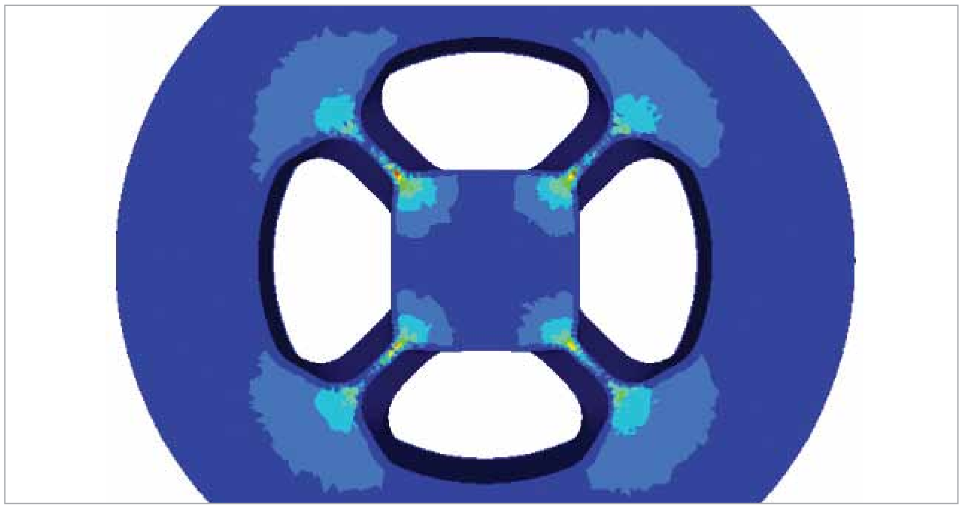
Extending Extrusion Die Life Using HyperXtrude



Key Highlights

Industry
Aluminum extrusion

Challenge
Shorter die life and frequent die failures are critical factors that affect the productivity of extrusion of hard alloys.

Altair Solution
Altair® HyperXtrude® is used to predict die performance and run virtual die tryouts. Using these capabilities, die designs can be modified and tested to improve the die life and reduce the number of die trials.

Benefits
- Extend the service life of the mold
- Decrease the cost of production

Customer Profile

In recent years, there is a significant increase in the use of aluminum extrusions in a wide range of applications such as, automotive, aerospace, railway, medical, architectural and other industries. These applications have stringent strength and surface quality requirements; and often require use of newer alloys and in some cases hard alloys. Advances in Chinese aluminum fabrication technology are helping address these challenges and meet the ever increasing demands from both domestic and international markets.

One of the challenges in extruding hard alloys and newer alloys is the applicability of existing die design practices. These guidelines tend to produce dies that have shorter life. This results in increased production costs and decreased productivity. After extensive research, the Conglin Group organically combined design philosophy, manufacturing experience and its skills in using the finite element simulation software HyperXtrude to overcome these challenges. By analyzing the extrusion dies using HyperXtrude and interpreting the simulation data, Conglin is able to predict the service life of an extrusion die accurately.

The Challenge:

A well performing extrusion die not only produces high quality products but also help increase productivity. The two most important factors that determine the

Keywords: Conglin Group, HyperXtrude, Aluminum Extrusion, Stress, Die Life

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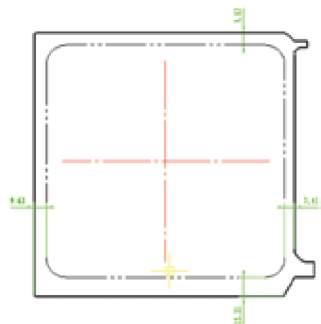
life/productivity of a die are the levels of stress concentration and their distribution. The stiffer the extruded material, the harder it is to extrude, and it results in higher levels of stress in the die, thereby causing it to fail quickly. Hence, the service life of a die used for extruding hard aluminum alloy is often short and has low production efficiency. In this case study, analysis and experimental results of two different designs of a die used for extruding hard alloys conducted by the Conglin group are presented. This study clearly demonstrates the value of using HyperXtrude in understanding and overcoming the design challenges posed by hard alloy extrusions.

Results and Discussion:

Extrusion of a hard alloy, AA5083, was performed at the process conditions listed in Table 1. The shop floor tryouts and HyperXtrude analysis were performed using these conditions for both the die designs. The image on the right shows the cross-section of the extruded profile.



Cross-section of the extruded profile.

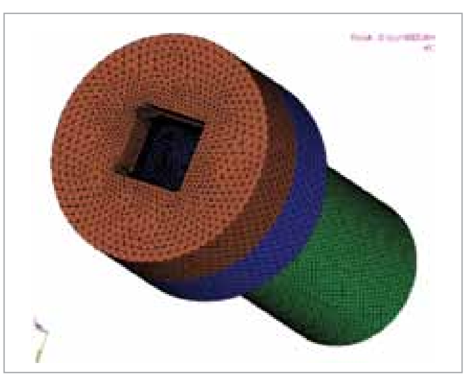
Alloy	Billet Diameter	Billet Preheat	Die Preheat Temperature	Container Preheat Temperature	Ram Speed
AA5083	460mm	500 °C	490 °C	450 °C	1.2mm/s

Table 1: *Process Parameters*

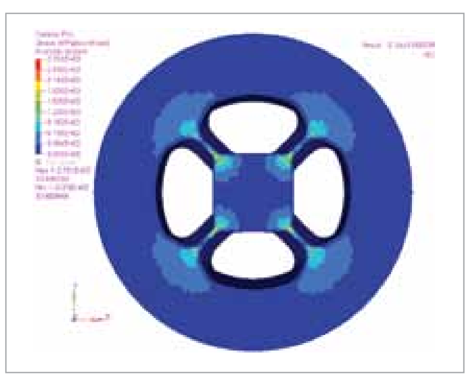
Die Design I

In the first design die is made of two components: die-cap and mandrel (below). Stress contours in the mandrel and die cap are shown in the images below. These images clearly show the regions of stress concentration and their intensity.

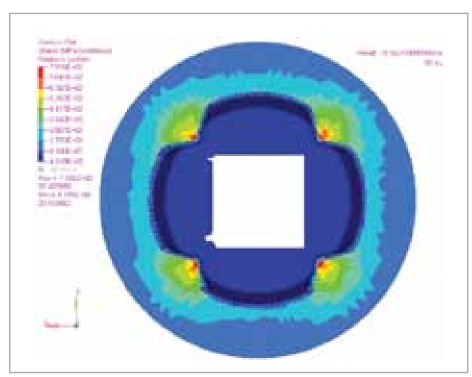
According to the simulation results, maximum stress in the mandrel is very high near the bridge, and it will cause the die to break in this region. The predictions matched with observations from the extrusion press data. The die fractured at the root of the shunting bridge after extruding just 10 billets.



Die set is made of two components, die cap and mandrel.



Stress contours in the die mandrel. A maximum stress of 2751 MPa occurs at the root of the shunting bridge.



Stress contours in the die cap. Image shows a maximum stress of 792 MPa in the pier region.

Mandrel cracked in the bridge region as predicted by the HyperXtrude analysis.

Die failed at the root of the shunting bridge after extruding more than 100 billets.

Die Design II

The second design of the extrusion die has three components (mandrel, die plate, and die cap). This design took the HyperXtrude results of the first die into consideration and adjustments were made to overcome the high levels of stresses. Another feature of this die is that it has several portholes feed material to different regions of the die and produces a balanced flow at the die exit.

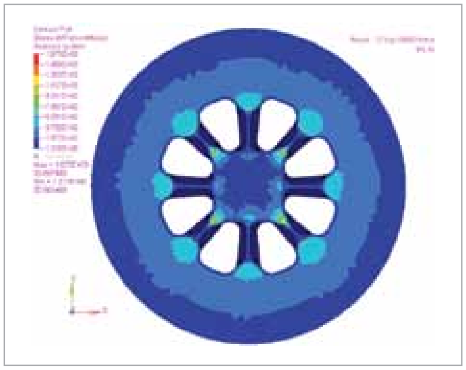
The maximum stress in the second design in the bridge region is less than the first die, thereby extend the die life. This is confirmed from the press data. The new die did not fail even after extruding 100 billets. At this point the die surface wear becomes a factor. This shows that using HyperXtrude, we were able to extend the die life, increase productivity, and reduce production costs.

Results and Conclusion

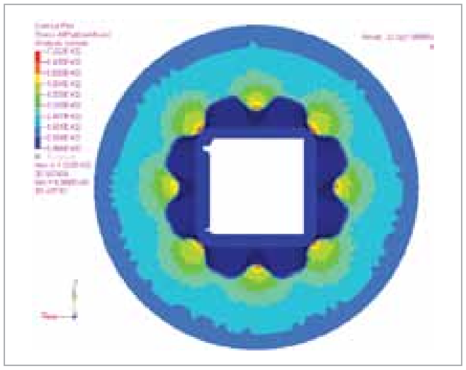
Conglin group performed this study on many different dies; after repeated and large-scale comparisons between the simulation results and the experimental results, and following conclusions were reached. Production life of an extrusion die is critically dependent on the maximum stresses – especially in the thin regions of the die.

This was observed while extruding profiles under a range of process conditions.
In general, the higher the stress, the lower the profile production level and lower the service life of the die. Conversely, lower the stresses, the higher the profile production level and the higher the service life of the die. The service life of a die depends on both the level of stress concentration and the region where it occurs. For example, higher stress in bridge (thinner) regions is more critical than higher stresses in thicker regions of die cap.

HyperXtrude is a valuable tool for understanding the material flow and balancing the die. In addition, its use in tool deflection analysis helps to understand the die performance and improve the design to increase extrusion service life. By studying the die performance using HyperXtrude at the design stage, Conglin group is able to arrive at design that has the longest life and thus greatly reduce the cost of aluminum extrusions of hard alloys.



Stress contours in the mandrel. Root of the bridges had a maximum stress of 1675 MPa.



Stress contours in die cap. A maximum stress of 722 MPa is predicted in the pier regions.

The second design had a much longer production life and was able to extrude more than 10 tons of the alloy.

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