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PRESSING TECHNOLOGY

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DEVELOPMENT DIVISION

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MASTER

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Pantex Plant

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PRESSING TECHNOLOGY

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Advancing the state-of-art and developing processes related to pressing explosives.

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Section H

PRESSING TECHNOLOGY

ABSTRACT

A new process has become available that might be useful for compacting ~~FR~~ materials. The process is triaxial: it utilizes the familiar isostatic compression vectors to form a billet and for lateral reinforcement while a shear action of higher pressure is included over the billet ends with a mechanical punch.

The 20-inch press has been inspected at the site of manufacture and is in transit to Pantex Plant.

DISCUSSION

A laboratory test to measure the physical properties of soil has used the triaxial concept for several years. The work has been concentrated in the field of civil engineering with bibliographies referencing reports in 1936. Previous compacting pressures have customarily been 150 psi to 1,000 psi.

R. M. Koerner, of Drexel University, has recently investigated the technique as it may be related to processing powdered metal. The first known publication of this work appeared in the *International Journal of Powder Metal*, July, 1971. R. M. Koerner's work has continued the basic test but at pressures up to 100 kpsi.

The triaxial system of compaction offers a new pressing technique because it results in a difference in the movement of crystals of explosives.

Previous methods of HE compaction (isostatic, hydrostatic or mechanical) results in a crystal movement that is primarily toward the part center with resultant tendencies to bridge against each other and create high pressure spots that often break the crystals. The resulting cracks within the crystals are so fine that the binder cannot be extruded into them and a density limitation is encountered that is related to the problem of not completely filling the intracrystalline voids with the plasticized binder.

The triaxial system seems to compact material in such a fashion that each crystal wants to move closer to all of its neighboring crystals, rather than being just pushed toward the center by its adjacent outboard neighbor. When a crystal is dislocated and moved closer to its neighbors, it alters the environment of nearby crystals, and as they also begin to move a condition of flux is generated throughout the billet.

The triaxial compression process uses a combination of isostatic and mechanical forces to impose uneven loadings. This can also be accomplished in a conventional isostatic press by attaching an intensifying piston/cylinder on one end of a housing that contains the HE charge. See Fig. 1 for the concept.

→ Isostatic Vectors
→ Mechanical Vectors

Fig. 1. Triaxial Tooling Concept

Accurate listings of desired studies with a triaxial system cannot be made at this time; there is not enough known about the process. The studies listed are obvious ones that will be needed. Others will surely be presented as the investigation progresses.

1. Suitable ratio of isostatic pressure to shear pressure. This will necessitate at least two substudies:
 - a. Optimum pressure
 - b. Optimum dwell period
2. Density increase, if any, by repressing in a water-bag.
3. Results of physical properties once a range of suitable density is obtained.
4. Minimum preheat temperatures required for suitable pressings.

MECHANICAL PRESSING EVALUATION

The objective of this discussion is to reconsider the merits of mechanical pressing, taking into consideration the various problems and advantages. Pellet pressing, while conducted in similar equipment, is specifically not considered a part of this discussion. Pellets may be defined as small cylinders, less than 1 inch in diameter and weighing less than 20 grams.

The problems of mechanical pressing are concerned basically with safety, ergonomics and design limitations enter the consideration, but to a lesser degree. The primary problems are:

1. Alignment of Press Parts

The punches and the matching die must be maintained in a condition of precise alignment when pressing high explosives. This alignment is subject to alteration for a variety of reasons. These reasons can be as subtle as bearing lubrication and include bushing fit, bushing or bearing failure, objects left on press platens that will be moving during operation, strain-rod failure, temperature variations, and uneven loading of the explosive within the die prior to compaction. Alignment may be satisfactory during a checkout but not remain so at all punch positions during compacting operations.

2. Lateral Flow

Extreme conditions of uneven loading can combine with the resistance of HE to flow so that some areas of a pressed part may not be compacted. This in turn causes a concentration of force against the punch faces which can result in breakage, distortion or destruction of alignment.

3. Heated Punch and Die Sets

The high thermal conductivity of steel and the intimate position to the explosives make preheating an obvious choice for high quality pressings. The result of a heating control failure here is more critical than would be the case in a preheating oven where the raw material is not being subjected to intensive work.

4. Design

Punch and die parts must be considerably stronger than would be required for pressing plastics or other inert parts. Cracks cannot be tolerated and chipping or spalling have the potential of causing a detonation. This is a complex field in its own right and the person responsible for design needs a solid background of metallurgy and HE characteristics.

5. Part Ejection

Ejecting straight cylindrical parts more than 1 diameter tall is a bruising operation at best and it becomes desirable to induce a slight taper in the die to reduce the friction. However, a taper presents limitations on what shapes may be pressed and causes problems with the gap between the punch and die.

6. Friction

Compaction forces normally transfer from the punch into the HE and a portion is expended as friction against the die wall. Thus, a portion of the compacting force is born by the die itself. The ratio of die loading to working load is directly proportional to the surface area of the die that is in contact with the HE and normally amounts to about 20% of the total force, but may become as high as 80% in situations of poor surface finish or particularly abrasive materials. This results in pressure and density gradients within the billet, presenting limitations on the ratio of height to diameter that can be successfully pressed.

7. PBX Extrusion

Plastic bonded explosives tend to be extruded into the narrow joints between the punch and die. These thin films of explosives, confined between metal parts, present a particular hazard in that they may be subject to very heavy frictional loading if there is subsequent motion.

8. Drifting in Double Acting Presses

Double acting presses are subject to a hazard not found in single acting presses. An imbalance in the hydraulic systems can allow drifting, either up or down, of the punches while they are maintaining the approximate load of compaction. If this condition of imbalance is severe enough one punch may become withdrawn from the die and cause the PBX

to shear as it is extruded through the opening joint between punch and die. The extruding material causes a reduction of the restraining force against the opposite punch and the action will continue at an accelerated rate.

9. Foreign Material

Foreign material that is included in the PBX at the time of die loading may be forced into intimate contact with the die surface and generate a point of high shear concentration as the HE is compacted. The reaction probability is increased if the melting point of the foreign material is high (influenced by hardness).

10. Capital Investment

Punches and dies suitable for pressing explosives comprise an expensive assembly of tooling. A basic cylindrical configuration to press parts 6 inches in diameter, including a heat-jacket and the capacity for vacuum sealing, will cost on the order of \$3,000.00. This investment escalates rapidly as shapes become more complex. Punch and die sets used for pressing a complex shape have cost \$30,000.00 and it would be very easy to envision \$50,000.00 in similar shapes at today's prices.

Shape pressing to final dimensions becomes more difficult when pressing thin parts, because of the above described problem of lateral flow. In such situations it would be advisable to press the shape across one surface and around the periphery; then machine the simpler surface, probably the inner radius. Dimensional control and the density problems described above would then be improved.

Some machining will probably be required for high-quality parts most adaptable to shape pressing.

ADVANTAGES

Advantages of shape pressing are primarily economic. There is no significant improvement in safety and usually little in quality. Advantages are as follows:

1. Production capability

Mechanical pressing presently has about 1/2 the turn-around time of isostatic pressing and this could be reduced further by use of automated equipment. Thus, if complex shapes are being considered and the subsequent machining operations can be reduced or eliminated, mechanical pressing could result in a considerable economic advantage. This advantage particularly increases when NC machining time is considered. We are already in possession of the NC machines so investments for that capital equipment need not be considered, although increased maintenance expense for the NC machines is a definite factor.

2. High Density PBX

The overall density of a mechanically pressed part is usually higher than that of a similar part pressed isostatically. Isostatically pressed parts will have a higher density only after a repressing operation. Density spread within pressed-to-shape parts can be reduced by machining away that portion of a piece that had been added to allow lateral flow of the HE.

HYDRAULIC PUMP

The hydraulic pump that drives the intensifiers of the Elmes press has broken down. Inspection without complete disassembly indicates that at least one piston has broken and generated metal scraps in the pump and hydraulic circuit. The pump has been shipped to the manufacturer for rebuilding. The Elmes press is not expected to be operational until late January.

20-INCH PRESS

The 20-inch isostatic press and pumping station is in transit from the manufacturer. The vessel was tested hydrostatically to 20 kpsi and cycled for system-operation several times before leaving the manufacturer. The operational tests proved the fit of the modified breech and the fluidic interlocks to detect improper assembly. Press installation should be started by mid-January.

CONCLUSIONS

A few pressings of 90010 Mock have been made by the triaxial technique. The facilities at Drexel University, under the direction of Koerner, were used to press seven small billets in their triaxial equipment. Density was higher than obtained in isostatic pressings at 20 kpsi. The chamber containing the HE will have to be evacuated prior to compaction. No change from present practice. Final development of this concept will probably allow isostatic pressures lower than those presently used to compact HE's, or it will generate a higher density if the present norm of 20 kpsi is continued.

MECHANICAL PRESSING

The enormous expense incurred as a direct result of a significant detonation incident would seem to make mechanical pressing undesirable at this time if there is another way to make the part. The qualification "at this time" is added because the balance could tilt in favor of mechanical pressing if it becomes urgent that we produce at maximum capacity. Mechanical pressing is faster than isostatic and may be justified for sizable production runs of several thousands of pieces in that situation.