The Critical Interaction of the Dummy Block and Container in Modern Extrusion Presses

In an optimized extrusion process, it is important that the tooling system be virtually invisible by performing consistently to the highest standards. The objective of course, is to produce extrusions to the correct alloy composition, with no surface defects, no inclusions, and dimensionally and mechanically compliant for the intended application. To enable this at high productivity levels, with good process control and consistency, minimal variability is essential. Well designed and maintained dummy blocks and containers play a key part in achieving these objectives. With precise container and dummy block technology in place, interacting well together, the extruder can be comfortable that the process will continue efficiently and with minimal interruptions and delays.

The dummy block must repeatedly pass smoothly through a perfectly round and straight container, while maintaining a constant clearance between itself and the container liner. This produces a controlled skin of alloy residue on the container liner, making it able to clear that skin during stem retraction, or when loading a new billet. A reliable container tooling system is therefore the hidden heart of any successful extrusion process.

Recent equipment developments through advanced finite element analysis and design have improved front loading direct extrusion presses with high quality main components and materials. Improved alignment, advanced hydraulics, and controls have led to a new era in extrusion with excellent equipment utilization and uptime with short dead cycles of <15 seconds on typical 8 inch presses, and with longer container lengths, up to 1.3 m.

The potential for improved extrusion productivity using the new generation of presses can be significant—longer billets lead to increased contact efficiency percentage (i.e. live cycle time expressed as a percentage of the total cycle time including dead cycle), which is also influenced by much shorter dead cycles. In addition, the newer presses, with improvements in component reliability, electronics, controls, and tooling, result in reduced downtime and increased utilization of capital equipment.

Dummy Block Design

A dummy block is a critical tooling element in the aluminum extrusion process. During an extrusion cycle, the dummy block is exposed to severe high stress and low cycle fatigue; yet it must expand in a controlled manner and, on release of extrusion pressure at the end of the cycle, must retract clear of the inner diameter of the liner plus any alloy skin. Under high specific pressure situations, the high stress amplitude can lead to plastic deformation making the dummy block diameter increase steadily over time losing its ability to expand and retract as designed.

A typical press in common use today extrudes commodity products in 6063 or 6060 alloy, operating at specific pressures of around 50-65 kg/mm² (70,000-85,000 psi), with maximum billet lengths no more than approximately four times the billet diameter. For example, a direct rear loading 2,000 MT/210 mm press with a specific pressure of 58 kg/mm² extrudes up to 32 inches (810 mm) long billets. Considering a modern front loading press of 25 MN force with a 210 mm container (8 inch billet), the specific pressure is 74 kg/mm² (105,000 psi) and a maximum billet length of 47 inches (1.2 m), or almost six times the billet diameter—28% higher specific pressure and 47% longer billet length capability compared to older design presses.

Figure 1 illustrates the effect of billet length on specific pressure, and why today's longer container presses must operate with higher tonnage for a given container diameter, and at higher specific pressures to maintain the necessary die face pressure to enable extrusion under optimal conditions.

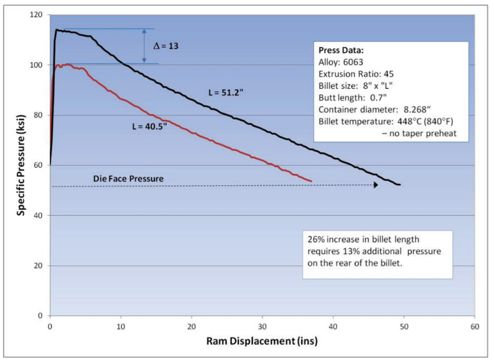

Figure 1. Specific extrusion pressure for two different billet lengths.

Such higher specific pressures directly impact a dummy block's mechanical integrity. Figure 2 reveals that under a high specific pressure of 84 kg/mm² (120,000 psi) the dummy block ring and holder are already subjected to stresses higher than the material yield strength at operating temperatures. After a few extrusion billets, the dummy block is likely to lose its ability to retract. This excessive plastic deformation can lead to aluminum buildup, blisters, container explosions, and extrusion surface finish defects.

Castool has introduced new high-pressure dummy block that has evolved from a simple yet effective basic tool to a technically sophisticated device that incorporates the results of extensive research and development using finite element analysis to improve its performance. Figure 3 shows the newly developed dummy block, operating under 84 kg/mm² (120,000 psi) specific extrusion pressure. The high stress areas are almost eliminated and

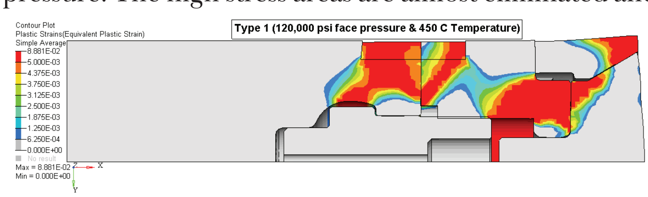

Figure 2. A dummy block under 84 kg/mm² (120,000 psi) specific extrusion pressure.

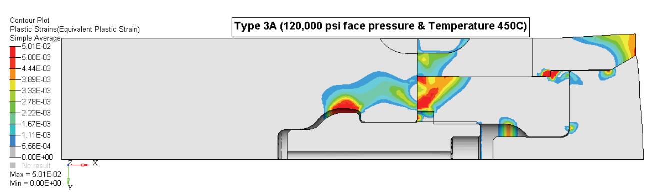

Figure 3. New high-pressure dummy block under 84 kg/mm² (120,000 psi) specific pressure.

the dummy block is now able to expand repeatedly under high pressure and maintain a secure seal with the container wall, leaving a desired thin film of aluminum alloy on the liner.

Container

During extrusion, deformation heat is generated within the billet and transferred in part to the container. The heat generated depends on the billet length, billet temperature, alloy types, extrusion speed, and extrusion ratio. The temperature can increase by as much as 150°C near the deformation zone immediately in front of the die. This increase in temperature can induce surface cracking, affect extrusion run-outs, and disturb alignment. A combination of this thermal effect and mechanical expansion under varying applied pressure during an extrusion push can result in a changing clearance between the dummy block and container, and a resulting variable alloy skin thickness on the liner. Simply put—nothing in extrusion is uniform.

A container with a built-in stable thermal gradient is the optimal extrusion condition. The mantle becomes a large thermal heat sink, efficiently and safely extracting heat without introducing thermal stresses. Physically, a heat sink can absorb any arbitrary amount of heat from target without significantly changing the target temperature. Three key components are required for heat sink: 1) a temperature gradient between target and surface of heat sink, 2) high thermal conductivity materials of heat sink, and 3) constant physical contact of target and heat sink. Quick response cartridge heaters positioned near the liner maintain a constant and stable thermal gradient. A high thermal conductivity material used as a heat sink in the container mantle, with the liner as a target, can take away a large amount of heat without significantly changing the liner temperature. The mantle is always contacting the liner by a controlled shrink fit, ensuring contact along the entire available surfaces. The liner exit temperature can be stabilized and maintained at approximately 30°C below billet temperature at all times, controlling and reducing forward billet surface inflow onto the extrusion, reducing potential surface finish scrap.

The Critical Interaction

Dimensional control of both the dummy block and the container during extrusion is important. The role of temperature and mechanical deformation of both must be fully understood.

It is generally recognized that 0.015 inches (0.4 mm) is the preferred maximum gap between the dummy block and the container during the extrusion process. If at any time the gap is too large, alloy may penetrate the space and flash or blow-by can occur. If the gap becomes too little, there is a danger of interference that may cause excessive wear on both the dummy block and the liner. Both situations can increase the likeliness of blisters and defects in the extrusion.

The interaction between the dummy block and the container is therefore critical. Unless each is operating at close to optimum efficiency, the operating life of both may be substantially reduced. Figure 4 shows the expansion curves of a typical dummy block and conventional two-piece container design. It clearly shows that the dummy block will plastically deform around 100,000 psi and cause aluminum build-up, blister and container explosions.

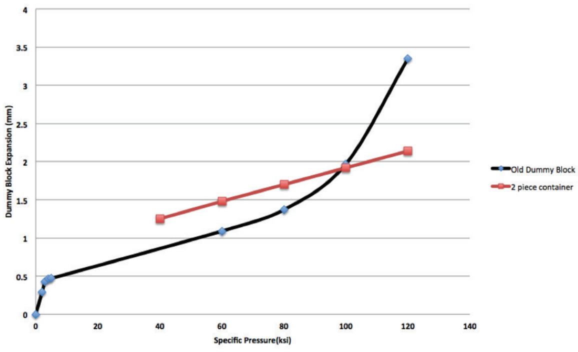

Figure 4. Typical dummy block and container expansion behavior.

Ideally, the dummy block and container should expand and contract in harmony under variable conditions throughout the entire ram stroke of an extrude cycle. This produces a constant container skin thickness, thus minimizing billet surface inflow—helping to maintain good extrusion surface finish by also minimizing blow-by and alloy build up on the dummy block, which can intensify billet surface flow effects, but also generate a blister defect on the extrusion. Optimized container and dummy block designs for long containers (such as an 8 inch press up to 1.3 m container length) and specific pressures up to 85 kg/mm^2 (120,000 psi) are being developed.

Figure 5 shows the expansion curves of Castool's new high pressure dummy block and three-piece subliner container design. The new high-pressure dummy out-performs a typical dummy block. The gap between container liner, and the outer diameter of the dummy block is controlled to be around 0.5 mm all the time. Currently further work is in progress to both model and test the relationship between container expansion and dummy block expansion, as well as the resulting mechanism for container skin control.

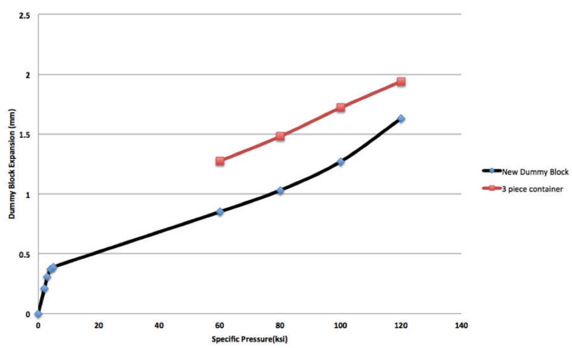

Figure 5. The interaction of new high-pressure dummy block and three-piece container.

Conclusion

To best benefit from today's longer container presses, the extruder must understand the interaction between the dummy block and container at high pressure. The dummy block needs to be able to function under high extrusion pressure. The container needs to have minimal deflection under high pressure and be able to dissipate extrusion heat. Only then can the extruder maintain the maximum ram speed for the die throughout the entire extrude cycle. The only limiting factor should be the alloy being used and the required dimensional and mechanical properties of the part and its finish. An absolutely reliable tooling system is in truth the hidden heart of any successful extrusion process.