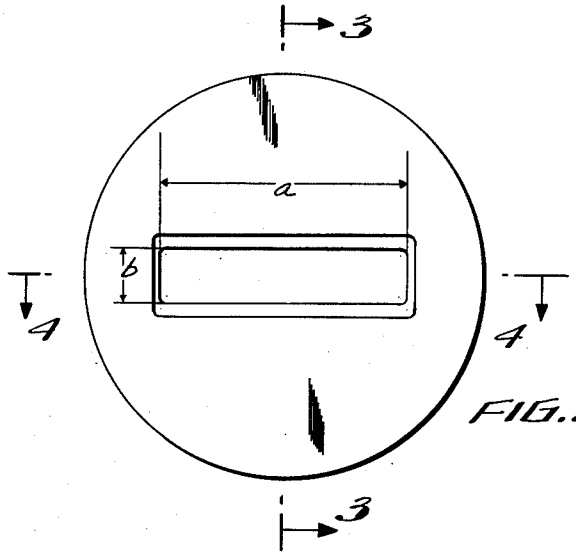


FIG. 2.

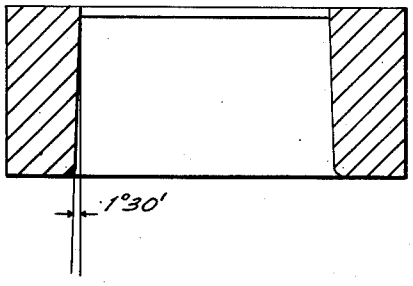


FIG. 4.

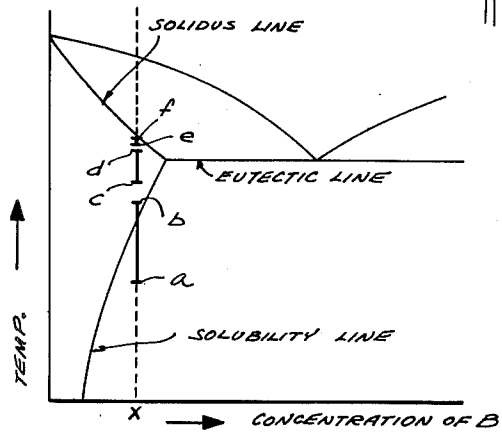


FIG. 5.

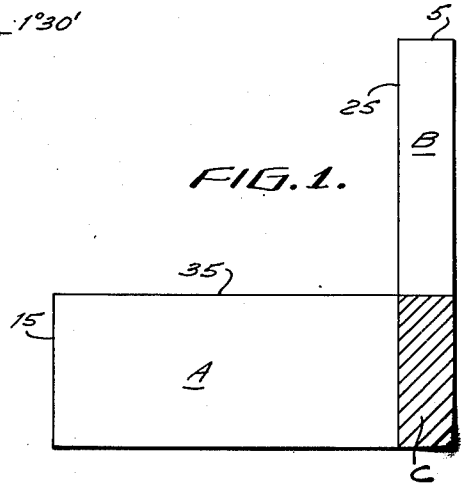


FIG. 1.

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PROCESS OF PRESS FORGING METAL ALLOYS

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6 Claims. (Cl. 207—10)

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The present invention relates to a process for the manufacture of full and hollow sections on a forging press, and more particularly to a process for the manufacture of full and hollow sections on a forging press which is performed at a high pressing speed and at a high starting temperature of the billet and at high temperatures of the tools.

The output of a forging press having a predetermined specific pressure is influenced by three factors, namely, the deformation of the material to be imparted by the press; the flow pressure and the pressing speed. Principally the press forging allows a high deformation in contradistinction to rolling and drop forging. The flow pressure and the pressing speed are in a well known reciprocal relation to each other. At a low temperature of deformation an unfavorably high flow pressure is combined with a relatively high pressing speed. At a high temperature of deformation conditions are reversed. For reasons of economy in forging presses low temperatures of deformation are principally maintained because the output of the forging press is influenced in the first line by the pressing speed owing to the relatively long flow path of the work to be pressed. If the pressing speed is increased the production of full and hollow sections by means of forging presses leads to stresses which may have the effect of producing cracks and fractures in the section.

According to a process for fast pressing which has recently become known, pressing speeds are applied which are considerably higher than the hitherto usual speeds, an increase in temperature of the section extending from the press being prevented by compensating the increased production of heat owing to the higher pressing speed by using intermittently or permanently cooled tools (holder, punch, pressing plunger) and/or by reducing the starting temperature of the billets.

According to another suggestion high pressing speeds are used in combination with high starting temperatures of the billets and high temperatures of the tools in contradistinction to the just mentioned process. The high frictional heat and the heat of deformation is withdrawn immediately at the place of its production, i. e. at the frictional surface of the die, by means of a heat carrier flowing along and in contact with the die. The die used in this process has a duct arranged as a ring at a small distance from the frictional surface of the die which is flown through by the heat carrier, preferably water at

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an influx temperature of about 10° C., a heat insulation being provided on the wall of the duct opposite to the frictional surface.

It has been discovered in tests by the inventor in which flat rods were pressed from cast billets consisting of an aluminum alloy of the type Al-Cu-Mg with a pressing degree exceeding 90%, a starting temperature of the billet amounting to 490° C., and at a pressing speed of 25 m. per minute without any cooling of the pressing tools that the section extruding from the die at a temperature of about 540° C. showed not the least cracks or other surface faults in spite of a so-called hot shortness which had to be expected based on the experience hitherto collected by the persons skilled in the art. This unexpected result caused the inventor to work out, as far as he knows, for the first time, the conditions under which cracks and fractures can occur at all in press forgings. The knowledge gained hereby rendered it possible under application of the results of further tests to state the conditions under which the novel press forging process according to the present invention can be carried out generally successfully at high extruding temperatures of the sections and at large pressing speeds.

According to the observations of the inventor in press forging metallic materials two kinds of cracks and fractures occur which are denoted hereinafter as "violent fractures due to heat" and "heat fractures proper." The first kind of fractures is observed as having the shape of cracks running under an angle of about 45° with the direction of pressing. The second kind of fractures differs from the first kind in outward appearance in that they mostly penetrate very deeply into the section and run at an angle of not quite 90° to the direction of pressing. A further observation of the microstructure has shown that the fractures or cracks of the first kind are intracrystalline, whereas those of the second kind are intercrystalline, which proves that the two kinds must be caused by different causes. Still, both kinds of fractures are caused by the same stress exerted on the material and which is particular to forging presses. The reason for this is as follows:

The power required for press forging serves on the one hand for overcoming the resistance against the deformation or flowing of the material and on the other hand for overcoming the external frictional forces. The resistance to flow (internal friction) to be overcome, which by the way is dependent on the type of alloy used, has

equal magnitude in the center and marginal zones of the section. Therefore equal forces acting in the pressing direction are required in the central and marginal zones of the section for overcoming this resistance. By an additional power the external frictional resistance at the frictional surface of the die has to be overcome which is transferred to the marginal zones of the section and tends to keep back the marginal zones against the central zone in the direction opposite to the flow of the material. This results in stresses between the marginal zones and the central zone which may lead to a separation of material in the section. This separation occurs at the cracks which run mostly in an intracrystalline way and have been noted above as "violent fractures due to heat." They are due to the fact that the rigidity of the heterogeneous components present within or on the boundaries of the mixed crystals can no longer meet the stresses occurring at increasing pressing speed or increasing temperature of the extruding section. The separation can be avoided if the stresses between marginal and central zones are kept low by using dies having a frictional surface as small as possible and if the rigidity of the heterogeneous components is kept high by applying relatively low flowing speeds and leaving temperatures of the section. This method of operation has been used for instance for press forging of alloys of the type Al-Cu-Mg. The inventor has discovered that a second method for avoiding the "violent fractures due to heat" consists in that the temperature of the extruding section is increased from the range below the solubility line, at which the internal energy is relatively low, to the homogeneous temperature range of the mixed crystal, at which the internal energy is considerably increased.

The phenomena called hereabove "heat fractures proper" occur at higher temperatures than the "violent fractures due to heat" and are observed in alloy materials having a limited miscibility in the solid state. They are caused by the softening of those heterogeneous components of the substance of the grain boundaries which are soluble in the mixed crystal but insoluble in the basic structure the fusing point of which is below the solidus point of the mixed crystal or the basic structure which explains that these fractures occur along the boundaries of the grains. In the temperature range in which a softening or fusing of the components soluble in the mixed crystal occurs in the boundaries of the grains, the mixed crystal has a lower absolute rigidity and in any case an increased elongation which renders the difference between the forces occurring in the marginal and central zones of the section negligibly small, the mixed crystal having an extraordinary increased ductility and internal energy. Therefore for avoiding the "heat fractures proper" it is required according to the present invention to effect by the conditions of deformation a spontaneous and practically complete solution of these components of the boundaries of the grains and to prevent their fusing. It has been stated above that these conditions are satisfied for instance in aluminum alloys of the type Al-Cu-Mg if the section leaving the die has a temperature of 540° C.

In the press forging of alloys such as those of the type Al-Mg with for instance 7% Mg having a solidus point at 546° C. normally the "violent fractures due to heat" are not observed at all, the conditions of the deformation of these alloys being such that the temperature of the section in the aperture of the die is increased to about 440° C. and thus approaches the solidus point so much that the mixed crystal has a high elongation at these temperatures. Above this temperature range, however, is a critical range of transition for the temperature of the leaving section made of these alloys in which intercrystalline heat fractures occur owing to the fusing of the material of the boundaries of the grains. If however, conditions of deformation are such that the section in the die aperture reaches temperatures above the critical temperature range the intercrystalline heat fractures are avoided.

In press forging of the technically applied alloys of the type Al-Cu-Mg having solidus temperatures of about 600° C. the temperatures of the extruding section are as a rule about 470° C. under the hitherto used conditions of deformation so that the temperatures lie in the heterogeneous domain of the state diagram. Above these temperatures of the leaving section there is a transitional range giving rise to the intracrystalline "violent fractures due to heat" and a transitional range giving rise to intercrystalline "heat fractures," these ranges lying close to each other or merging into each other.

In the above mentioned processes which have recently become known for increasing the pressing speed and thus the efficiency of press forging, the temperature of the extruding section is according to the alloy used either below the critical temperature range for "violent fractures due to heat," as for instance for Al-Cu-Mg, or below the critical temperature range for "heat fractures", as for instance for Al-Mg. In the process using low starting temperatures of the billet and low temperatures of the tools the section does not reach the lower limit of the critical transitional range even with the additional heat produced by friction and deformation, so that the "violent fractures due to heat" and "heat fractures" mentioned above are avoided. In the other process using higher starting temperatures of the billet and higher tool temperatures, the temperature of the section in the aperture of the die is kept low by an intensive cooling of the frictional surface of the die so that the same effect is obtained.

The keeping of the temperature above the critical transitional range of the "heat fractures" throughout the length of the section present in the die is dependent on, or made possible by, several factors namely the specific pressure of the forging press, the degree of pressing, the initial temperature of the billet, the pressing speed maintained during the pressing operation, and the conicity of the frictional surface of the die. In view of the requirement to dissolve practically completely during the pressing operation the heterogeneous components of the boundary of the grains soluble in the mixed crystal, an as high as possible starting temperature of the billet should involve technical advantages since it favors an equalization of the concentration in the structure which goes as far as possible. The higher the starting temperature of the billet is, the sooner the billet starts flowing at a predetermined pressure of the forging press. By using longer and more conical frictional surfaces of the die, more frictional heat is produced than

by using short and non-conical pressing tools. Higher degrees of deformation have the effect of increasing the preliminary pressing time at the predetermined pressure of the forging press; however, they cause production of more frictional heat than lower degrees of deformation. Thus with increasing the degree of deformation the lengths of the frictional surface can be reduced and the angle of inclination to the direction of pressing can be smaller which has a favorable effect in view of the high starting pressure required. High pressing speeds allow high temperatures in the section to be reached in a short time. A relatively high pressure of the forging press renders it possible to keep high degrees of deformation at short preliminary pressing times combined with relatively low starting temperatures of the billet at high pressing speeds.

The above mentioned effects of the pressing conditions are partly known in the art. It is to be kept in mind, however, for the obtaining of a constant temperature above the critical transitional range for the "heat fractures proper" that the specific pressure of the given forging press is constant and that the degree of deformation and the pressing speed should be as high as possible in order to render the manufacture more economical. Since the heat of friction and deformation is produced to the greatest part in the aperture of the die, a difference in temperature always exists between the billet and the section in the die.

In order to avoid a sticking of the section to the die due to fusing the initial temperature of the billet must not be too high. As a rule the initial temperature of the billet is not higher than 20° below that at which the sticking of the cast structure to the die due to fusion starts. Starting temperatures of the billet which are below this upper limit by 10°–20° C. allow on the one hand a fast initial pressing and on the other hand the constant maintaining of high pressing speeds. The heat required for maintaining the temperature difference between the billet and the section is then produced by the heat of friction and deformation the magnitude of which is conditioned by the degree of deformation and the length and conicity of the frictional surface. According to recent discoveries by the inventor the maximal amount of frictional heat is obtained at angles of 2 to 6° between the frictional surface of the die and the direction of pressing. According to the cross sectional area of the section, however, often angles of inclination amounting at least to ½° and going up to 12° are permissible. Corresponding conditions hold for the length of the frictional surface which can amount to 3 mm. at profiled rods with the smallest technically produced cross section and to 200 mm. for the largest cross section.

If the cross section is symmetrical as in cylindrical and square rods the length and conicity of the frictional surface of the die is kept constant over the perimeter of the rod. With flat rods the length of the frictional surface can be constant but in order to avoid cracks on the smaller sides which are caused by the tendency of the center of the rod to lead, the angle of inclination of the frictional surface must be smaller on the smaller side than on the wider side. The following Table 1 shows the ratios of the angles of inclination preferably to be kept.

Table 1

Ratio between narrow side and broad side	Angle of inclination at the broad side	Angle of inclination at the narrow side
1:1	α	α
1:2	α	0.7α
1:3	α	0.6α
1:4	α	0.5α
1:5	α	0.4α

In sections having portions of unequal cross sections an adaptation of the length of the frictional surface to the magnitude of the cross section is required, the length of the frictional surfaces of the several cross sections being in the same ratio as the cross sections divided by their perimeters. This is more fully explained by the following example in connection with the appended drawings in which Fig. 1 shows the cross section of an angle profile. Figs. 2–4 illustrate an example of a die, to be more fully described hereinbelow in plan view and sections taken along the lines **3—3**, and **4—4**, respectively. Figure 5 shows the temperature range for carrying out the process of the present invention.

Referring now to the drawing and first to Fig. 1, an angle profile is represented in cross section the arms of which have both a length of 40 mm. whereas the horizontal arm has a height of 15 mm. and the vertical arm a thickness of 5 mm. In the drawing the horizontal leg is denoted by A, the vertical arm by B, and the portion common to both arms by C.

During the pressing operation with equal length of the frictional surfaces the cross section B would tend to lag behind the cross section A owing to the comparatively larger external friction. In order to prevent that and to avoid the formation of cracks caused thereby in cross section B, the length of the frictional surface has to be reduced for this cross section relatively to that of cross section A. This has to be done according to the following formulae:

$$\frac{R_A}{R_B}=\frac{\frac{Q_A}{U_A}}{\frac{Q_B}{U_B}}$$

$$R_A=R_B\cdot\frac{Q_A}{Q_B}\cdot\frac{U_B}{U_A}$$

Here is:

R_A=the length of the frictional surface on cross section A
R_B=the length of the frictional surface on cross section B
Q_A=the area of cross section A
Q_B=the area of cross section B
U_A=the perimeter of cross section A
U_B=the perimeter of cross section B

If R_B is chosen as 8 mm. which has been found preferable for a thickness of 5 mm., R_A is calculated according to the above formula as follows:

$$R_A=8\cdot\frac{525}{125}\cdot\frac{60}{100}=20.16$$

thus approximately 20 mm.

At the high temperature of the material the components of the grain boundary which are soluble in the mixed crystal are dissolved almost spontaneously although, of course, the dissolution is a phenomenon depending on time as any equilibrium reaction. In view of the high press-

ing speed or more correctly the high flowing speed of the cross section through the aperture of the die the frictional surface should be made sufficiently long in any case so that the dissolution is completed with certainty before the cross section extrudes from the aperture of the die.

The temperature ranges which are referred to in the preceding description as those in which complete dissolution of the components of the grain boundaries occur are illustrated in Fig. 5. Referring to this figure, which shows an equilibrium diagram of a binary alloy in which the concentration of a constituent B in a constituent A is shown by the abscissa and in which the ordinate indicates temperature; the point x indicates the concentration of B in a given alloy which is to be worked. The vertical line from the point x on the abscissa is marked to show temperature ranges a—b, c—d and e—f. The "violent fractures due to heat" occur in the temperature range a to b while the "heat fractures proper" occur in the range c—d. Theoretically the range a—b should not rise above the solubility curve and the range c—d should not extend below the horizontal eutectic line. Actually, however, the concentration of the constituents is not constant at all parts of a fused alloy and, furthermore, the inevitable impurities are not equally distributed within the alloy. Hence certain departures from the theoretical diagram are experienced and these are indicated in the diagram by extending the range a—b above the solubility curve and the range c—d below the eutectic line.

Hitherto extruding processes were carried out at temperatures in the ranges a—b and c—d. When, however, carrying out the invention the temperatures are maintained in the range e—f which extends below the solidus line but above the temperature ranges within which "violent fractures due to heat" and "heat fractures proper" occur. By keeping the temperature of the material in the range e—f, the components of the grain boundaries are completely dissolved before the material extrudes from the exit opening of the die.

Thus the present invention relates to a process for the manufacture of full and hollow sections particularly of light metals on a forging press at high pressing speeds and high starting temperatures of the billet and high temperatures of the pressing tools comprising the steps of keeping the temperature of the section extruding from the aperture of the die sufficiently high and making the frictional surface of the die sufficiently long for effecting during pressing and before the leaving of the section a practically complete dissolution of the components of the boundary of the grains fusing below the solidus temperature of the grains and being soluble in the mixed crystal.

In a preferred embodiment of the present invention the components of the grain boundaries of the primary crystals of the cast structure as well as the secondary crystals of a block which has been subjected previously to a homogenizing treatment and which fuse below the solidus temperature of the grain and are soluble in the mixed crystal are practically dissolved during the pressing of the section before the latter leaves the aperture of the die. Thereby the section is imparted a low absolute rigidity and an increased elongation at which the difference between the forces occurring in the marginal and central zones of the section becomes negligibly small and the material has a much increased ductility and internal energy. By quenching the section immediately after it leaves the aperture of the die the extent to which the substance of the grain boundaries is dissolved can be easily checked or ascertained.

On principle the process according to the invention can be applied to all alloys having a temperature range of complete miscibility in the solid state and which have components of the grain boundaries fusing below the solidus temperature of the basic structure which are completely dissolved by the mixed crystal. This temperature range (distance between solidus line and separating line) is variable from alloy to alloy in its absolute height and in its extension. The following Table 2 contains the values for some well known alloys which are technically used. It should be noted that these values may be, of course, subject to slight corrections by more recent measurements; for the following discussion, however, this circumstance is without importance. Table 2 contains also the values of the elongation at 300° C. more fully discussed hereinafter.

Table 2

Alloy	Temperature of Solidus Line	Temperature of Separating Line	Temperature Difference Between Solidus Line and Separating Line	Elongation of Pressed Rods at 300° C.
	Degrees	*Degrees*	*Degrees*	*Percent*
I. Type Al-Cu-Mg with about 3% Cu	600	470	130	18
II. Type Al-Cu-Mg with about 4% Cu	580	500	80	13
III. Type Al-Mg with about 5% Mg	573	262	311	65
IV. Type Al-Mg with about 7% Mg	546	301	245	60
V. Type Al-Mg with about 9% Mg	523	333	190	55
VI. Type Mg-Al with about 9% Al	480	387	93	30

The essential feature of the invention is the temperature of the section extruding from the die. This temperature is of course in each case below the solidus point (fusing of the mixed crystals) and is chosen some 10°–20° below the solidus point in view of a safe carrying out of the process. Since the solidus line is at different temperatures for different types of alloys and even with alloys of the same type for different contents of the components, it is a matter of course that generally valid numerical values for the upper temperature limit of the extruding section according to the present invention cannot

be given. The temperature of the extruding section, however, has to be above, and more particularly sufficiently above, the separating line in order to ensure that the heterogeneous components of the grain boundaries which are soluble in the mxied crystal are dissolved before the section leaves the aperture of the die. Therefore numerical values as to the lower temperature of the extruding section cannot be given either.

Since the temperature difference between the solidus line and the separating line becomes smaller with increasing content of the alloy, with higher percentage alloys a smaller interval for the temperature of the leaving section is available as with smaller percentage alloys. The well known statement as to the greater difficulties in working higher percentage alloys by means of the known press forging processes (temperature of the section below the critical transition range) is valid per se also for the process according to the invention. It should be pointed out, however, that this circumstance does not prevent the process according to the invention from being carried out for higher percentage alloys but only influences it insofar as the maintaining of the temperature above the critical transition range, and the factors conditioning the deep fractures such as starting temperature of the billet and the pressing degree, can only be changed within narrower limits.

Essential for the deformation at the high leaving temperatures of the section is doubtless the elongation of the material which is extraordinarily increased at these temperatures. From the elongation of the alloys at 300° C. given in the last column of Table 2 it can be seen that this value at the leaving temperatures of the section according to the invention is higher as to order of magnitude than even at the maximal extruding temperatures of the section which have been applied in the known press forging processes. For instance, for the alloys I–V, etc., the following values according to Table 3 can be chosen:

Table 3

Alloy	Temperature of the extruding section—	
	According to the invention	According to the process hitherto applied
	Degrees	*Degrees*
Al-Cu-Mg with ca. 3% Cu	500–540	410–470
Al-Cu-Mg with ca. 4% Cu	510–540	410–470
Al-Mg with ca. 5% Mg	460–540	380–450
Al-Mg with ca. 7% Mg	470–520	380–450
Al-Mg with ca. 9% Mg	480–500	380–450
Al-Zn-Mg with ca. 1–6% Zn and ca. 1–6% Mg.	480–550	400–460
Mg-Al-Zn with ca. 6% Al, 1% Zn	380–470	320–370
Mg-Al-Zn with ca. 8% Al, 1% Zn	400–460	320–370

EXAMPLE

Cast billets of 170 mm. diameter and 760 mm. length consisting of an aluminum alloy containing 3.2% Cu, 1.22 Mg, 0.81% Mn, 0.53% Si, 0.59% Fe, remainder Al, were pressed on a forging press with a total pressure of 1500 metric tons at a starting temperature of 485° C. to flat rods of 15 x 30 mm., the pressing degree amounting to 95%. The frictional surface of the die shown in Figs. 2–4 had a length of 55 mm. and its inclination with respect to the pressing direction amounted to 4° on the broad side of the rod and to 1.5° on the narrow side of the rod. The temperature of the section pressed at a speed of 25 to 30 meters per minute amounted to 535° C. The temperature of the pressing residue was, at a consecutive pressing of 20 billets, constantly between 460 and 470° C. The rods cooled in air had a largely recrystallized structure. The rods were heated to 490° C. during 1½ hours in an air furnace, quenched and aged for 5 days at room temperature, and then subjected to a 1% cold drawing. The resulting strength values are to be seen from the following Table 4:

Table 4

	Longitudinal values	Transversal values
Tensile strength (σB)	50 to 52 kg./mm.^{2}	46 to 48 kg./mm.^{2}
Yield point (σ0.2)	37 to 40 kg./mm.^{2}	31 to 34 kg./mm.^{2}
Elongation (δs)	15 to 17 percent	17 to 20 percent.

Since the rods owing to the spontaneously occurring extensive recrystallization of the structure at the high temperature of deformation did not show the so-called pressing effect which leads to particularly high values of the tensile strength and the yield point in the pressing direction an appreciable reduction of the strength values might have been expected according to experience. As Table 4 shows the pressing effect, which has been extensively obliterated by the spontaneous recrystallization of the deformed structure, is more than compensated owing to the practically complete solution of the hardening components. Thus, the process according to the present invention yields a qualitative improvement of the produced semi-finished material.

In the process of reducing to final dimensions by press forging parts consisting of alloys such as the type Al-Zn-Mg, the homogenizing temperatures of which are within the range of the hitherto used temperatures of hot deformation, the section has been quenched in water directly after leaving the die and in this way an operation, namely a renewed heat treatment, has been saved. On principle this operation is also applicable to alloys of the kind Al-Cu-Mg; in doing so, however, only lower strengths values of the hardened work pieces are obtained. Owing to the high temperature of deformation this very economical process can now be applied to all hardenable alloys, for instance those of the type Al-Cu-Mg without putting up with the reduction of the strength values. Since the mentioned temperatures are high the cooling should be done under particularly effective conditions.

According to further experiments in drop forging of work consisting of a magnesium alloy containing 7% Al, 1% Zn, and 0.12% Mn which has been made from a starting material produced on a forging press according to a process according to the present invention, this material can be drop forged at higher temperatures than hitherto applied without incurring the danger of formation of a coarse recrystallized structure so that higher speeds can be applied.

As to the causes of the difficulties experienced in shaping does not involve cutting it is said in the relevant literature (see "Praktische Metallkunde" von G. Sachs, 2. Teil, Berlin 1934) that it is very difficult to predict whether a novel material can stand a deforming process under heat without heavy damage, for instance, without incurring cracks. With most materials it is

said to be necessary to find and define a definite process of production by experiments, this process having to be kept more or less accurately according to the material in question unless heavy damage is to be incurred. It is also noted in the literature that the susceptibility of a material for deformations under heat plays an important part because it is so small in certain critical ranges of temperatures that a cracking occurs. The conditions however for this are said to be hitherto hardly known.

In press forging always care has been taken not to choose the starting temperature of the billet too high and to render innocuous the higher heat of friction and deformation which is produced by the increased pressing speed by seeing to it that the material did not reach temperatures during the deformation which are near the solidus point. Since to almost all materials at these temperatures the property of the so-called hot-shortness was acribed this seemed to be justifiable on the basis of practical experience.

In this argumentation, however, it was not taken into regard that the cracks caused by fusing occur only in the immediate neighborhood of the mouth of the aperture of the die.

It was not appreciated that in press forging of alloys having components of the grain boundary substance fusing below the solidus temperature of the basic structure and completely soluble in the mixed crystal, it is only necessary to effect a practically complete dissolution of these components before the section extrudes from the aperture of the die. The temperature of the section reached under these conditions permits the keeping of high pressing speeds without being given any obligation on the operator's part to limit oneself to low degrees of deformation as in the initially mentioned known rapid pressing processes.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of processes for the manufacture of full and hollow sections on a forging press differing from the types described above.

While I have illustrated and described the invention as embodied in processes for the manufacture of full and hollow sections of light metals on a forging press, I do not intend to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of my invention.

Without further analysis, the foregoing will so fully reveal the gist of my invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What I claim as new and desire to secure by Letters Patent is:

1. A process of press forging metal alloys, comprising the steps of passing a metal alloy at high speed at a temperature between the temperature of complete miscibility in the solid state of the components of said alloy and the solidus temperature of said alloy through a die channel having a frictional surface and sufficient length to effect during passage of said metal alloy through the channel at said temperature complete dissolution of the components of said alloy in each other; and extruding at the end of the die channel said metal alloy at said temperature through an aperture so as to form an extruded metal alloy piece free of heat fractures.

2. A process of press forging metal alloys, comprising the steps of passing a metal alloy at high speed at a temperature between the temperature of complete miscibility in the solid state of the components of said alloy and the solidus temperature of said alloy through a die channel having a frictional surface and sufficient length to effect during passage of said metal alloy through the channel at said temperature complete dissolution of the components of said alloy in each other; and extruding at the end of the die channel said metal alloy at said temperature through an aperture and quenching the same so as to form an extruded metal alloy piece free of heat fractures.

3. A process of press forging metal alloys, comprising the steps of passing a metal alloy at high speed at a temperature 10–20° C. below the solidus temperature of said alloy through a die channel having a frictional surface and sufficient length to effect during passage of said metal alloy through the channel at said temperature complete dissolution of the components of said alloy in each other; and extruding at the end of the die channel said metal alloy at said temperature through an aperture so as to form an extruded metal alloy piece free of heat fractures.

4. A process of press forging metal alloys, comprising the steps of passing an aluminum alloy at high speed at a temperature between the temperature of complete miscibility in the solid state of the components of said alloy and the solidus temperature of said alloy through a die channel having a frictional surface and sufficient length to effect during passage of said aluminum alloy through the channel at said temperature complete dissolution of the components of said alloy in each other; and extruding at the end of the die channel said aluminum alloy at said temperature through an aperture so as to form an extruded aluminum alloy piece free of heat fractures.

5. A process of press forging metal alloys, comprising the steps of passing an aluminum alloy at high speed at a temperature 10–20° C. below the solidus temperature of said alloy through a die channel having a frictional surface and sufficient length to effect during passage of said aluminum alloy through the channel at said temperature complete dissolution of the components of said alloy in each other; and extruding at the end of the die channel said aluminum alloy at said temperature through an aperture so as to form an extruded aluminum alloy piece free of heat fractures.

6. A process of press forging metal alloys, comprising the steps of passing a metal alloy at high speed at a temperature between the temperature of complete miscibility in the solid state of the components of said alloy and the solidus temperature of said alloy through a die channel of 3–200 mm. length sufficient to effect during passage of said metal alloy through the channel at said temperature complete dissolution of the components of said alloy in each other, and extruding at the end of the die channel said metal alloy at said temperature through

an aperture so as to form an extruded metal alloy piece free of heat fractures.

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