How to Choose Between a General Bolster and a Tailored Insert

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Editor's Note: "FEA in Extrusion Die Design" is an ongoing series dealing with the opportunities that finite element analysis (FEA) offers to the extrusion industry. Topics will include addressing extrusion defects through die design, the effect of die design on aluminum microstructure, novel approaches to prototyping, and more.

Extruded channel profiles have been known to have geometry defects since the industry first developed. These defects typically occur when the die legs pull back while the base side of the die is simultaneously running, which causes the gap to close. Extruders can combat this tendency by improving the temperature management during extrusion (for example, isothermal extrusion can reduce the differences between the beginning and the end of the push) and supporting the die with the best backer, bolster, or other support possible in order to reduce die deflection. Regardless of these efforts, die caps can deflect under load, thus causing the bearings to not work flat and causing the geometry defect to occur.

In this situation, the die maker can make his own contribution to minimize the defect by selecting a design that minimizes cap deflection (discussed in a previous article from the August 2019 issue of *Light Metal Age*), as well as helping the extruder to choose the best support option among the ones available. This article will discuss the process of selecting the best support option. In particular, the article will investigate the difference in given support among tailored inserts and general "U" shaped full bolsters.

Case Study

Figure 1 is showing a channel profile and the die design used for the case study. The die set is three pieces (feeder, cap and backer), all made of H13 hot work tool steel hardened at 48 HRC. Figure 2 shows the stack assembly options investigated in order to quantitatively evaluate the effect of different support practices on tool deflection. The total support thickness is fixed; therefore, the thickness of the full bolster and bolster-holder are both equal to 10 inches. Assembly A and B vary based on the thickness of the insert that is held by the bolster-holder, which is 3 inches and 6 inches, respectively. Meanwhile assembly C is comprised of a die and bolster only. For completeness, the schematics of Figure 2 show the geometry of the pressure ring that was included in the FEM model.

Flow simulations were performed using HyperXtrude software and tool stress analyses were conducted using the Altair SimLab multiple physics approach. Steady state simulations were performed, considering the use of a 7 inch direct extrusion press and a 420°C liner. The study considered the extrusion of a preheated AA6063 billet (700 mm long) at 480°C (same as the die and bolster), with a ram speed of 10 mm/s. Attention was paid to the preparation of the 3D CAD models and an almost identical size of the tetra-elements were adopted for each model of workpiece and tool.

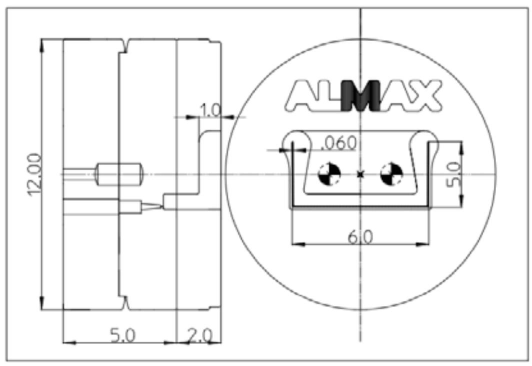

Figure 1. The channel profile and die design under investigation (dimensions in inches).

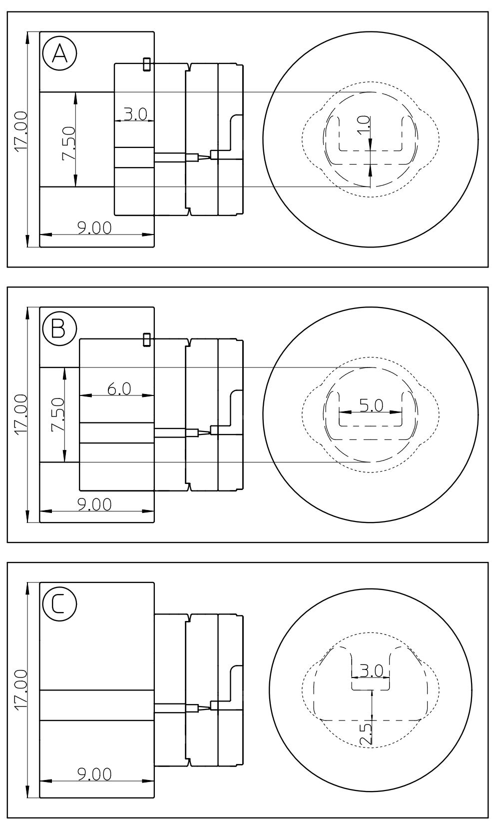

Figure 2. The die assembly options investigated by means of FEA (dimensions in inches), with the dotted line representing the pressure ring shape and the short dashed shapes representing the inserts and bolsters. The bolster-holder bore is a circle with diameter of 7.5 inches.

Results and Discussion

Figures 3 shows a magnification of the tool set deformation under load for assembly A. It can be noticed that the bending of the cap in the extrusion direction is mainly concentrated in the region that is in direct contact with the aluminum flow. Results also show that, due to the big gap between the insert tongue and bolster-holder bore, the load is not being properly transferred to the bolster-holder. Thus, the lack of support given by the insufficient thickness of the insert becomes detrimental.

Figure 4 shows the element stresses in the bearings region for assembly B. For assemblies B and C, the stress is limited to the small radii at the base of the tongue. For assembly A, a high stress level was seen through the entire thickness of the cap, which could lead to incipient cracking.

Numerical results are summarized in Table I, showing the cap displacement in the extrusion direction for the three geometries investigated. The measurement point was fixed on the cap at the contact with the backer. As expected, assembly A showed a significant cap deflection of more than 1.25 mm. Meanwhile, the adoption of a 6 inch thick insert (assembly B) did demon-

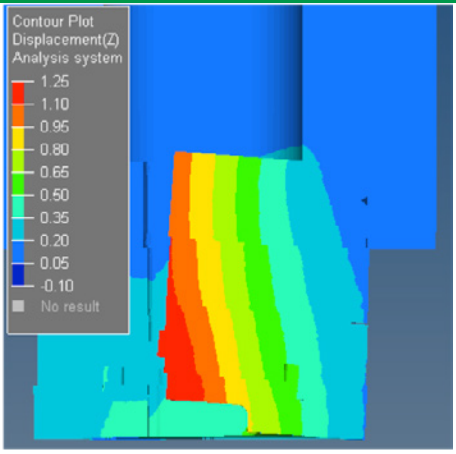

Figure 3. Magnification of the elastoplastic deflection for the complete tool stack of assembly A (values in mm).

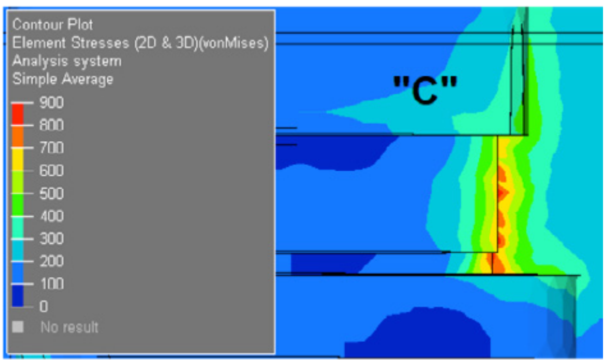

Figure 4. The element stresses in the bearings region of assembly B (measured in MPa). Assembly B showed lower stress on the cap section.

Assembly	CAP Deflection
A	1.25 mm
B	0.75 mm
C	0.75 mm

Table I. Numerical results for the three tool stack assemblies in terms of cap deflection in the extrusion direction (mm). The reference point is the contact between the cap and backer. Therefore, extruders should ban the usage of 3 inch thick inserts.

strate a strong reduction of the tongue deflection, down to 0.75 mm compared to assembly A.

Assembly C showed the same deflection as assembly B, thus becoming by de facto the best option. This shows that it is better to use a few general U-shaped bolsters than many tailored inserts, both from an economical and a handling point of view. Finally, it must be pointed out that, in the case of a rectangular-shaped bolster-holder bore (and not round), the results would have been different.

Recommendations

A relatively thin insert is not capable of properly supporting the die cap. Therefore, its adoption should be avoided unless the solid shape is without tongues and/or shows an high linear weight. The adoption of a tailored thick insert is as good as a general bolster used for different channel profiles. The recommendation is then to invest money in a new tailored insert only if a U-shaped full bolster is not available; in that case the insert should be at least 6 inches thick. ■