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LUBRICATION OF DIES

Philip R. Kalischer, Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

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This invention relates to the shaping of metal, particularly powdered metals in dies under high pressure.

In pressing powdered metals in dies, it is customary to mix a lubricant such as graphite or a metallic soap with the powder being pressed in order to provide for satisfactory pressing and ejection of the molded member from the die. The lubrication of the die has also been obtained by an alternate scheme in which a lubricant such as graphite has been applied to the die surfaces. In general, the benefits secured by either method are quite similar in so far as the ejection pressures are concerned.

No lubricant has been discovered which may be added to aluminum powders or which may be applied to die surfaces for the satisfactory molding of metal powders such as aluminum, magnesium or alloys thereof. It is a fact of common knowledge that aluminum and aluminum alloys cannot be commercially cold pressed into compacts at the present time. This applies to magnesium and magnesium alloys as well.

The object of this invention is to provide for applying to dies employed in the forming of metals under pressure a lubricant that will permit the cold pressing of powdered metals heretofore regarded as not cold pressable.

A further object of the invention is to provide for applying a lubricant to molding dies to greatly reduce the ejection pressures whereby more satisfactory work is produced.

Other objects will, in part, be obvious and will, in part, appear hereinafter.

According to this invention, unexpected results are obtained in lubricating dies, particularly dies employed in the cold pressing of metal powder, by applying thereto finely divided molybdenum disulphide, molybdenum telluride, tungsten disulphide, tungsten selenide and molybdenum selenide. Similar crystalline plate-like metallic compounds of sulphur, selenium and tellurium in which the metallic atoms are arranged in a plane layer with a layer of the nonmetallic or semimetallic atoms of sulphur, selenium or tellurium on each side of the layer of metallic atoms. Hereafter the compound molybdenum disulphide will be referred to as representative of this group, but it is intended to include all the members of this group of compounds, which may be employed with equal success.

Particularly successful results have been achieved when molybdenum disulphide has been applied as a lubricating coating on the surfaces of dies in which metal powders have been pressed into compacts. In some cases, powdered metals which had been regarded heretofore as not being cold pressable into compacts have been successfully pressed by the employment of molybdenum disulphide as a lubricant for the dies.

In applying the molybdenum disulphide to dies, it is preferred to employ the compound in the form of a highly purified powder approaching colloidal fineness. The powder is most satisfactory when substantially free from oxides, silica, free sulphur, and other abrasive or deleterious material. One convenient method of securing molybdenum disulphide of such purity and fineness is disclosed in the copending United States patent application of E. B. Kaercher entitled "Treatment to produce solid lubricants," Serial No. 469,121, filed December 15, 1942. In some cases, it may be feasible to produce a highly purified molybdenum disulphide and the like by subjecting finely divided molybdenum, tungsten or other equivalent metal to gaseous sulphur, hydrogen sulphide, or other sulphurous substances at elevated temperatures. A pure molybdenum disulphide suitable for use in the practice of the invention may be prepared by other methods.

The molybdenum disulphide is most conveniently applied to die surfaces by suspending the finely divided compound in an easily volatilizable liquid such as ethyl alcohol, acetone, benzene, water or the like, depending on how rapidly evaporating of a film of the liquid is required. The proportion of liquid to the molybdenum disulphide should be such as to facilitate application to the die. For the pressing of aluminum, a fairly heavy suspension is preferable in order to deposit a heavy coating of the molybdenum disulphide upon the die surfaces. For pressing powders which are less liable to weld or seize to the die walls, a thinner suspension resulting in a thinner lubricant coating upon the die surfaces is satisfactory.

All the die surfaces, including punches, core rods, and the like, are coated with the suspension of molybdenum disulphide by brushing or by spraying thereon or applying in any other convenient manner. The applied suspension is dried in order to deposit an adherent coating of molybdenum disulphide upon the die surfaces coming in contact with the powder being molded. A rapid evaporating liquid, therefore, is advantageous in preparing the suspension for this purpose.

In order to show the unexpected and highly advantageous results produced by the application of this invention, powdered metals, including those welding to dies and those free from welding

to dies, were compressed with and without the use of conventional lubricants and with lubricant of this invention. The results shown in the following table were secured with nonwelding metal powders:

Table I

Powder	Powder lubricant	Die lubricant	Ejection pressure
			Tons/sq. in.
Copper	None	None	9.3
Do	Copper stearate	do	6.0
Do	None	Graphite	6.0
Do	do	MoS_2	2.67
Iron	do	None	11.0
Do	do	Graphite	6.67
Do	Iron stearate	None	6.67
Do	None	MoS_2	1.3

In each case in the above table, a cylindrical die one inch in diameter was employed and a pressure of 100 tons per square inch was applied to form the compact. It will be noted that the ejection pressure required by the press when molybdenum disulphide is applied to the die surfaces is materially decreased as compared to the application of the other die lubricant. In the case of iron powders, the reduction in ejection pressure is approximately 80% as compared to that of the conventional lubricants.

The cold pressing of die-weldable metals, such for example, as aluminum, magnesium and alloys thereof, in powder form, has been heretofore regarded as commercially impossible. When aluminum, for example, is pressed in dies, it is the common experience that the powder "welds" to the die walls. Upon ejection pressure being applied, the pressed compact is usually destroyed and at times the die is ruined by reason of the tearing out of flakes of the die steel. Molybdenum disulphide, when applied to dies, prevents welding and may be employed in forming cold pressed compacts of aluminum powder with success. The following table is indicative of the benefits produced by the application of molybdenum disulphide to the die.

Table II

Powder	Powder lubricant	Die lubricant	Ejection pressure
Aluminum	None	None	Welded to die.
Do	Zinc stearate	do	Do.
Do	Iron stearate	do	Do.
Do	None	Graphite	Do.
Do	do	Lub. oil	Do.
Do	do	MoS_2	Less than 1 ton/sq. in.

A pressure of 100 tons per square inch was employed in producing cylindrical compacts 1 inch in diameter. It will be noted that all the conventional lubricant expedients listed in the second, third, fourth and fifth examples were entirely useless. It was necessary to regrind the dies after each pressing operation in order to remove the aluminum powder welded to the die walls. Molybdenum disulphide permitted the formation of satisfactory compacts with phenomenal ease in ejection and no welding to the dies took place.

The molybdenum disulphide lubricant is not only satisfactory for cold pressing operations but is highly beneficial in the lubrication of dies for not pressing powders of all kinds. The improvement in the lower ejection pressure is as outstanding as with cold pressing. The molybdenum disulphide may be applied to dies which are operated at temperatures of up to 500° C. or even higher with great success.

In applying the molybdenum disulphide lubricant to dies, the coating need be relatively thin to secure the benefits of the invention. With usual types of molding metal powders, a very thin film of the lubricant is entirely satisfactory. The thickness of the film is less than, or about that of the punch and die clearances. Metal powders which tend to weld to dies, for example, aluminum, zinc, lead, gold, silver and the like, may require a slightly heavier coating as mentioned hereinbefore. The pressed compacts will carry the thin layer of molybdenum disulphide due to adhesion and the final member will have a surface coating of the lubricant. Although the amount of molybdenum disulphide removed by the compact is relatively small, and a number of pressings may be made before the lubricant may be reapplied to the die, it is a better practice to reapply the suspension of lubricant between each pressing.

Since certain changes may be made in the above invention and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above-described disclosure shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. The method of lubricating a die to provide for the pressing of material in the die and for the satisfactory ejection of formed material from the die, which comprises applying to the die surfaces a coating of a lubricant selected from the group molybdenum disulphide, tungsten disulphide, molybdenum telluride, tungsten selenide, and molybdenum selenide and similar crystalline plate-like compounds in which the metallic atoms are arranged in a plane layer with a layer of nonmetallic atoms of elements of the group sulphur, selenium and tellurium on each side of the layer of metallic atoms.

2. The method of lubricating a die to provide for the pressing of material in the die and for the satisfactory ejection of formed material from the die, which comprises applying to the die surfaces a coating of a lubricant carried in a volatile liquid, the lubricant selected from the group molybdenum disulphide, tungsten disulphide, molybdenum telluride, tungsten selenide, and molybdenum selenide and similar crystalline plate-like compounds in which the metallic atoms are arranged in a plane layer with a layer of nonmetallic atoms of elements of the group sulphur, selenium and tellurium on each side of the layer of metallic atoms.

3. The method of lubricating a die to provide for the forming of compressed bodies from powdered material and for a satisfactory ejection of formed bodies from the die comprising, in combination, applying to the die surfaces a coating of a lubricant selected from molybdenum disulphide, tungsten disulphide, molybdenum telluride, tungsten selenide, and molybdenum selenide and similar crystalline plate-like compounds in which the metallic atoms are arranged in a plane layer with a layer of non-metallic atoms of elements of the group sulphur, selenium and tellurium on each side of the layer of metallic atoms.

4. The method of lubricating a die to provide for the forming of compressed bodies from powdered aluminum, magnesium and alloys thereof, and for a satisfactory ejection of formed bodies from the die comprising, in combination, applying to the die surfaces a coating of a lubricant

selected from molybdenum disulphide, tungsten disulphide, molybdenum telluride, tungsten selenide and molybdenum selenide and similar crystalline plate-like compounds in which the metallic atoms are arranged in a plane layer with a layer of nonmetallic atoms of elements of the group sulphur, selenium and tellurium on each side of the layer of metallic atoms.

5. The method of lubricating a die to provide for the forming of compressed bodies from powdered aluminum, magnesium and alloys thereof, and for a satisfactory ejection of formed bodies from the die comprising, in combination, applying to the die surfaces a coating of a purified lubricant selected from molybdenum disulphide, tungsten disulphide, molybdenum telluride, tungsten selenide and molybdenum selenide and similar crystalline plate-like metallic compounds of the elements sulphur, selenium and tellurium in which the metallic atoms are arranged in a plane layer with a layer of nonmetallic atoms on each side of the layer of metallic atoms.

PHILIP R. KALISCHER.