

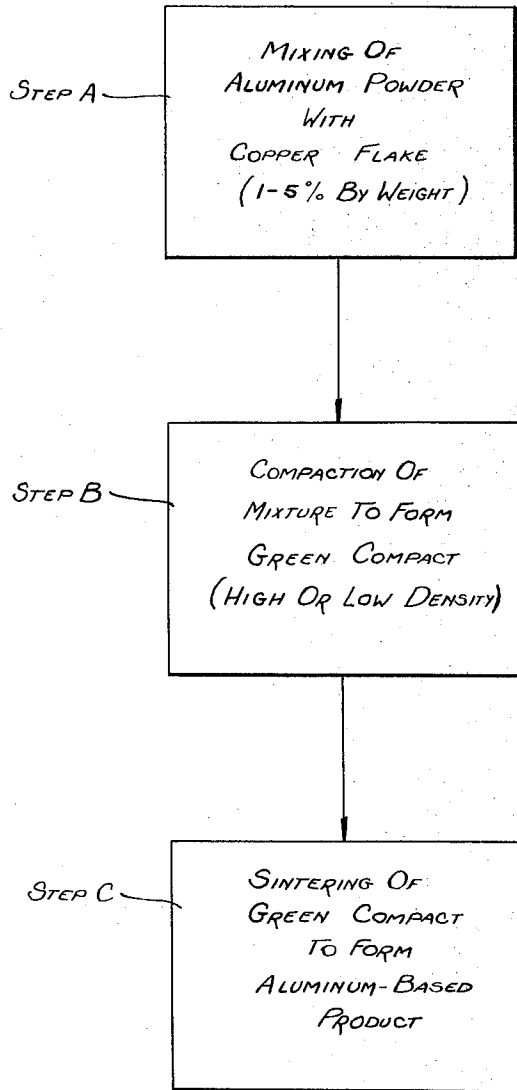
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A. BARTOSZAK

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TECHNIQUES FOR COMPACTING ALUMINUM POWDER MIXTURES

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INVENTOR.

ANTHONY BARTOSZAK

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TECHNIQUES FOR COMPACTING ALUMINUM POWDER MIXTURES

Anthony Bartoszak, Brooklyn, N.Y., assignor to Alloys Research & Manufacturing Corporation, Woodside, N.Y., a corporation of Delaware

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This application is a continuation-in-part of application Serial No. 202,582, filed June 14, 1962, and now abandoned.

This invention relates generally to powder metallurgical techniques for fabricating solid and porous bodies by pressing and sintering aluminum and copper powder mixtures, and more particularly to techniques for improving the pressing characteristics of such mixtures and facilitating the sintering of compacts formed thereby.

In the co-pending application of Samuel Storchheim, filed November 7, 1961, Serial No. 150,826, there is disclosed a technique for forming porous and high-density bodies, such as porous bearings and structural parts, by compacting a powder mixture of aluminum and copper particles, the copper content being in the range of 1% to 5% by weight. The green compact is removed from the die and then sintered to form the desired product.

Aluminum powders are notoriously difficult to compact, for they exhibit severe galling and seizing tendencies when pressed in steel dies. This characteristic is particularly troublesome when the powders contain substantial percentages of fines (—325 mesh fraction). As a result, it has heretofore been the practice to mix in die lubricants such as stearates with the powders. However, it has been found that the excessive use of lubricants results in discoloration, oxidation, lower strengths, and lack of ductility in the sintered compacts. In fact, when such compacts are subjected to high pressures to obtain better densification in the green compact, catastrophic cracking often occurs on ejection from the die. Therefore, it has been felt that die wall lubrication rather than powder lubrication is the only possible solution to the compaction problems encountered.

This solution, however, is not commercially feasible when one considers that a commercially competitive powder metallurgy process requires the pressing of 30 or more pieces per minute. If die wall lubrication is used, it is found that commercial press manufacturers have difficulty in designing high-speed presses in which the die walls are cleaned and then relubricated between pressings. Other problems encountered in sintered parts are aggravated

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vated by the fact that mixtures having approximately 40 w/o —325 mesh aluminum powder, provide tremendous surface for ultimate contamination. Also to be taken into account, is that finely divided powders involve the hazard of explosions or fires which may occur in normal production handling operations.

The object of this invention is to overcome the above-noted problems heretofore encountered in pressing powder mixtures including aluminum fines, and in sintering the green compacts.

I have discovered that the use of flake powders as alloy additions (e.g., copper) to other metal powders such as aluminum, results in improved pressing and sintering characteristics not heretofore attainable with spherical and/or atomized aluminum powders regardless of mesh size or fractions used. The following basic advantages are found to exist:

- (1) The use of flakes results in uniformly coating metal particulates of the major metal or alloy with a metal that is soft and malleable, which in turn provides better pressing characteristics than attainable with other powder additions.
- (2) The use of flake material results in uniform distribution of the alloying element throughout the green compact, which leads to maximum uniformity of diffusion in sintering and dimensional control.
- (3) Flake coating has been found to be applicable to all shapes and sizes of powders or particulates, and has been used on needles as well as atomized powders.
- (4) Flake coating allows one to press parts with higher L/D to ratios than normally feasible. It is believed that this is partially due to the fact that the flake material has lubricating properties.
- (5) The powder mixtures can be vibrated with no apparent settling occurring, provided that a lubricant such as Sterotex is added to the mixture. Without the Sterotex addition, the powders cannot be blended.
- (6) It is now possible with this development to chop up scrap metal, coat it, and then press and sinter.

For a better understanding of the invention as well as other objects and features thereof, reference is had to the following detailed description to be read in conjunction with the accompanying drawing, wherein the single figure is a flow chart illustrative of the steps involved in the techniques.

I have discovered that aluminum powders containing 40 w/o or more of the —325 mesh fraction can be safely handled and efficiently pressed at a rapid rate by adding small percentages of a flake powder such as copper to the aluminum, as described in the following examples.

TABLE I
Summary of compaction data obtained for powders containing 40 w/o or more fines

Mixture composition	Theoretical density, gm./cc.	Weight of compact, qms.	Height of compact, in.	Compacted percent theoretical density
A ¹ -----	2.62	4.99 4.82 4.89	0.556 0.553 0.555	80.5 78.7 79.0
B ² -----	2.62	4.93 4.93	0.265 0.265	96.8 96.8
C ³ -----	2.62	----- -----	0.767 0.767	95.5

¹ Composition A—96 w/o aluminum powder, 100 w/o through 40 mesh and 40 w/o through 325 mesh. Average particle diameter, 26 microns. Average apparent density, 1.0 gms./cc. Approximate specific gravity, 2.72. 1 w/o copper flake #44. 1 w/o copper powder, 95-100 w/o +200 mesh. Apparent density, 4.0-5.0 gm./cc. 2 w/o Sterotex.

² Composition B—46 w/o aluminum powder, 72.2-81.4 w/o +200 mesh, 18.2-24.2 w/o —200 +325 mesh, 0.25-1.85 w/o —325 mesh. 50 w/o aluminum powder, —325 mesh. 2 w/o copper flake #44. 2 w/o Sterotex.

³ Composition C—96 w/o aluminum powder, 100 w/o through 40 mesh and 40 w/o through 325 mesh. Average particle diameter, 26 microns. Average apparent density, 1.0 gm./cc. Appropriate specific gravity, 2.72. 2 w/o copper flake #44. 2 w/o Sterotex.

⁴ Maximum density obtained in a single pressing. Further compaction would result in lamination of the compact upon ejection from the die.

In Step A, the powder mixture compositions indicated in Table I were mixed in a blender for approximately one hour prior to compaction in a commercial automatic double-acting mechanical press at a rate of over 30 compacts per minute. The data for compactibility recorded in the table were obtained on typical random samples. No galling or seizing of powders on the die walls or punches occurred in any case.

In Step B, Composition A was pressed using a 0.750" diameter steel die with a core rod having a 0.4985" diameter, thereby producing a sleeve-type cylinder. Composition B was pressed into solid cylinders using 0.750" diameter solid punches and no core rod.

In Step C, samples of Composition A were sintered for 1/2 hour in a dry hydrogen atmosphere at temperatures

Ordinarily, green densities above 80% of theoretical are not attainable when using mixture of similarly shaped powders. This limitation occurs because of die-sticking and/or seizure and die-scoring problems. In the present discovery, the flake particles, not only coat the aluminum particles, but also apparently help to lubricate the die surfaces or limit the frictional forces that develop in pressing at high pressures.

The final strength properties attainable are dependent on the final sintered density attained. Heretofore, aluminum parts with crush strengths above 20,000 p.s.i. and acceptable ductility, were attainable only by pressing to low density, sintering, and then coining to high densities. Needless to say, elimination of coining results in great savings.

TABLE II
Data for Aluminum—4 w/o copper flake
single-pressed samples

[#44 natural copper fine flake used in all cases]

Powder mixture	Green density percent theoret.	Sintered density percent theoret.	Crush strength, p.s.i.	O.D. deflection percent	Sintered in dry hydrogen	
					Hrs.	Temp.
Cu flake plus Reynold's (#12120) free flow aluminum.	92.7	84.8	24,200	12.4	0.5	620
	92.7	88.9	26,600	12.1	0.5	620
	92.7	88.5	26,400	11.5	0.5	620
	92.7	86.5	25,900	12.4	0.5	620
	92.7	88.0	26,750	11.1	0.5	620
	92.7	88.4	26,100	11.6	0.5	620
	84.8	83.5	21,400	11.5	0.5	620
	84.8	83.8	22,500	11.7	0.5	620
Cu flake plus V.M.P. 100/200 mesh aluminum.	85	84.8	20,100	9.65	0.5	608
	85	84.5	19,700	9.16	0.5	608
	75	75.4	11,700	7.23	0.5	608
	75	74.8	11,600	7.75	0.5	608
Cu flake plus V.M.P. fine aluminum needles.	85	79.8	11,150	12.15	0.5	615
	89	84.2	12,300	10.03	0.5	615
	95	88.4	14,800	9.42	0.5	600

ranging from 612° C. to 628° C. Crush strengths of 8,500 to 17,000 p.s.i. (pounds per square inch) were obtained concomitantly with O.D. deflections ranging from 3% to 14%. Samples sintered at 614° C. to 621° C. had a slight shrinkage of .002" to .003" on the O.D.

Composition B was sintered at 640° C. for 1/2 hour in a dry hydrogen atmosphere and densities of 96.5% of theoretical were attained. Following this the samples were coined to 100% of theoretical density; original diameter of 0.736" coined to 0.752" diameter. This was followed by resintering at 640° C. for 1/2 hour and the final density attained was 98.5% of theoretical.

Composition C was pressed into sleeve-type cylinders in the same die as used for Composition A. However, green density was increased to 95.5% of theoretical. The resultant compacts were then sintered at various temperatures and the following results obtained.

Sintering Temp., ° C.	Crush strength, p.s.i. (average)	Percent O.D. deflection
615.....	15,200	5.94
622.....	20,300	11.9
631.....	28,800	20.5

In addition to the above, it was found that aluminum powder containing 100 w/o —325 mesh fractional could be compacted successfully by adding 2 w/o copper flake and 2 w/o Sterotex.

Table II summarizes further data obtained for other examples. It is noted that the copper flake is efficient in coating various shapes and particle sizes of aluminum powder as exemplified by Reynolds Free Flow, Valley Metallurgical 100/200 mesh, and Valley Metallurgical needles.

Thus, a commercially competitive method has been developed for compacting aluminum powder mixtures, particularly those containing 40 w/o and more —325 mesh aluminum. This method includes the use of a flake powder and nominal amounts of Sterotex capable of adequately lubricating the powder to prevent galling and seizure. Furthermore, the copper flake offers a means of protecting the fine aluminum powder from contamination during the sintering process. The pressing operation can be carried out at low pressures and high pressures.

The process described herein is applicable to the production of porous, self-lubricating parts and high-density structural aluminum components.

While the flake materials has been particularly described in terms of copper flakes, it is understood that other flake materials can also be added to the aluminum powder partially or completely in place of the copper flakes, in approximately the same amount. Such other flake material can be, in general, any metallic element or alloy, other than aluminum, of course, which can be produced in flake form. Representative other metals include, for example, brass, zinc, magnesium, and tin. As a typical example, —40 mesh aluminum powders containing 40 weight percent —325 mesh material is mixed with 3 weight percent brass (70% copper, 30% zinc) flake, and 1/2 weight percent lubricant for 30 minutes, pressed to over 90% of theoretical density and sintered for 30 minutes at 580° C. to 620° C. in hydrogen.

While there have been shown what are considered to be preferred techniques in accordance with the invention, it will be appreciated that many changes may be made therein without departing from the spirit thereof as set forth in the appended claims.

What is claimed is:

1. A process for facilitating the compaction of particulate aluminum comprising mixing particulate aluminum with from about 1% to 5% by weight based upon the weight of the mixture of flakes of another malleable metal and applying pressure to the mixture in an amount sufficient to compress the mixture to the desired density, the flakes therein acting as a sliding lubricant, thereby facilitating compaction.

2. A process as in claim 1 wherein an auxiliary die lubricant is also present in the mixture before pressure application.

3. A process as in claim 1 wherein the mixture is compacted to a density above 80% of the theoretical density.

4. A process for facilitating the compaction of particulate aluminum comprising mixing particulate aluminum with from about 1% to 5% based upon the weight of the mixture of flakes of another metal selected from the group consisting of copper, brass, zinc, magnesium and tin and applying pressure to the mixture in an amount sufficient to compress the mixture to the desired density, the flakes therein acting as a sliding lubricant, thereby facilitating compaction.

5. A process as in claim 4 wherein the flakes are magnesium flakes.

6. A process as in claim 4 wherein the flakes are copper flakes.

7. In the process of forming aluminum based bodies, the steps comprising mixing aluminum powders with copper particles in flake form, the copper content of the mixture being between about 1% to 5% by weight, and compacting the mixture to form a green compact, said mixture during compacting being subjected to pressure

and said copper flake therein acting as a sliding lubricant facilitating compaction of the mixture.

8. The process as set forth in claim 7, further including the addition of an organic die lubricant in said mixture in an amount not in excess of 5% by weight.

9. In the process of forming high-density aluminum based bodies, the steps comprising mixing aluminum powders with copper particles in flake form, the copper content of the mixture being between about 1% to 5% by weight, and compacting the mixture to a green density above 80% of theoretical, said mixture during compacting being subjected to pressure and said copper flake therein acting as a sliding lubricant facilitating compaction of the mixture.

10. The process as set forth in claim 9, wherein the copper content is about 2% by weight.

11. The process as set forth in claim 9, wherein the green density is about 95.5%.

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LEON D. ROSDOL, *Primary Examiner.*

REUBEN EPSTEIN, L. DEWAYNE RUTLEDGE,
Examiners.

R. L. GRUDZIECKI, *Assistant Examiner.*