Patented Mar. 29, 1938 2,112,632

UNITED STATES PATENT OFFICE

2,112,632

PROCESS AND COMPOSITION FOR PLASTIC DEFORMATION OF METALS

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No Drawing. Application December 17, 1935, Serial No. 54,960

7 Claims. (Cl. 113—51)

This invention relates to a new process for effecting the plastic deformation of sheet metals and also to a series of materials and compositions new to the art and highly useful in the practice of the process hereinafter described. In view of the fact that the concepts of the present invention deviate appreciably from those of conventional practice, an analysis of the art of plastic deformation is requisite in order to appreciate the full novelty of the method herein disclosed and likewise to account for the unexpected nature of the advance in an art so highly developed.

The art of configurating sheet metal is a very old one. In its initial stage of development it comprised little more than the bending or stretching of metal, but by gradual evolution the principle of plastic deformation developed, perhaps, with little conscious recognition in its earlier stages. At the present time the principle of causing unheated metal to flow by pressure to accomplish a desired objective is well recognized and constitutes the essence of many operations by which fine sheet formations and highly configurated objects are produced. Present day rolling and configurating operations contemplate the plastic flow of metals to such a high degree that many new problems are introduced into the art as a whole, and especially into the problem of "lubrication" of the work piece with respect to the tools by which it is being transformed. The sheet mills, by metallurgical control, heat control, and manipulation of rolling presses have striven continuously to provide sheet metals more suitable to the metal configurators, from the point of view of plastic deformability. Improvements in the machines and instrumentalities adapted to be used in plastic deformation also foreshadow the accomplishment of difficult and complex deformations. Still, in spite of better machines and better metals with which to work, a large margin for improvement is indicated by numerous failures and rejections of work pieces, cracked, wrinkled or otherwise too imperfect to be used. The present invention has for its object the reduction or complete elimination of this economic waste, and also, the bridging of the gap which exists at present between the actual results now obtained, and the superior results which should be obtained in view of improved machines and metals.

As a general thing, plastic deformation is accomplished by placing the sheet metal to be configurated between cooperating instrumentalities, one or both of which may be power driven. For example, in the case where sheet metal is to be deformed to a given convolution, as by pressing, the metal usually is configurated between a male and a female die, the former usually being a moving element carried by a ram. It has been customary in many operations to hold the metal, adjacent its edges, by an additional die which clamps down upon it and exerts a pressure tending to retard its flow in relation to the dynamic force of the ram. This latter die, throughout the remainder of the specification, is referred to as the "draw ring" and the pressure exerted by it will be termed "hold down pressure".

In the rolling of sheet steel, a piece to be shaped or reduced in thickness is passed through driven rollers under pressure sufficient to cause the metal to flow to the extent necessary to accomplish the result intended.

With the gradual recognition of the principle of plastic deformation and with the development of improved methods for configurating metals, the skilled in the art have developed certain concepts regarding lubrication of the sheets being operated upon. Dies (and rolls), usually being made of special steels hardened to a high degree, are almost always very expensive especially when they are large or complexly configurated. In order to protect these tools from wear, prolong their life, and preserve their finish, it has been conventional in the past to dispose a film of lubricating compound on the material to be worked under compression so as to prevent metal to metal contact both under static and "flow" conditions.

Moreover, the accepted theory put into practice in the past has been that the coefficient of friction between the tool surface and the work piece must be low so that a minimum amount of energy be expended in overcoming skin friction. Aside from this it has been thought that the presence of rubbing friction at the metallic surfaces resulted in uneven drawing and led to the generation of heat sufficient to cause actual fusion of microscopic surfaces in direct contact leading to scoring or galling of the work piece or tool.

To provide the lubricating films heretofore considered necessary, practically the entire range of mineral lubricants, fatty lubricants, soaps, waxes, and lubricative pigments have either been suggested or actually employed. The property characterizing each of these so-called drawing compounds is that of oiliness or lubricity, even though the physical consistency of any given one of the substances might be grease-like, liquid, or as an emulsion.

Practically speaking, in other words, the skilled in the art have thought that since sheet metal was bound to slide with respect to the instrumentality effecting its plastic deformation, then the way should be paved to permit such sliding movement with least friction and with least possibility of contact, and thus the lubricity or oiliness of a compound has been a primary criterion.

While the principles of lubrication may have

been, and perhaps were, of critical importance to the success of the old configurating processes predicated mainly upon metal bending and stretching, the skilled in the art have adhered too long to these principles in modern configurating operation. In the past, it was customary to deform metals to a far lesser degree than it is today. When labor costs were cheaper it was quite conventional to limit the degree of deformation even though it entailed additional operations of joining several pieces together to constitute the desired article. But modern designs, the necessity to reduce labor costs, and the demand for increased production have led to the practice of completing the deformation in one operation whenever possible, even though the percentage of scrap is increased materially. These new impositions require substantially the cold molding of sheet metal rather than its simple deformation, and involve substantially a new principle. It is for these reasons that the old concepts of lubrication have led to anomalous results.

Briefly, I have discovered that plastic deformation is best accomplished with the aid of a psammous film interposed between the surface of the work piece and that of the deforming or holding instrumentality. Otherwise expressed, the present invention is predicated upon the concept and determination that a film layer of substance having the property, generally described as abrasive, possesses the capacity to eliminate unevenness, buckling, waviness, distortion, and scoring in the surfaces of configurated objects, the capacity to maintain relatively positive separation between the work piece and tool surfaces, and the capacity to augment the bite or grip of the tool upon the sheet metal, thus to promote plastic flow during the deforming period.

Broadly speaking, it may be said that the process contemplated by the present invention comprises the step of coating the metal prior to deformation with a film containing psammous matter adapted to provide a separating and slightly abrasive interface between the metal and the deforming or pressure instrumentality, then effecting the desired deformation, and finally removing said coating.

While the thought of using a material which is at all abrasive in character, is one exceedingly unorthodox with respect to the conventional point of view, yet adoption of the process herein described has led to unexpected success in the accomplishment of many difficult and complex deformations. The percentage of scrap is lowered to an inconsequential amount, scoring is substantially eliminated, and the surfaces of the articles produced are in a smooth and polished condition.

According to the present invention, the film contemplated comprises psammous or pumiceous matter preferably harder than the sheet metal being worked and possessed of the capacity to integrate itself upon the sheet with respect to the deforming or pressure instrumentality. Moreover, while this psammous or pumiceous matter has the property under certain predetermined conditions of acting as an abrasive, the film thus comprised, according to the present invention has also the function of maintaining separation between the work piece and tool surfaces. Lastly and especially in deep drawing and rolling operations, the films disclosed herein are effective for correlating plastic flow of the metal within a given cavity and slippage movement of the metal past the hold down member of the deforming tool. Through this coordination, the sheet is held taut during the deforming period, whereby distortion or waviness is eliminated; but at the same time the film facilitates bite of the dynamic element or the hold down or draw ring upon the metal being urged to flow plasticly, whereby undue stretch is eliminated and substantial uniformity in the metal thickness of the objects being configurated is accomplished.

It is relatively impossible to state precisely the exact function or mechanical action of the film described herein. Presumably the finely divided hard particles of the film slide over one another during the initial deforming period until localized clearance irregularities are accommodated and the sheet is subjected to substantially uniform pressure at the particular area in contact with the dynamic hold-down or draw ring. The mobility of the film ceases, however, when the layer or film is diminished to the thickness of one layer of particles. These particles, being relatively harder than the metal itself, entrench themselves into the metal as the pressure increases, and lateral movement of the work piece with respect to the die surface apparently takes place with the peaks of the particles embedded riding the hard polished surface of the die itself.

Generally speaking, any finely ground hard pulverous matter, such as finely divided silica, pumice stone, alumina, limestone, emery dust, beryl, feldspar, or the like, is suitable for the purpose described. It is recommended that the psammous material selected for a particular purpose have an effective hardness slightly greater than that of the work piece to be deformed. Furthermore, in view of the fact that the state of subdivision of the material bears a relationship to the danger of abrasion or excessive wear of tool surfaces, I prefer to use a psammous material pulverized to pass a screen of about 250 mesh or finer. A material passing a screen of about 300 mesh is well suited to most plastic deformation operations.

For practical purposes, it is preferable that the psammous matter, above referred to, be suspended or dispersed in a vehicle adapted to facilitate application of the bodies to the work piece to be configurated. It is preferred that the vehicle selected for this purpose have the capacity to wet metal surfaces and thus confine the particles over the particular area desired. Oleaginous substances such as cutting oil, lard oil, tallow, wool fat, mineral oil, and the like are suitable. It is frequently desirable to prepare the admixture of psammous matter and vehicle appreciably in advance of the time at which it will be used, and in such instances stable emulsions of the oil in water or water in oil type, adapted to suspend stably the divided solids, are recommended. The physical consistency may be liquid or relatively viscous or quasi-solid if it is desired to use a brush in applying the admixture to the work pieces. Furthermore, in view of the fact that it is conventional to cleanse the sheets or pickle subsequent to this configuration, it is recommended that the vehicle selected should be easily removable as by washing in a cheap alkaline or organic liquid. It is, of course, undesirable to use any vehicles corrosive or chemically active with respect to sheet metal, or any which are toxic or unduly odorous.

To assist the skilled in the art in the practice of the present invention the following formulae are disclosed as examples:

EXAMPLE 1

Water in oil emulsion

	Percent
Wool fat (or degras)	15
Soap stock	10
Calcium carbonate	15
Finely-divided silica	10
Mineral oil	25
Water	25

EXAMPLE 2

Oil in water emulsion

	Percent
Soap stock	15
Mineral oil	35
Calcium carbonate	15
Finely-divided silica	10
Water	25

EXAMPLE 3

Oil in water emulsion

	Percent
Water-soluble cutting oil	35
Finely-divided silica	15
Talc carbonate	10
Water	40

The emulsions of the oil in water type are dilutable with water if desired. At the time of use, any one of these products is applied to the work (or the die surfaces) by brushing, spraying or dipping, then the work is drawn or pressed.

The percentage of psammous matter in a given vehicle may vary according to the nature of the deforming operation and the sheet metal being deformed. Usually, from about 2% to about 15% based upon the total weight of admixture is satisfactory.

From the point of view of stability of suspension of the solid particles in the vehicle selected, and also from the point of view of effectiveness of the admixture when used for the purpose intended, I have discovered that a percentage of free fatty acid, such as palmitic, oleic, stearic, tallow acid and the like, or mixtures thereof, is very advantageous in many instances. If, for example, the vehicle is to be of the soap base emulsion type, the acid may be left in free state in the admixture by using an amount of alkali less than that required for complete saponification. The presence of free fatty acid maintains the emulsion in thickened and stabilized condition, whereas its absence in a composition similar in other respects is apt to lead to a thin watery consistency. In this respect, free fatty acid may be said to have the capacity to maintain the emulsion in swollen condition which consistency aids in the suspension of the particulate matter. Generally from about ½% to about 3% of free fatty acid is suitable. Examples of admixtures of this type are as follows:

EXAMPLE 4

	Percent
Wool fat	15
Soap stock	10
Free fatty acid—oleic—palmitic	3
Calcium carbonate	12
Finely-divided silica	10
Mineral oil	25
Water	25

EXAMPLE 5

	Percent
Water soluble oil	35
Finely-divided silica	15
Free fatty acid	1.5
Talc	10
Water	38.5

Though it may, to the skilled in the art, seem dangerous and impractical to use any material having properties commonly associated with those of an abrasive, in drawing or rolling operations, nevertheless my experience indicates that the materials of the group exemplified possess genuine merit and value. In the first place, the apprehension of excessive die or tool wear is unfounded in fact. Most metals used in present day die fabrication are hardenable to a very high degree and are very tough. Furthermore, advances in the machine tool arts have made it possible to polish the configurated surfaces of the dies to a fine state of smoothness without undue expense. The hard and polished surfaces effectually resist excessive abrasive or excoriating action of the hard particles in the film of the work piece, and whatever wear actually does take place is infinitesimal and is more than offset by pronounced reductions in configuration costs. Instead of being scored or galled, the die or tool surfaces are left in a smooth and polished condition.

Draw rings usually are used in the heavy configurating of sheet metals of sixteen gauge or lighter, in order that buckling or wrinkling of the sheet be prevented during the drawing operation. The more lubricative the film used at these areas becomes, the greater must be the hold down pressure exerted upon the sheet to maintain the desired tautness. Obviously, if the film is very slippery, undue slippage takes place regardless of the amount of pressure.

This high pressure naturally involves a narrow throat between the draw ring elements thereby reducing the space available in which the plastic flow of metal is to take place. It will be seen therefore that the present invention contemplating a film having the capacity to provide uniform friction provides a method in which the hold down pressure need not be as great or the throat between the die need not be as constricted as was formerly necessary.

This hold down pressure in conventional practice is determined initially by a set up adjustment, then thousands or ten thousands of blanks are run through the press. The psammous film of the present invention provides a deposit which does not vary from piece to piece in its characteristics. In other words, it provides a constant friction between the sheet and the rim or dynamic element of the deforming tool, and the scrap of defective articles is reduced to the lowest possible quantity.

Furthermore, the working surfaces of the rings (and also the other parts of the instrumentality) are rarely if ever microscopically smooth and even, but exhibit high spots at local areas which have a marked tendency to pierce through any ordinary lubrication film into the metal of the work piece resisting even movement and causing the metal to lock. The presence of psammous matter, slightly abrasive, in a film intermediate the cooperating surfaces apparently evens out localized irregularities through abrasion, or the hard particles cushion the pressure by becoming imbedded partially in the surface of the work piece. At any rate binding or locking of the metal inhibitory of plastic flow is substantially eliminated.

Moreover, the psammous matter in the processing film, in many instances, operates to smooth and polish the surface of the work piece, leaving it in a more desirable condition, free of scoring or galling. Likewise in the deformation of large thin sheets into complexly configurated articles,

the capacity of the film to increase skin friction tends to retard slightly the flow of the sheet metal into the die cavity, with the result that the sheet is more tightly held at the draw ring without the exertion of excessive hold down pressure.

When sheet metal is rolled according to the process of the present invention, the capacity of the preferred composition to increase friction promotes traction of the roll with respect to the sheet metal in engagement therewith and wear of the roll caused by slippage is substantially reduced. Likewise, since the generation of heat attendant slippage is minimized there is but little risk or danger of scoring or "pick ups" on the surface of the metal being worked or on the roll.

Having described my invention, I claim:

1. A composition of matter adapted to use in the art of configurating sheet metal by plastic deformation comprising a liquid consisting of about 2–15% by weight of finely divided matter of the type exemplified by ground silica, ground pumice stone, ground alumina and the like of about 250 mesh fineness stably dispersed in an oleaginous vehicle.

2. A composition of matter adapted to use in the art of configurating sheet metal by plastic deformation comprising about 2–15% by weight of finely divided matter of the type exemplified by ground silica, ground pumice stone, ground alumina and the like stably dispersed in an oleaginous vehicle, said divided matter being at least about 250 mesh in fineness.

3. A composition of matter adapted to use in the art of configurating sheet metal by plastic deformation comprising a small quantity of finely divided matter of the type exemplified by ground silica, ground pumice stone, ground alumina and the like of about 250 mesh fineness dispersed in an oleaginous vehicle containing free fatty acid sufficient in amount stably to maintain the finely divided matter in the vehicle.

4. A composition of matter adapted to use in the art of configurating sheet metal by plastic deformation, an emulsion containing a small quantity of fine particles of abrasive such as ground silica, of about 250 mesh fineness.

5. The method of drawing a sheet of metal by means of dies adapted to deform the metal of sheet plastically, which method comprises coating the sheet of metal with a composition comprised of about 2–15% by weight of abrasive, psammous substance such as ground sand of about 250 mesh fineness, to provide a layer on the sheet adapted to maintain separation of the surfaces of the sheet and the surfaces of dies during drawing, and then drawing the sheet by means of the dies.

6. The method of drawing a sheet of metal by means of dies under heavy pressure which comprises coating the surfaces of the sheet of metal with a liquid containing a small quantity of hard, fine particles of material such as ground sand of about 250 mesh fineness in order to provide a layer on the sheet which assists the dies in gripping the metal to facilitate plastic deformation of the metal, but which also possesses the capacity to maintain separation of the surfaces of the sheet and the surfaces of the dies to prevent scoring of the surface of the metal by the dies, and then drawing the sheet.

7. The method of drawing a sheet of metal by means of dies under heavy pressure which comprises coating the surfaces of the sheet of metal with a liquid containing about 2–15% by weight of finely divided, hard particles of material of the type exemplified by ground sand of about 250 mesh fineness, to provide a layer on the sheet which assists the dies to bite into the metal of the sheet to facilitate plastic deformation but which particles also possess the capacity to maintain separation of the surfaces of the sheet of metal and the surfaces of the dies to prevent scoring of the metal and the capacity to provide uniform frictional pressure over the areas of the dies.

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