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THE INFLUENCE OF LUBRICATION ON THE COMPACTABILITY OF MAGNESIUM-GREEN SALT BLENDS FOR BOMB REDUCTION

by

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Sufficient lubrication of the die surfaces during the final compacting of blends of uranium tetrafluoride (UF_4) and magnesium is necessary to prevent magnesium from seizing to the die walls.

Thick lubricants such as mineral oil and Dag 217 were the most effective in preventing seizing over a period of time because they remained on the die surfaces longer than did the more fluid lubricants. When mineral oil was applied after every third press, 18 compacts could be pressed before seizing became severe; 78 compacts were pressed when Dag 217 was applied in the same way. Some promising results were obtained when compacts were pressed from material containing about 0.33 w/o Ceremul "C" mixed with the powder. A total of 40 compacts were pressed with the use of this additive without extensive seizing or magnesium buildup.

Punch clearance was found to have little or no effect on the seizing problem itself; however, a slight taper at the bottom of the die cavity lessened the possibility of the punch becoming stuck during the compact-ejection step of the operation.

INTRODUCTION

Efforts to compact blends of uranium tetrafluoride (UF_4) and magnesium preparatory to bomb reduction to uranium metal have been seriously hindered by the magnesium in the blend seizing to the die surfaces. This seizing takes place in the compacting portion of the die when insufficient lubricant is present on the die walls. During compacting of the briquets, the magnesium particles adjacent to the die wall seize to this surface and pull out of the compact. The punch comes in contact with this magnesium buildup and is galled and wedged. The compacts themselves are badly broken up around the edges from rubbing against the magnesium particles adhering to the die wall while being ejected from the die.

Compacting studies at Battelle concerned with this seizing problem proceeded along two lines: investigation of the effect of lubrication and punch clearance.

PROCEDURE

In order to duplicate as well as possible the pressing conditions used in production, a die similar to that utilized by NLO was designed for use in the compacting studies conducted at Battelle. Figure 1 shows the die and all of its components.

There is one significant difference between the die used by NLO and the one made at Battelle. This difference is a 10-min taper in the portion of the die cavity where the final compacting of the briquet is accomplished. It was thought that a taper would be beneficial in ejecting the compact from the die. When there was no seizing, no difficulty was encountered in ejecting any of the compacts from the tapered die.

The die and its components were made of mild steel and oil-hardening die steel. The yoke or support ring for the die cylinder was made of mild steel as was the base plate, except for a 1/8-in. piece of die steel which was placed under the die when pressing. The die cylinder and all of the punches and inserts were made of oil-hardening die steel hardened to 57 to 58 Rockwell C.

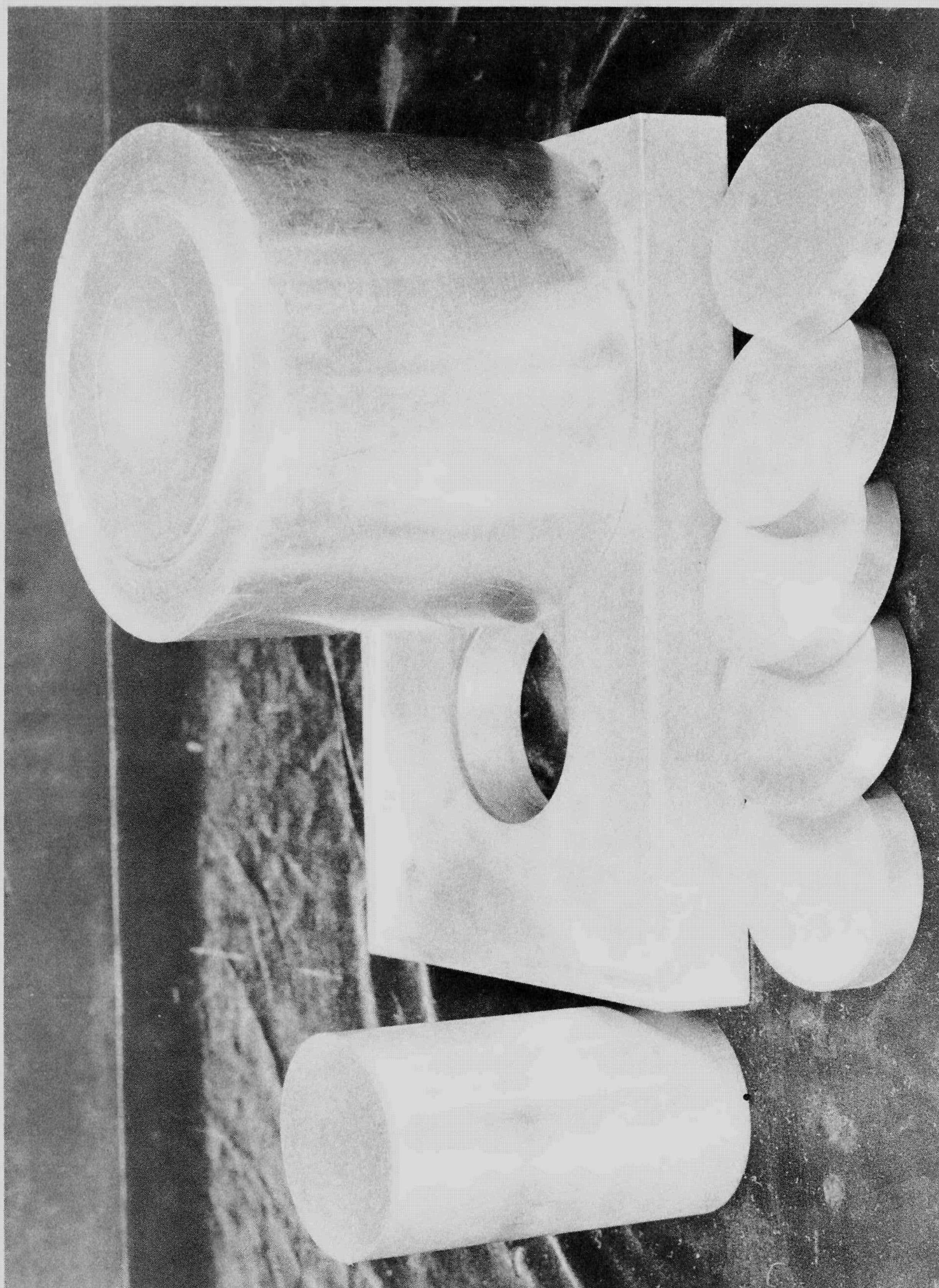
The individual samples weighed approximately 485 g. In some tests, the lubricant was applied to the die surfaces at different pressing intervals and in other cases it was incorporated in the powder blend. The compacting was done at 120 tons, giving a unit pressure of 20 tsi. The compression ratio for this powder mixture was approximately 1.4:1.

Various parts of the die were lubricated at different times. In some cases the punch and disk insert were not lubricated, but the die-cavity surface was lubricated. When a lubricant was mixed with the powder mixture, it was not necessary to lubricate any of the die parts.

A disk insert was used for each press and was placed between the powder and the punch to determine the effect of punch clearance on the seizing problem. Five inserts that had radial clearances with the die wall of 1 through 5 mils were investigated. As the compacting study progressed, it was found that varying the punch clearance did not effect the seizing problem. For the remainder of the program, the larger disks were used only to minimize the buildup of green salt around the punch.

After compacting the powder with the die positioned on the solid half of the base plate, the die was moved to the other end of the plate and the die cavity was lined up with the hole in the base plate (see Figure 1). At this point, the bottom punch fell out of the die. Pressure applied to the top punch then forced the compact and insert out of the die and through the hole in the base plate. Because of the taper in the compacting portion of the die cavity, it was necessary to move the compact only 1/4 to 1/2 in. to free it from the die wall.

Between 30 and 40 compacts could be pressed in an hour when no cleaning of the die was required. The average green density obtained on the compacts was 3.85 g per cm^3; this value was raised to as high as 3.94 g per cm^3 when the lubricants were mixed with the powder. The average size of the briquets was 2.75 in. in diameter and 1.30 in. in thickness.



N40810

FIGURE 1. COMPACTING DIE AND COMPONENTS

RESULTS AND DISCUSSION

Magnesium and uranium tetrafluoride (UF_4) blends were pressed while using Aquadag and Oildag as lubricants. Five compacts were pressed in succession for each of the five disk inserts used. The die and all components were lubricated after every second pressing. Only a small amount of seizing was visible on any of the die parts, but the compacts were broken on their edges to some degree when they were ejected from the die. Figures 2 and 3 show some typical compacts from this series. There was some buildup of green salt around the punch and disk insert, but this did not hinder the punch movement and could be easily wiped off. Figures 4 and 5 show the die-cavity surface after this series was pressed.

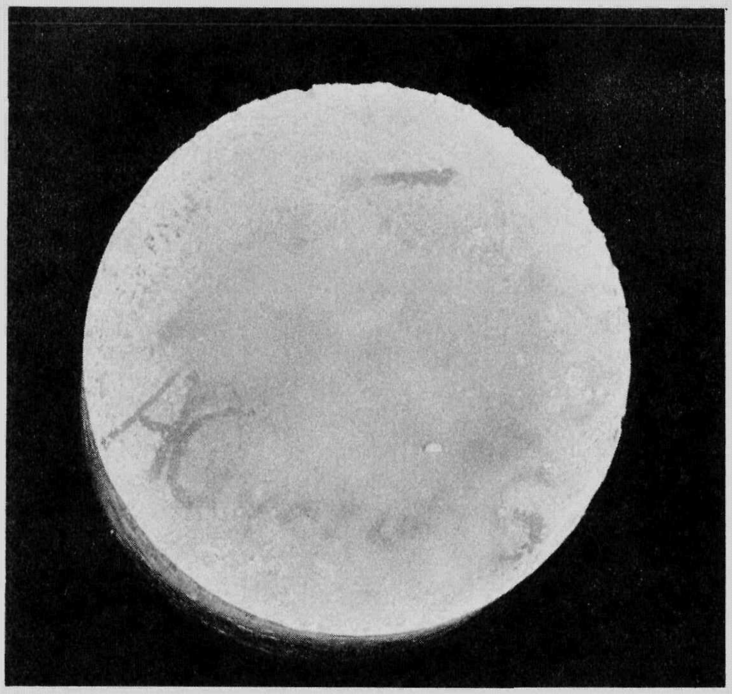
It was believed that repeating the compacting for a given disk insert and lubricant should show whether or not any seizing would occur over a period of time. When the disk insert having a 0.001-in. clearance with the die wall was used and was lubricated with stearic acid after every second pressing, seven compacts were pressed before an extensive magnesium buildup occurred. The magnesium had seized to the die surface where the final compacting was done rather than to the die surface adjacent to the top punch as had been expected. Figures 6 and 7 show a typical example of the appearance of the die cavity after magnesium seizing had taken place. When an attempt was made to press another compact, the magnesium buildup severely tore the bottom edge and side of the compact during ejection from the die.

These experiments were repeated with molybdenum disulfide (MoS_2) and Ceremul "C" as lubricants. Four compacts were pressed with MoS_2 and nine compacts were pressed with Ceremul "C" before magnesium buildup occurred. Once again, the seizing and magnesium buildup was in the compacting area of the die cavity rather than adjacent to the punch or disk insert.

It was first believed that the seizing was the result of magnesium particles becoming wedged between the top punch and die wall during compacting and then being extruded along the die wall as the punch was operated. However, when the disk-die wall clearance was increased, the only apparent effect was an increase in the green-salt buildup around the insert and punch. This was not shown to be harmful in any way, and no seizing was observed at the juncture of the disk insert and the die, while seizing was observed at the lower end of the compacting portion of the die.

At the time that the first sign of magnesium seizing was noticed, the lubricant appeared to be removed from the die surface. This would indicate that sufficient lubricant on the die surface is necessary for each compacting operation if seizing is to be avoided.

With the lubricants used up to this point, only a limited number of compacts could be pressed before the lubricant was wiped completely from the die surface. The ability of a lubricant to remain on the surface appeared to be the most important quality of the lubricant. Some lubricants such as Ceremul "C" and mineral oil are thick and will remain on the die parts longer than will more-fluid lubricants; consequently, more compacts can be pressed before the magnesium began to seize.

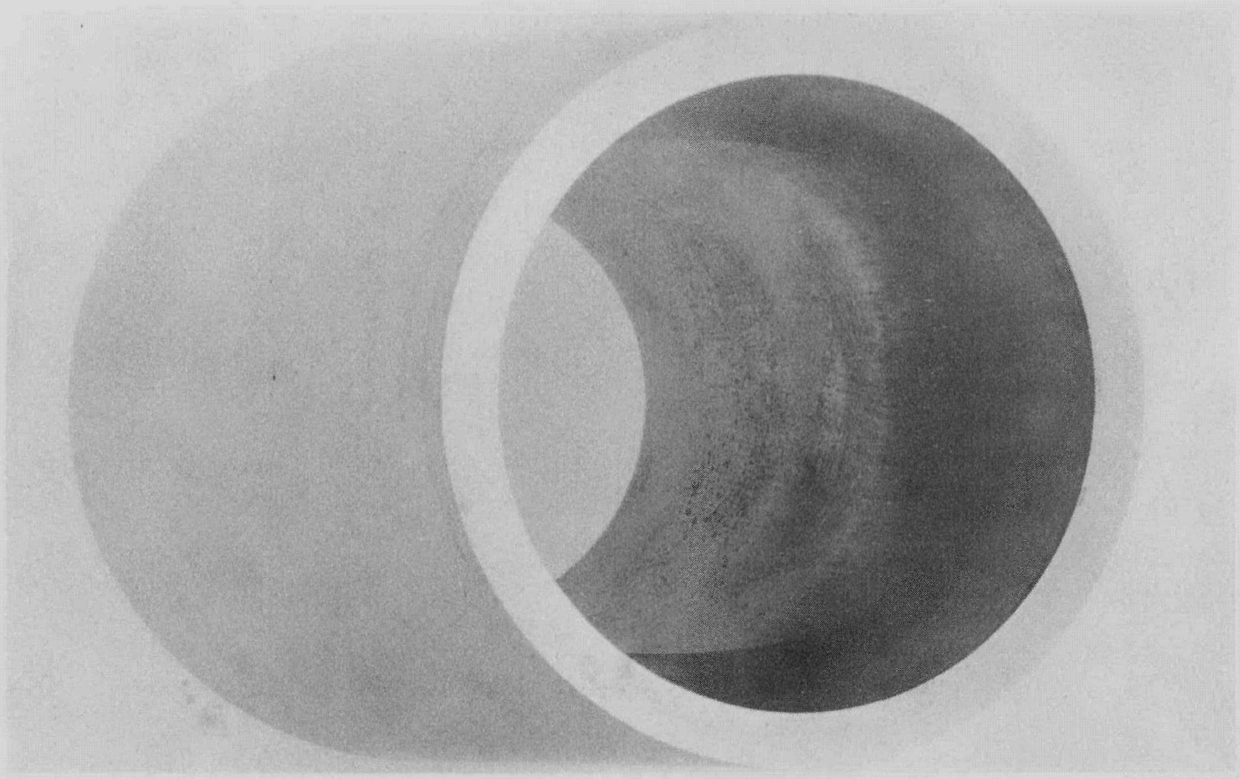


1X N41021

FIGURE 2. FIFTH COMPACT IN A SERIES WHEN LUBRICATING AFTER EVERY SECOND PRESSING WITH AQUADAG

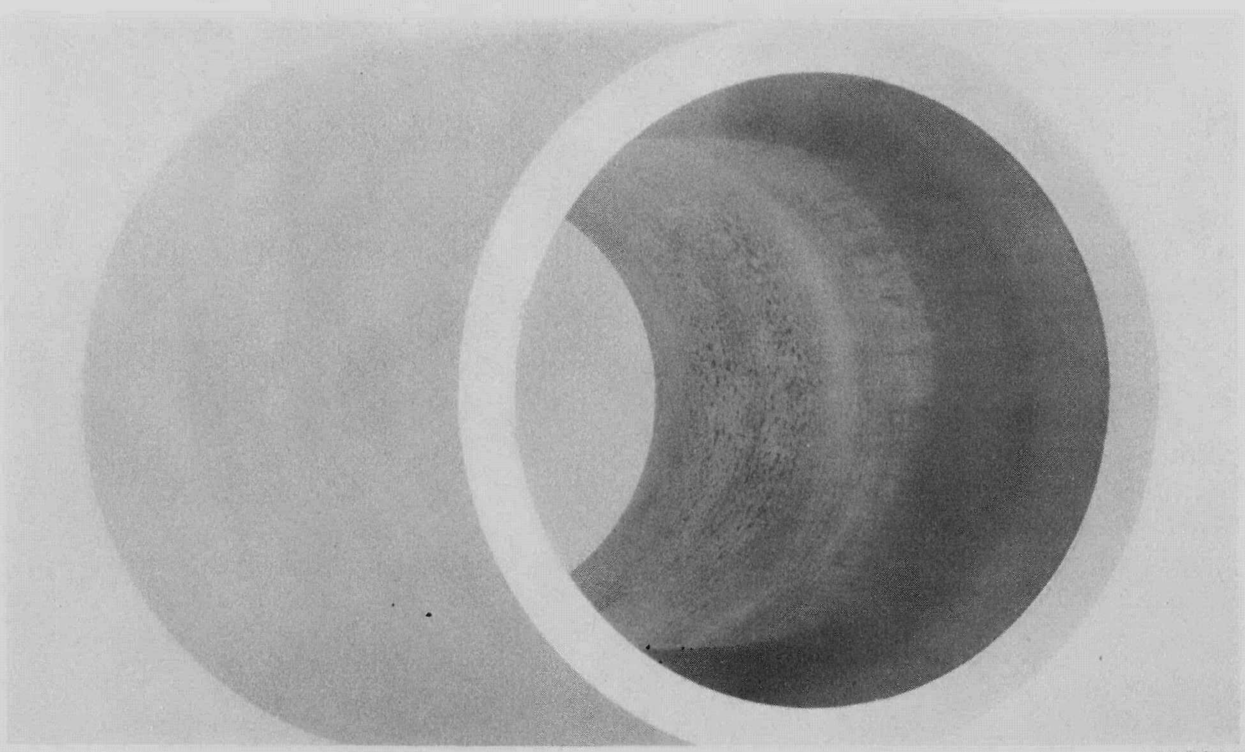
1X N41019

FIGURE 3. FIFTH COMPACT IN A SERIES WHEN LUBRICATING AFTER EVERY SECOND PRESSING WITH OILDAG



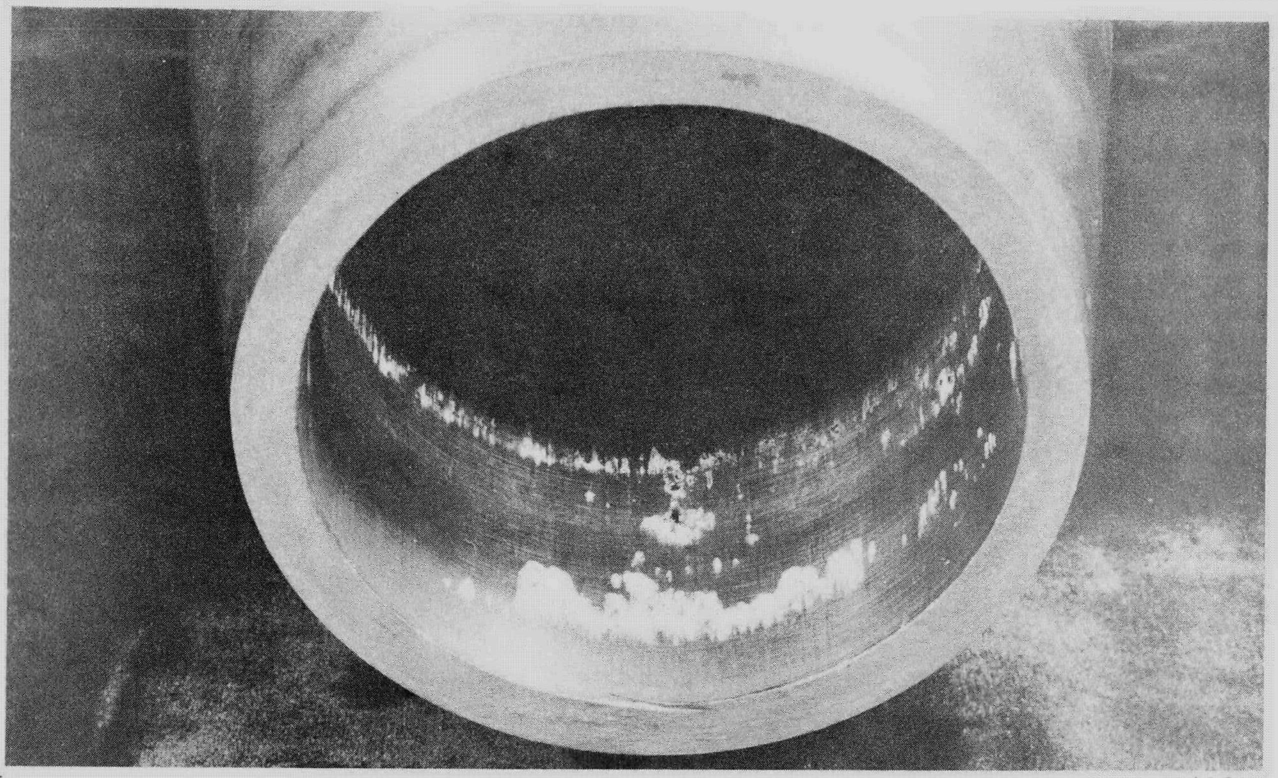
N39829

FIGURE 4. SURFACE OF DIE CAVITY AFTER 60 PRESSINGS USING AQUADAG AND OILDAG APPLIED AFTER EVERY SECOND PRESSING



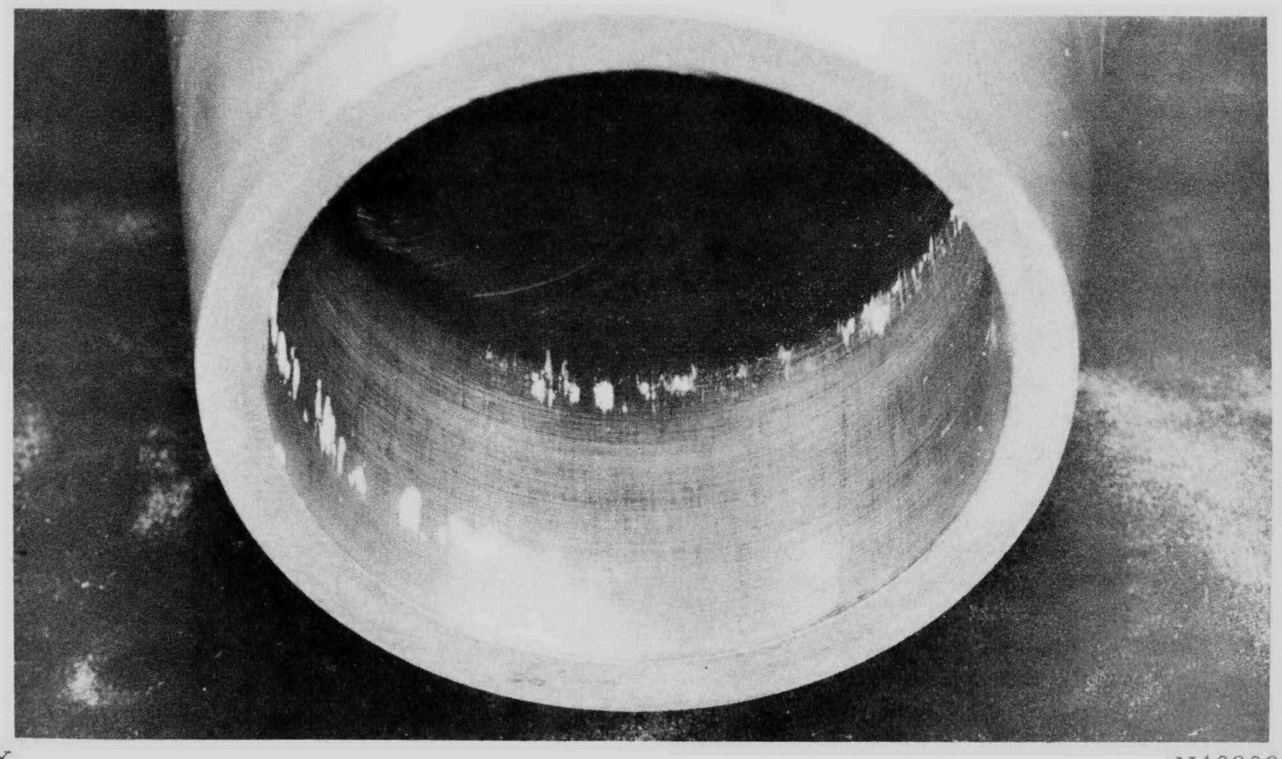
N39828

FIGURE 5. SAME AS FIGURE 4 EXCEPT THE OTHER HALF OF CAVITY SURFACE IS SHOWN



1X N40811

FIGURE 6. MAGNESIUM BUILDUP IN COMPACTING ZONE WHEN SEIZING HAS TAKEN PLACE



1X N40809

FIGURE 7. SAME AS FIGURE 6 SHOWING OTHER HALF OF DIE CAVITY

As a means of lubricating the die surface for each pressing, the possibility of incorporating a lubricant within the powder blend was considered. Material for several compacts was mixed with Ceremul "C". For each 485-g sample, 3 cc of this lubricant was incorporated in the blend.

A small amount of seizing occurred when this material was pressed; however, the magnesium buildup was small and did not interfere with the operation of the punch nor did it damage the compacts to any great degree. It was not necessary to lubricate any of the die parts. Additional material for 18 compacts was prepared as before and pressed again with very little seizing. The Ceremul "C" lubricant was chosen for three reasons: first, relatively good results had been obtained with it in earlier work when applied directly to the die surfaces; second, it is a paraffin emulsion suspended in a water carrier and has a negligible ash content; and third, its low melting point of 122 F would make it rather easy to volatilize.

A solution of camphor in alcohol was also prepared and mixed with the powder blend. Concentrations of 1, 2, 3, and 5 cc of this solution were used for each 485-g sample. Some edge breaking of the compacts occurred in all concentrations, and only a few compacts could be pressed before the breaking became severe. Although some seizing did occur, most of the time only a small trace of magnesium could be found on the die wall. It is not known why the magnesium buildup remained small when sometimes the compacts were badly broken when ejected from the die.

A study was also made to determine the frequency of lubrication necessary to prevent seizing. It was found that lubrication after each pressing with almost any of the lubricants used would prevent seizing. The next step in this study involved lubricating after every third pressing. The more promising lubricants were then used after every fifth pressing. The results of using the various lubricants after every three pressings are shown in Table 1. In this study, only the die cavity was lubricated.

The results show that the Dag 217 and mineral oil were the only lubricants of this series that gave any promising results. A total of 78 compacts were pressed when using the Dag 217 and 18 were compacted when using mineral oil before excessive seizing occurred. It should be pointed out that both of these lubricants are rather thick, and this again would indicate that the thicker lubricants are more effective in preventing seizing because they remain on the die surfaces for a longer period of time.

It was not possible to press five successive compacts without lubrication when using either the mineral oil or the Dag 217. However, a 1:1 mixture of the two lubricants allowed five compacts to be pressed with only a slight indication of galling. Even though the die was freshly lubricated, the sixth and seventh compacts began to show signs of breaking, which usually meant that the magnesium buildup was advanced.

To evaluate the effect of the taper in the compacting section of the die, several pressings were made on the straight portion of the die. Lubricants were used that were successful when compacting in the tapered end. To accomplish this, the die was turned upside down with the straight portion at the bottom. The compacting procedure was the same as before. It was found that even when no seizing was present, the compacts were much more difficult to eject than those compacted on the tapered end. It was necessary

TABLE 1. LIST OF LUBRICANTS AND NUMBER OF COMPACTS PRESSED WITH EACH WHEN LUBRICATING AFTER EVERY THIRD PRESSING

Number	Lubricant	Number of Compacts Pressed Before Seizing
1	Ceremul "C"[a]	12
2	Molybdenum disulfide	5
3	Camphor and acetone	1
4	Stearic acid	6
5	Oleic acid	6
6	Zinc stearate	2
7	Paraffin in benzene	2
8	Salicylic acid	1
9	Benzoic acid	2
10	Oildag[b]	2
11	Vermiculite	1
12	Mineral oil	18
13	Dag 217[b]	78

(a) A product of the Socony-Vacuum Oil Company, Inc.
(b) A product of Acheson Colloids Company.

for the punch to push the compact completely out of the die in the straight end. However, on the tapered end the compact needed only to be loosened, which usually required that the compact be moved about 1/4 to 1/2 in.

CONCLUSIONS

From the results obtained in this compacting study, it was found that seizing of magnesium to the die walls while compacting uranium tetrafluoride (UF_4) and magnesium blends was prevented only when the compacting-area surface was kept well lubricated. This was accomplished either by direct application of the lubricant to the die surfaces or by incorporating a lubricant in the powder blend.

The ideal method would be to lubricate the die cavity after each press. However, in production it is desirable to lubricate only as often as is necessary to prevent seizing.

The best alternate method would be to use the lubricants that were found satisfactory when applied at different pressing intervals. Mineral oil produced as many as 18 and Dag 217 produced as many as 78 compacts before extensive seizing occurred. In this series, the lubricants were applied after every third pressing. Both of these lubricants are rather thick and were retained on the die surface longer than the other lubricants used.

It was not possible to press five successive compacts between lubrications with the Dag 217 or the mineral oil. However, a 1:1 mixture of the two allowed five successive compacts to be pressed before seizing became too severe.

Lubrication by use of an internally mixed lubricant such as Ceremul "C" appeared very promising. Some 40 compacts have been pressed with only a small amount of seizing. This lubricant might be practical from a contamination point of view because Ceremul "C" can be readily volatilized, leaving behind only a small amount of ash.

The effect of ram clearance was found not to be of much consequence in Battelle's compacting studies because the seizing was found to be taking place in the final compacting section and not between the ram and die wall during compacting. The largest insert was used throughout the program to keep to a minimum the green-salt buildup between the punch and die wall. However, it is doubtful whether this buildup would become so great as to hinder the operation of the ram.

There seems to be some benefit gained by the 10-min taper in the compacting section of the die. Ejection of the compacts was found to be much easier with the tapered end than with the straight portion. There is also not as much contact between the ram and seized surface while ejecting the compacts. This would lessen the possibility of the ram jamming during this operation.

RECOMMENDATIONS

It is doubtful whether further work with externally applied lubricants would be justified. Some 20 lubricants were employed in this program. The ability of these lubricants to remain on the die surfaces seemed to be more critical in preventing seizing than their actual lubrication properties. Additional work on incorporating other lubricants within the powder mixture appears to offer promise. Only two lubricants were tried in this phase of the program because of time limitations, but some promising results were obtained with one of these.

A taper such as the one used in Battelle's compacting studies would be of some benefit in ejecting compacts from the die. Also a tapered area would be helpful in preventing the ram from sticking, even when some seizing does occur, by avoiding any contact between the ram and the magnesium buildup in the compacting area. A larger die would most likely require a larger taper.

The use of other die materials does not appear to be of much consequence at the present time. However, there may be some benefit gained from surfacing the die cavity with a metallic layer or plate that would not be as susceptible to seizing by magnesium as the oil-hardening die steel.

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