The Fixed Dummy Block

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ABSTRACT – The replaceable fixed dummy block is used on most aluminum extrusion presses. However, operating conditions such as aluminum alloy and dies, physical size, unit pressure, temperature and cycle time vary greatly from press to press. To ensure proper performance, CASTOOL has used finite element analysis and practical experimentation to provide an understanding of the factors affecting dummy block design. The replaceable fixed dummy block is now an essential part of an automatic aluminum extrusion press. Its performance is measured in terms of its ability to operate with minimum effect on the extrusion process, without disturbing the aluminum alloy coating in the liner, and the number of extrusion cycles before replacement or major maintenance. Properly designed, maintained and operated replaceable fixed dummy blocks remain on the extrusion press for many thousands of press cycles. Products (alloys and dies) can run on any given press. This paper reviews the research and development conducted by CASTOOL Tooling Solutions into the factors affecting the design and operation of this critical element of press tooling.

INTRODUCTION

The press stem is designed to carry the full load of the extrusion press, and is dimensioned to ensure adequate clearance between it and the container throughout its stroke. The traditional floating dummy block was required to separate the press stem from the aluminum billet. In this case, the floating dummy block was placed on the billet loader along with the next billet, and located-as the stem advanced-by a rounded stud or “button” screwed into the end of the stem. The dummy block was dimensioned smaller than the container bore so as to allow a layer of aluminum to separate the H13 steel floating dummy block from the H13 steel liner.

At the end of each extrusion stroke the dummy block, which had adhered to the butt-end of the aluminum billet, fell into the press foundation, along with the sheared butt. The butt and dummy block (if they had not already done so when they dropped) were separated: the butt to the scrap bin, and the dummy block to be quenched and re-cycled back to the billet loader.

On the smaller extrusion presses (up to 7-inch [178 mm]), the dummy block and the butt discard were placed on the billet loader and separated from the aluminum butt manually. On larger presses (8-inch [203 mm] and up) the weight of the dummy block and the resulting butt meant that the dummy blocks were loaded, retrieved from the press pit, separated from the butt, and quenched and circulated back to the billet loader automatically, using mechanical and gravity feed conveyors.

Loading and circulating the floating dummy block manually, or even with the aid of mechanical handling devices, required the operator to ensure the dummy block was properly aligned before the stem contacted the billet. Although the operator is usually (at least in recent years) aided by a sensor installed in the stem (in place of the “button” referred to above), a missing dummy block inevitably causes considerable press downtime.

On presses equipped with these mechanical handling devices, the cost of maintenance and repair, and lost press time incurred is considerable.

On the large presses (above 12-inch [305mm]) the weight of the dummy block and butt becomes so great that additional handling is required to prevent the butt and dummy from dropping to the floor when the butt is sheared. Alternatively, in the absence of handling systems, the floor must be "engineered" to withstand the impact and/or regularly repaired.

Rigidly fixing the dummy block to the press stem has solved part of the problem. This appears to have worked in many (but not all) large press applications, which tend to operate at lower unit pressures and are inherently stronger.

In order to simplify the engineering of the extrusion press and its operation, and to address the limitations of the truly "fixed" dummy block, expanding replaceable fixed dummy blocks were considered in the early 1970s.

THE DEVELOPMENT OF THE FIXED DUMMY BLOCK IN JAPAN

The aluminum extrusion industry in Japan has grown from a rate of about 60,000 tons per annum in 1954 to 970,000 tons in 1964-the time of the first oil crisis-finally reaching a level of over 1.2 million tons in 1996. This growth, which coincided with the rapid economic growth in Japan[1], created critical labor shortages. There became a need for improved productivity, much of which was achieved through automation.

The last 50 years have seen the evolution and adoption of the self-contained extrusion press, belt handling systems, one-man and automatic stretchers, and automatic saws and stackers. Most of these practices have resulted in labor savings. The fixed dummy block is an example of one of these developments.

As in other countries, on the small to medium size extrusion presses, which made up most of Japan's aluminum extrusion industry, the press operator handled the loose dummy block during each dead cycle. The operator would separate the dummy block from the butt discard, apply lubrication, and return it to the stem side of the container where one of a number of blocks was placed behind the next billet to be loaded. All work was manual. On large presses, a second operator and the early introduction of mechanical conveyors would assist. Finally, a fully automated system comprising a receiver (with a clamping device) for the dummy block and discard, a carrier, an elevator, a mechanical separator and a conveyor, was developed. These sophisticated systems worked, but added to the maintenance and press downtime.

Early fixed dummy blocks, designed to eliminate these handling systems, were made up of a curved plate with a flat outer edge. The plate was carried on a threaded rod passing through a hollow press stem. The design was effective. The force of extrusion would flatten the plate and increase the diameter to bring the flat outer edge (or land) close to the bore of the container. At the end of the extrusion stroke the plate relaxed, separating the butt. However, inconsistent expansion, trapped air between the concave plate and billet, and an overly thick butt led to the development of an alternative fixed dummy block.

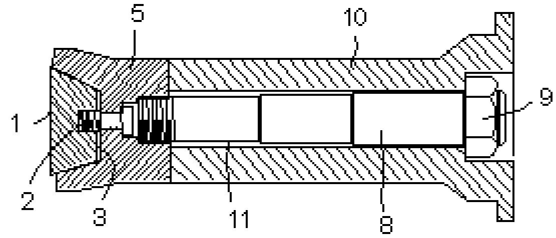
In 1974, the Nippon Light Metal Company and its subsidiary designed the system illustrated in Figure 1a.

A pressure plate (or mandrel) inserted into a concave depression in the dummy block was supported by a threaded connecting rod running through the hollow press stem. The angled pressure plate, which ensured consistent, finite expansion of the dummy block, was supported in the female body of the dummy block by a threaded bolt. When assembled, there was clearance between the body and mandrel causing the mandrel to protrude from the block.

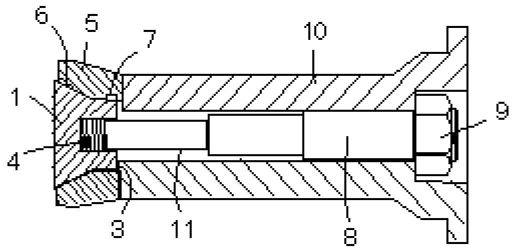
The dummy block was attached to a threaded rod having three diameters. The largest, in the region furthest away from the block, fitted into the hollow stem. The stepped taper, to the point at which the dummy block was attached, provided the flexibility required to match the alignment (or minor misalignment) of the press container and stem.

With experience, the pressure plate (mandrel) was modified and in 1979, was attached directly to the connecting rod. The thickness of the dummy block was reduced to form a ring, and a locating pin was employed to prevent rotation. These changes can be seen in Figure 1b.

The designs were applied to rectangular containers, and further developed to improve the quality of extrusion. Elements of the early designs can be found in many of today's fixed dummy blocks.



a. Original Type



b. Simplified Thin Type

1. Pressure plate
2. Connection bolt
3. Bottom of pressure plate
4. Female threaded hole
5. Dummy block
6. Inside wall
7. Locating pin
8. Connecting rod
9. Fastening nut
10. Stem
11. Hollow part

Figure 1. – Evolution of Japanese fixed dummy block[2]

FIXED VERSUS FLOATING DUMMY BLOCKS

The benefits of using an expanding, replaceable fixed dummy block can best be understood through the examination of its advantages over the floating (or loose) dummy block.

Injury Reduction

Operators no longer have to work around an operating billet loader and stem, strip butts, or handle floating dummy blocks. In fact, safety regulations in some jurisdictions prevent access to billet loader and stem when the extrusion press is working.

Reduced Press Downtime

Although the use of sensors minimizes the possibility of operating the press without the floating dummy block in place, constant vigilance is required on the part of the press operator to ensure a single dummy block is always in place, and properly aligned.

Simplified Press Systems

There are extra systems for handling, quenching and re-circulating the blocks. The blocks, which are in constant circulation, require additional sensors to be integrated into the press controls.

Simplified Press Installation

Press foundations have to be able to withstand the harsh conditions caused by falling blocks and butts. The ancillary structures associated with handling, quenching and re-circulating floating dummy blocks complicate the installation of the press.

Reduced Press Maintenance

Maintenance of the floating dummy block ancillary systems cannot be carried out when the press is running. Butts that inevitably fall into the foundation pit under the press must periodically be removed and as a result, the press must be stopped.

Increased Life of Liner

The floating dummy block is susceptible to damage when falling into the press pit, hitting other blocks during re-circulation, or when entering the container. Damaged floating dummy blocks can potentially gouge the liner, and chips of steel can cause further damage to the liner (and the die).

Improved Supervision of Extrusion Process

The operator must be positioned to watch the loading of the billet and block. However, the correct position should be at the platen so the operator can watch (in mirror or closed-circuit TV) the extrusions moving from die to the puller or run-out table.

Less Wasted Time at the Press

Time is wasted when the mechanical dead cycle of the extrusion press, as designed and engineered by the press builder, is extended by events occurring at the extrusion press. Placing or manipulating the floating dummy block for alignment is a common occurrence during which the dead cycle is interrupted.

Reduced Dead Cycle Time

Not only does the fixed dummy block eliminate the events referred to above, but the stem can also be moved faster without danger of dislodging the loose dummy before it had properly entered the container.

However, the fixed dummy block is not without its disadvantages. The successful expanding fixed dummy block is a complex product designed to operate at high temperatures and pressures for many thousands of press cycles. It must be properly engineered and maintained.

Some disadvantages of the expanding fixed dummy block include the following:

- The extrusion press must be properly aligned, and must be kept in alignment for long periods of time.
- The expanding, replaceable fixed dummy block must be maintained.
- Initial costs are higher for the fixed dummy block.

FIXED DUMMY BLOCK EVOLUTION

Evolved from a simple yet effective tool, the latest generation of blocks is a high-tech device that incorporates the results of extensive research and development.

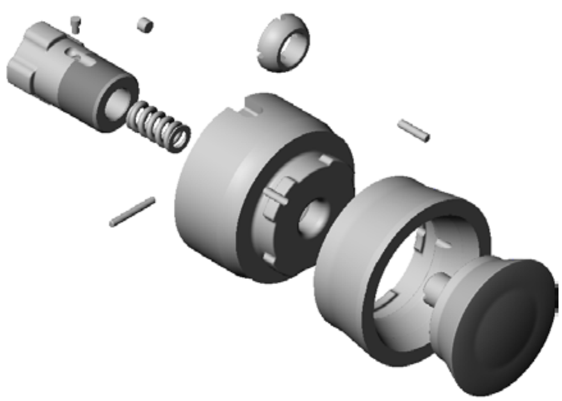


Figure 2. The components of the Castool E3 block.

Block Mechanics

To be effective, a dummy block must be designed to have a smaller outer diameter than its floating block counterpart. The increased clearance when the block is at rest allows for adequate air removal during billet upset, and ensures that the dummy block can be pulled back through the container easily at the end of the extrusion cycle. Then, under the pressure of extrusion, the block must expand to a proper working size. This expanded diameter must be large enough to prevent back extrusion while leaving a layer of aluminum within the liner.

An extremely effective approach to achieve expansion is by means of a tapered mandrel (also know as a cone), which is forced back into the block as pressure is applied from the billet. Axial pressure is redirected into a radial force that pushes against a surrounding ring, thereby expanding the block's outer diameter. As the pressure is released, the block contracts to its original state, so that it is free to retreat through the container.

A limited taper design effectively controls the amount of mechanical expansion and internal stress levels. Compared to a free-moving taper, this principle puts less stress on the surrounding ring, allowing it to have a thinner design. Therefore, less force is required to expand the block and the block reaches full expansion sooner in the extrusion cycle. This design is more flexible, which guarantees block contraction when pressure is removed.[3]

LATEST CASTOOL RESEARCH

In order to adapt dummy blocks to an ever-evolving market, it is necessary to fully understand the mechanics involved. This gives the ability to not only suggest optimal clearances, but also allows reasonable estimates for specialty applications. A strong knowledge base can be used to extrapolate designs for presses with severe pressures and temperatures.

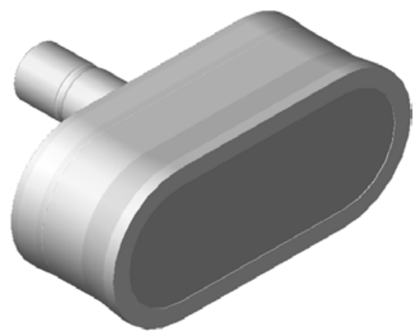


Figure 3. New geometries applied to a rectangular dummy block for the Japanese market

Recent analysis of the fixed dummy block has given an unprecedented understanding of the mechanics involved during an extrusion cycle. The latest evolution of replaceable ring blocks has been investigated using finite element analysis, along with physical and on-site testing.

Within the current dummy block design, there are many factors determining the action of expansion. An in-depth study examining the mechanics of the replaceable ring and mandrel has been performed.

The expansion/contraction properties of the dummy block ring are dictated by the stress-strain curves for the ring material (see Figure 4).

Initially, the strain varies linearly with the stress following the elastic modulus (denoted by O-A below). If the load is removed before the yield strength (O'_A), then the ring will return to its original size with no residual strain (elastic deformation).

Loads beyond the material yield strength are no longer linear, but follow a much more complex, experimentally determined curve. If the load is taken to O'_B and then released, the ring will gain a permanent deformation O-O' (plastic deformation). When the ring is similarly loaded again, it will follow the line O'-B, giving it a larger elastic range than before. This is known as work hardening, allowing the ring to withstand a higher load without undergoing further plastic deformation.

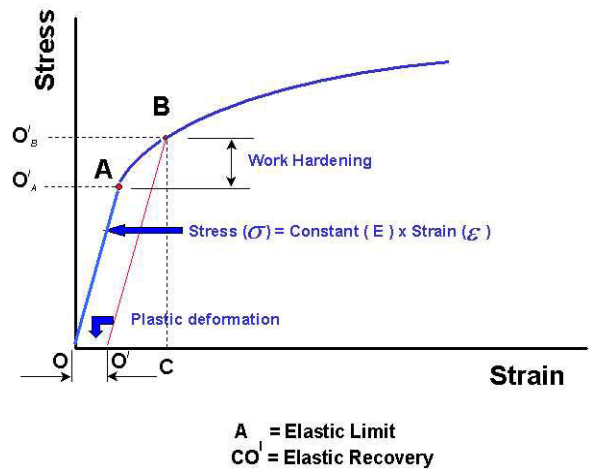


Figure 4. Stress/strain curve for tensile loading

The design of the block must take this curve into account, since the repetitive expansion and contraction of the dummy block ring will have to remain in the elastic range. One way to control the amount of ring expansion is to alter the amount of mandrel travel. By doing so, yielding of the ring can be controlled.

We can determine the amount of acceptable strain within the ring by looking at the stress/strain curve for the material at operating temperature. The mandrel and ring geometries can then be appropriately designed with the help of Finite Element Analysis and experimental testing.

Until recently, it was commonly assumed that the amount of ring expansion was equal to the amount of overlap between the inner diameter of the ring and the outer diameter of the collapsed mandrel. However, since the ring and mandrel are made of the same material (H13 hot work steel), displacement is shared by both components.

The amount of force expanding the ring is also contributing to the compression of the mandrel (see Figures 5 and 6).

We can see that the amount of actual expansion would be much less than previously thought. Therefore, the design must compensate for this in order to achieve the desired amount of expansion.

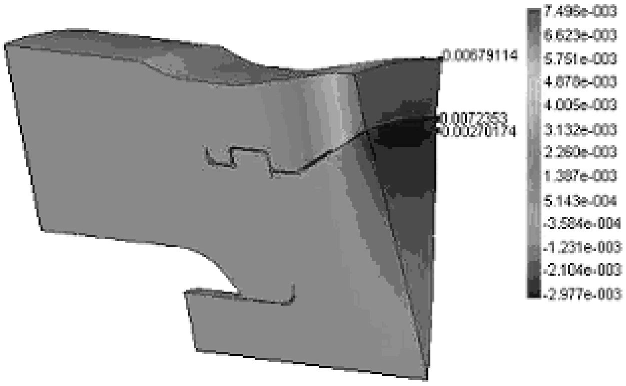


Figure 5. Pie slice of dummy block showing radial displacement in collapsed mandrel and ring

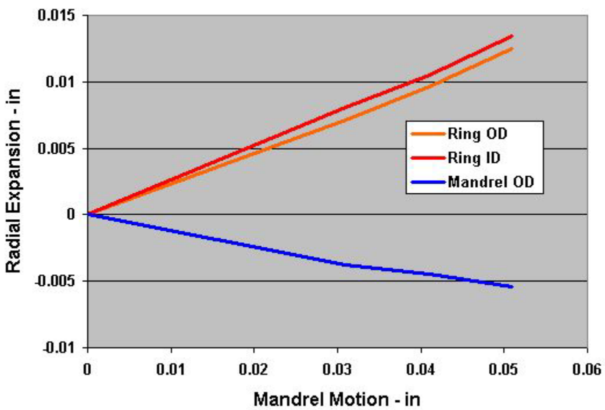


Figure 6. Radial displacement of mandrel and ring with mandrel motion

One more factor to consider is non-mechanical expansion of the ring after the mandrel has collapsed. As pressure in the extrusion cycle increases, the block diameter grows due to the properties of steel. This further expansion gives the plastic deformation that can be measured on the outer diameter of used blocks. Since this expansion is inevitable, it is taken into account when designing the block so as to not affect the block's performance. Fortunately, the increase in pressure also affects the inner diameter of the liner. Since this expansion affects both the block and liner at a very similar rate, proper clearances are maintained as shown in Figure 7.

By altering several variables in the block's geometry, it is possible to achieve different expanded outer diameters, while starting at the same relaxed diameter. Alternatively, the same expanded diameter can be produced from blocks with different relaxed diameters. Depending on press specifications, it may be advantageous to have a smaller ring with greater expansion, versus a larger ring with less expansion. Alloy, temperature, extrusion (die) ratio, and extrusion duration are some of the factors that must be considered when designing a block for a specific customer.

Figure 7. A cross-sectional view of the deflection of dummy block and container. Radial distortion has been exaggerated for emphasis.

SUMMARY

There are many strong reasons for extruders to switch from floating to fixed dummy blocks. This change, however, should not sacrifice tooling performance or extrusion quality. Many innovative progressions in tooling design have led to the development of extremely reliable, high quality tooling which satisfy the needs of today's demanding market. State-of-the-art engineering software is now being used to further advance extrusion-tooling designs. No longer are fixed dummy block design modifications simply reactions to reccurring problems. They're being designed with strong understanding and foresight. It's getting harder and harder to call a block a "dummy".

REFERENCES

1. Takagi, Shigeyoshi. *Light Metal Age*, October 2000, Vol. 58 (9,10), p. 6-20.

2. Examined utility model application publication, JP.55-014411.Y (1980), JP.54-020441.Y (1979), JP.59.002891.Y (1984), etc.

3. Bessey, G., "The Fixed Dummy Block," *Proceedings of Fourth International Aluminum Extrusion Technology Seminar*, Vol. II, cxxii, Chicago, Illinois, April 1988, Vol. II, Aluminum Extruders Council and The Aluminum Association.