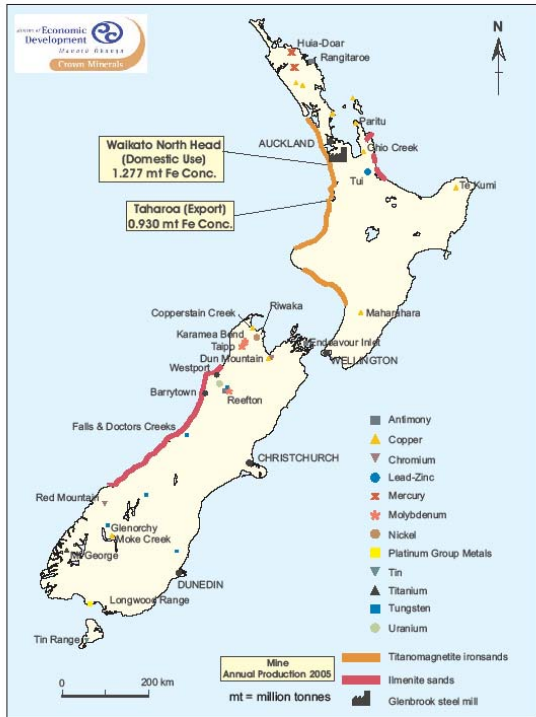


Optimization of pocket design for extrusion with minimal defects

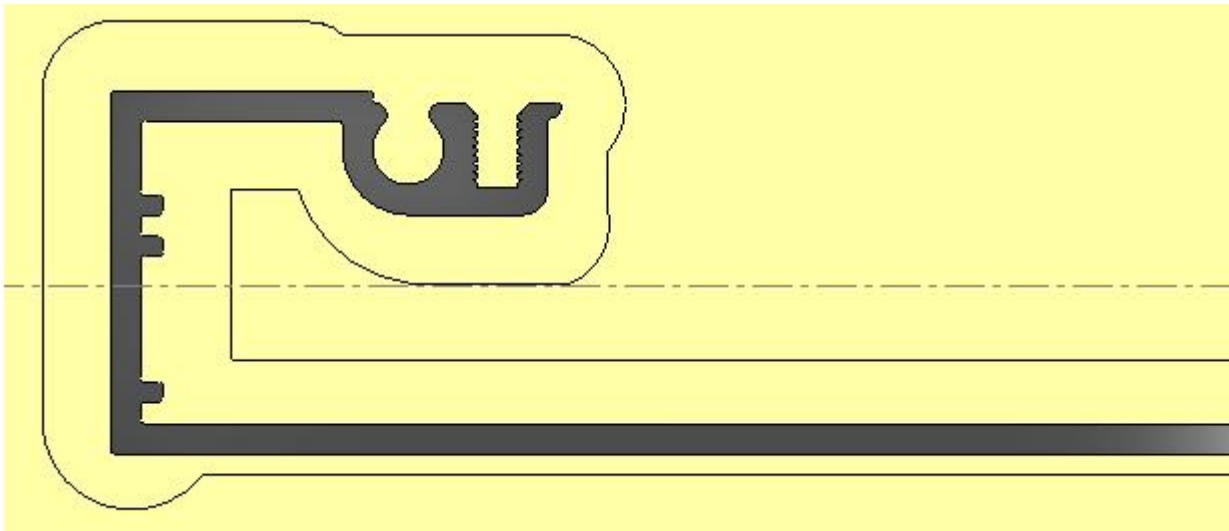
Kathirgamanathan, P., Neitzert, T.

New Zealand



The product considered for investigation

- Geometry of the die
- Material Al7075

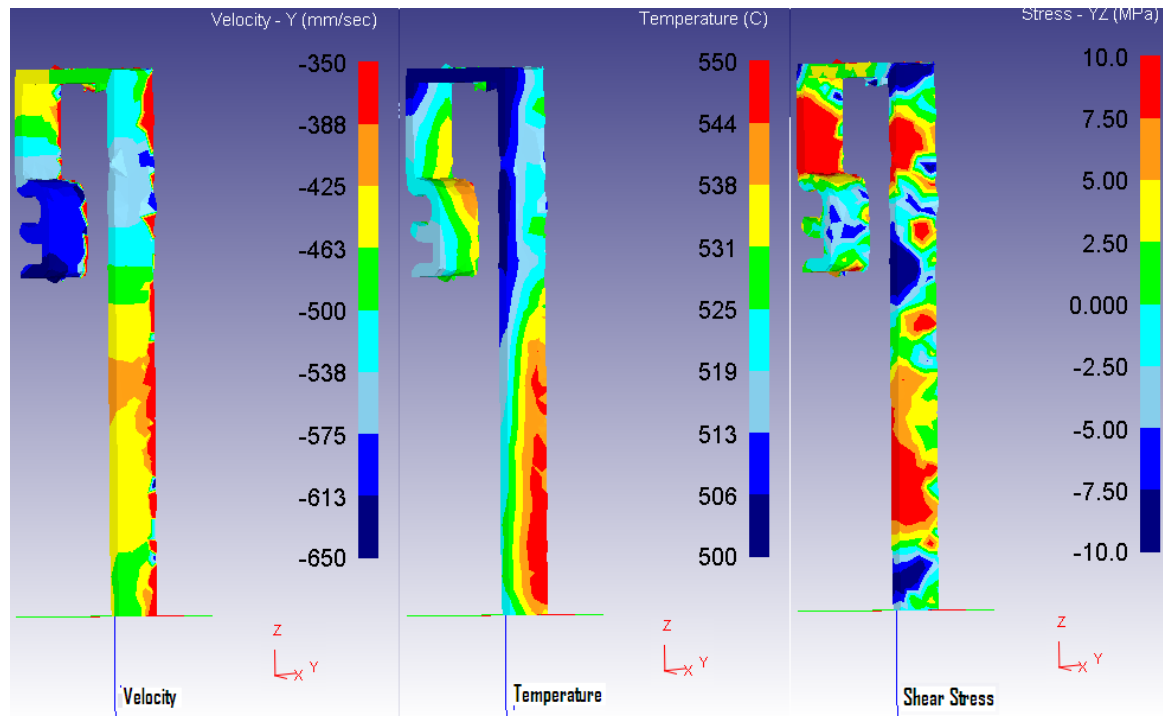


Surface quality problems

- The extruded product showed surface quality problems.
- After anodizing it had white lines along the extrusion direction that make an uneven visual surface.
- These lines tend to appear at different places on different production runs.
- These lines are seen as flow lines.

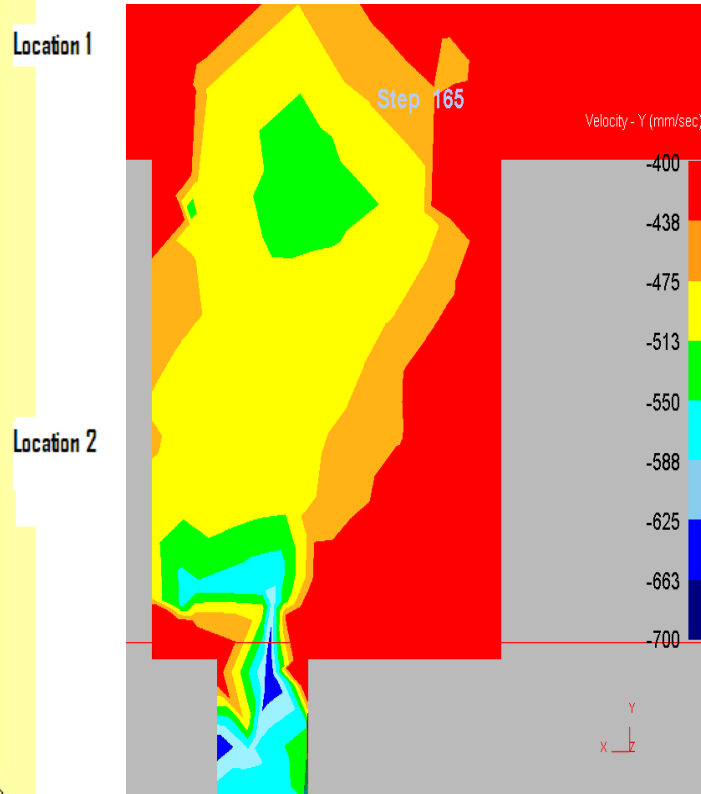
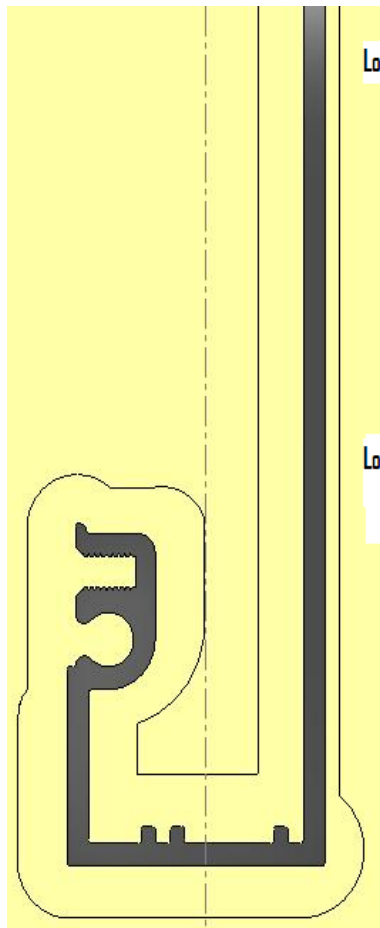
Initial product analysis

- Velocity, temperature, and shear stress distribution of the extruded product between the entrance and exit of the die.
- Initial billet temperature 450°C

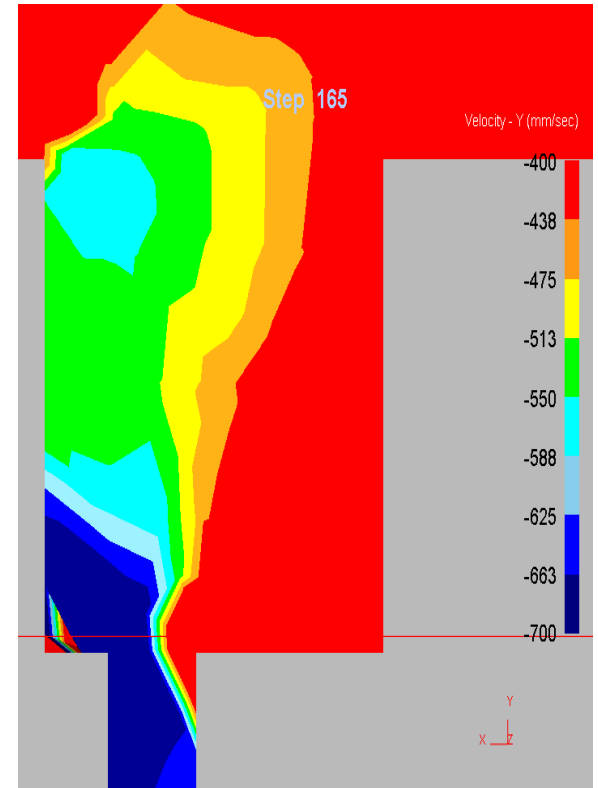


Initial product analysis cont.

Velocity distribution, cut plane XY



Location 1



Location 2

Observations

- It shows that the temperature, velocity and shear stress distributions are not homogenous.
- Further we found that the location of the higher stress area is moving with different initial billet temperature.
- All these results demonstrate the importance to improve the die design.

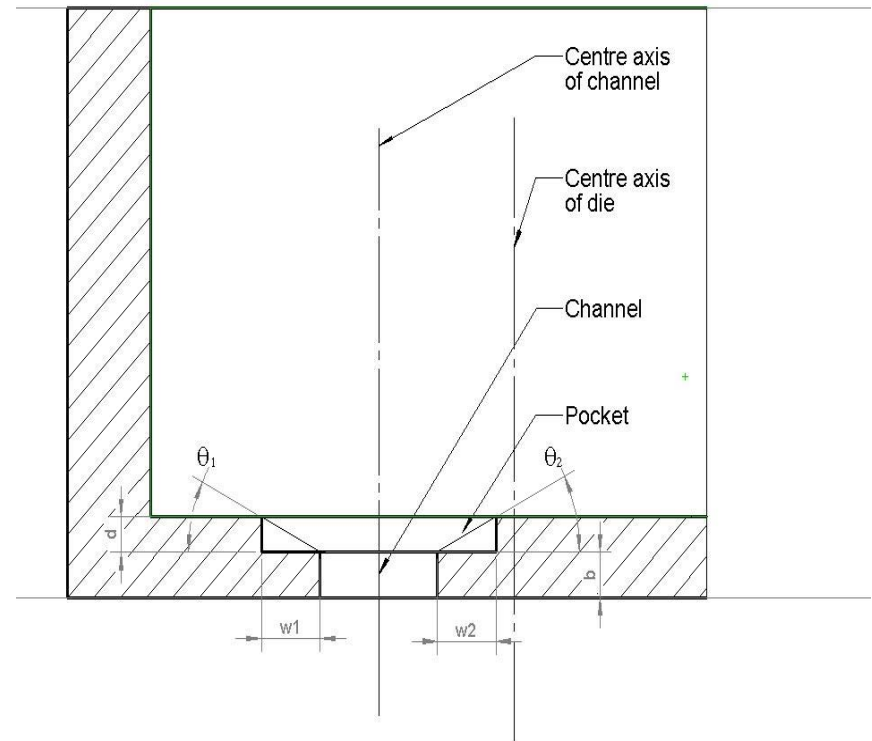
The surface qualities of extruded products

Depend on process and die design parameters.

- Process parameters are
 - Initial temperature of die and billet
 - Ram speed
 - Friction coefficient
- Design parameters are
 - Pocket depth
 - Pocket width
 - Pocket location

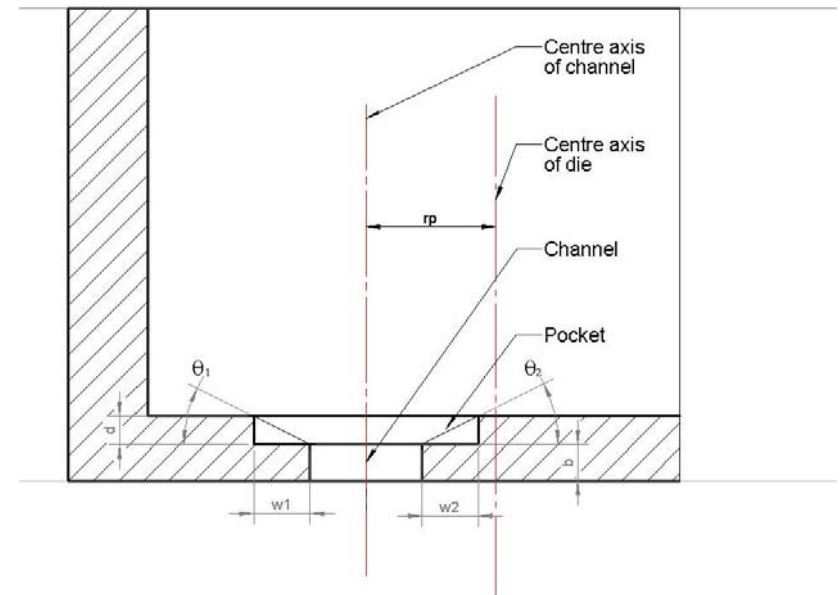
State of the art 1

- Li et al investigated the influence of pocket angle θ on metal flow.
- It has been shown that there is an inverse linear relationship between pocket angle and flow velocity, while $d^2 + w^2$ has kept constant.
- Pocket volume does not significantly affect the flow velocity.



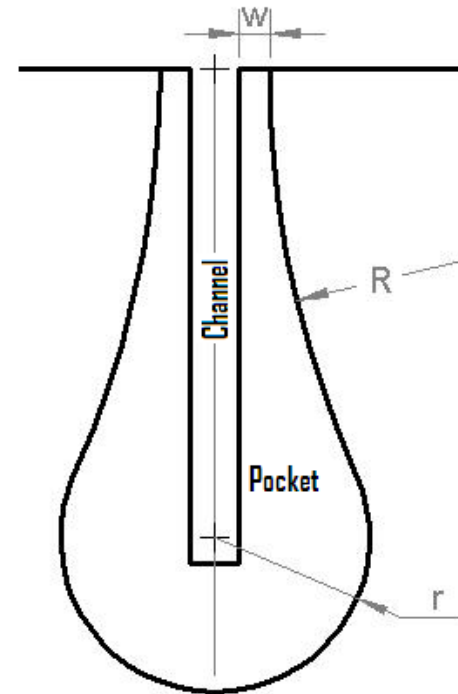
State of the art 2

- Peng and Sheppard demonstrated the sensitivity of the pocket axis location relative to the channel axis.
- They stated sensitivity of the difference $w_2 - w_1$
- Require more research to find the optimal difference between w_2 and w_1



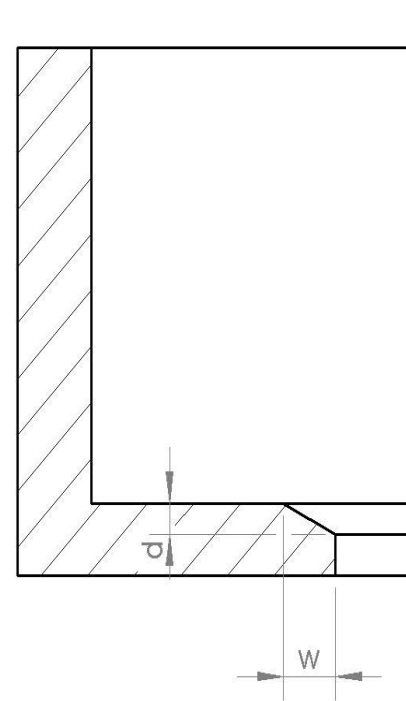
State of the art 3

- Fang et al designed the pocket to balance the metal flow.
- An increase in r leads to a significant increase in pocket cross sectional area and volume but it has very little impact on flow homogeneity.
- Changes in R lead to a significant impact on the metal flow.
- Pocket depth also significantly influences the flow speed.



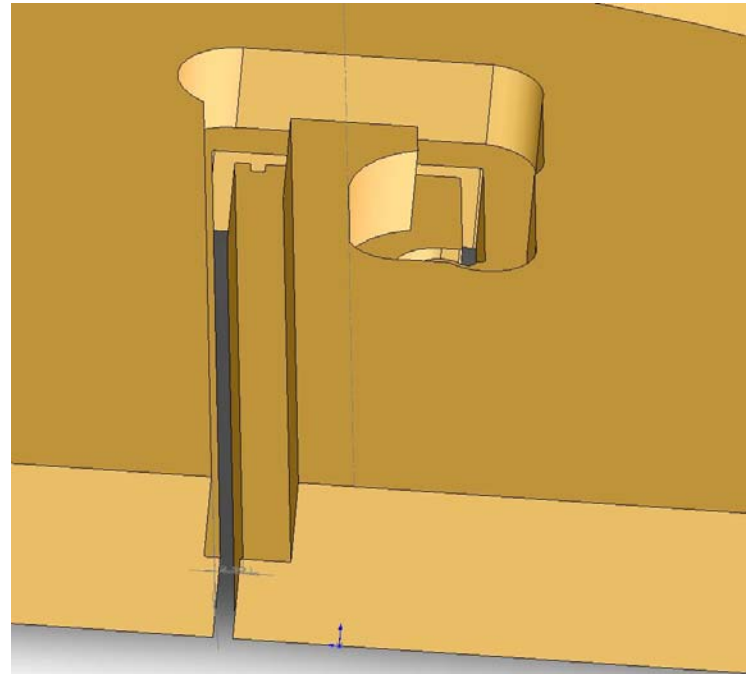
State of the art 4

- Yuan et al proposed a design with a guiding angle to reduce surface defects.
- They demonstrated using a series of numerical simulations that the metal flow is more homogeneous and the tendency to generate a dead metal zone is minimized.
- They also demonstrated that the axial stress on the die exit is decreased and therefore surface cracks caused by additional stress are avoided.



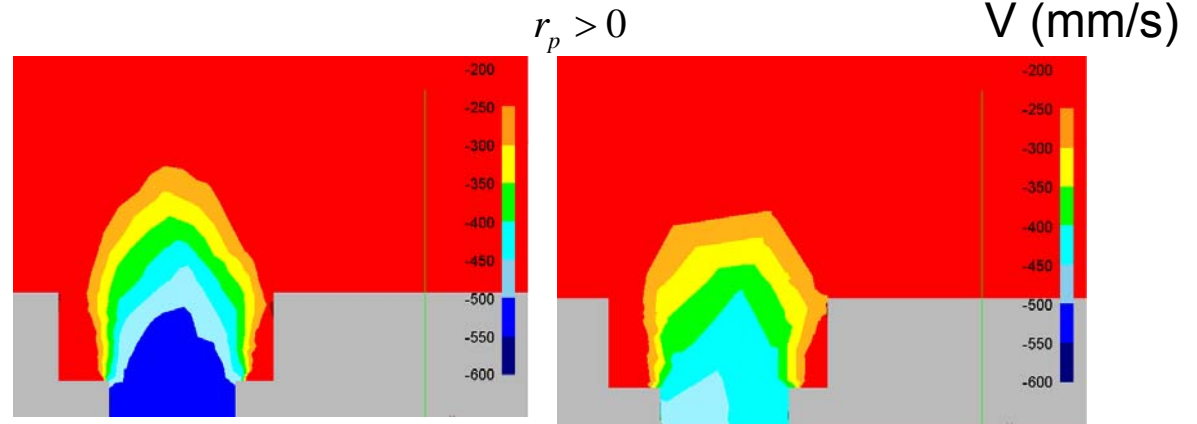
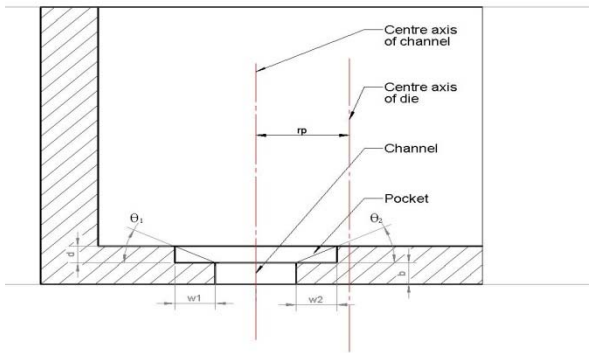
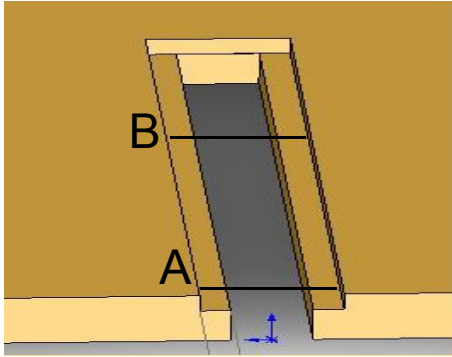
Analysis of the influence of pocket design parameters

- The surface finish of the extruded product is related to the flow pattern.
- The flow pattern depends on pocket design parameters
 - (1) pocket shape
 - (2) distance between the centre axis of the die and centre axis of the pocket
 - (3) pocket depth
 - (4) pocket width



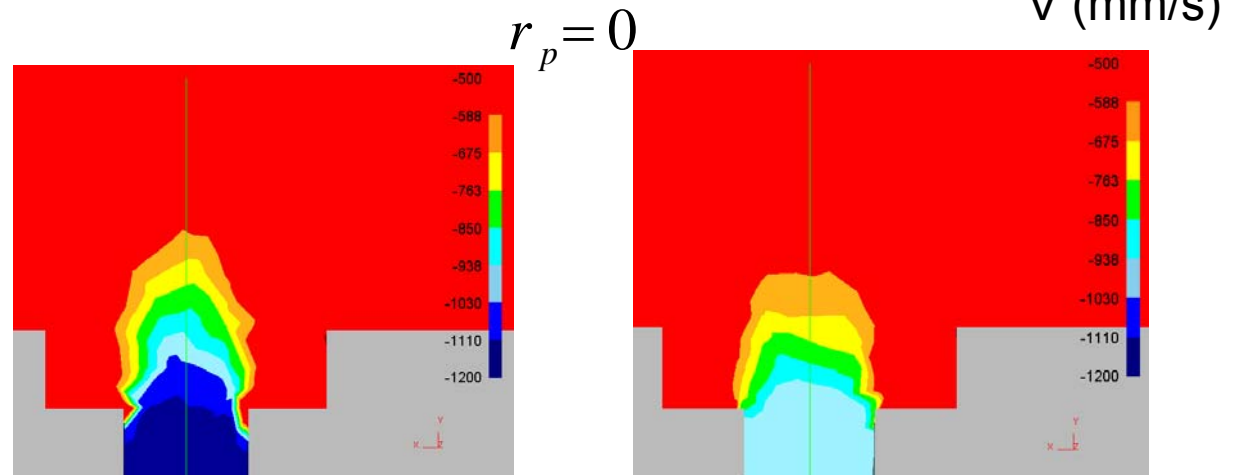
Influence of distance from die centre

Die Geometry



Position A

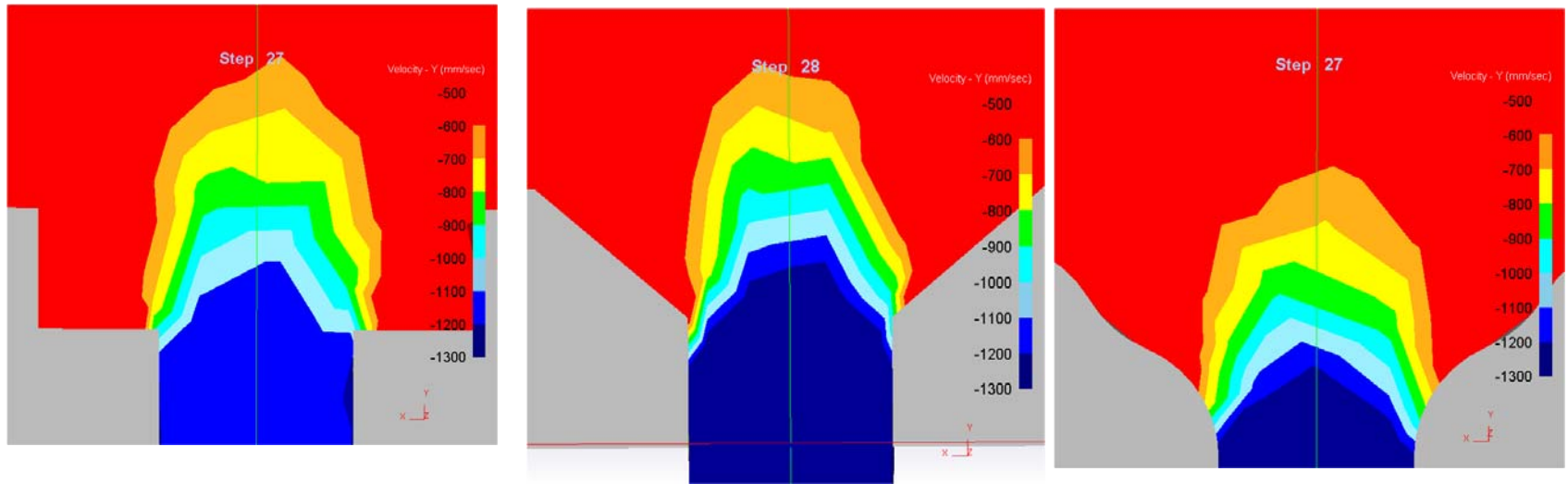
Position B



Position A

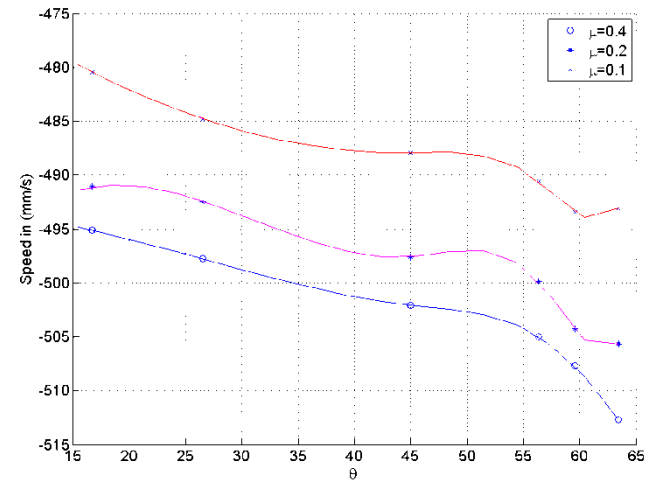
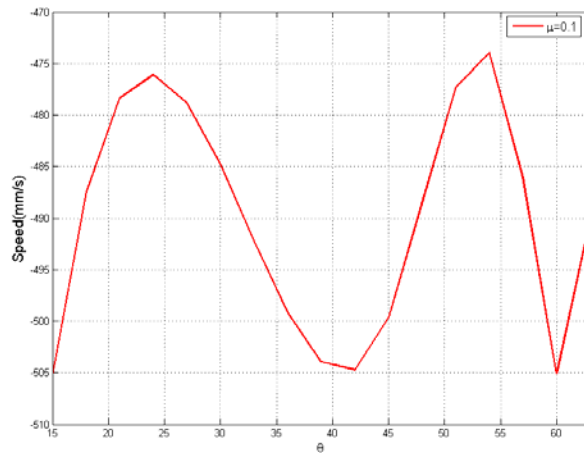
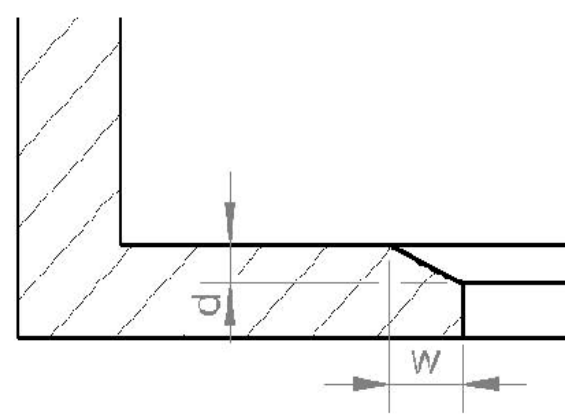
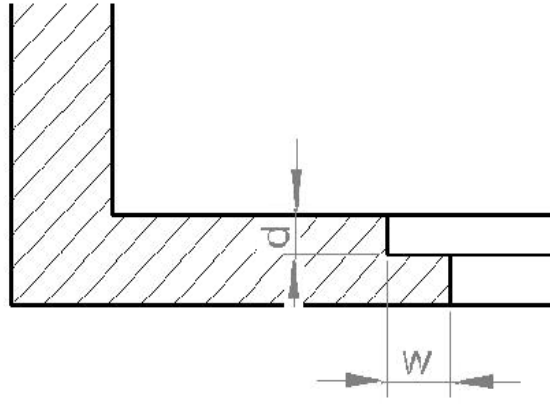
Position B

Influence of pocket shape



Shows homogeneity of flow with pocket shape:
(a) rectangle, (b) angle, (c) curved

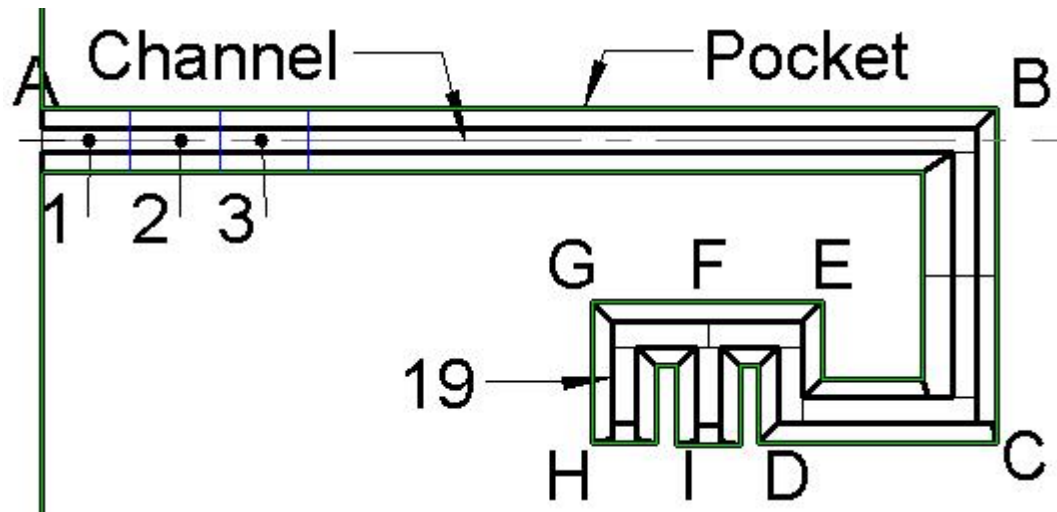
Influence of pocket angle



$$\tan \theta = \frac{w}{d}$$

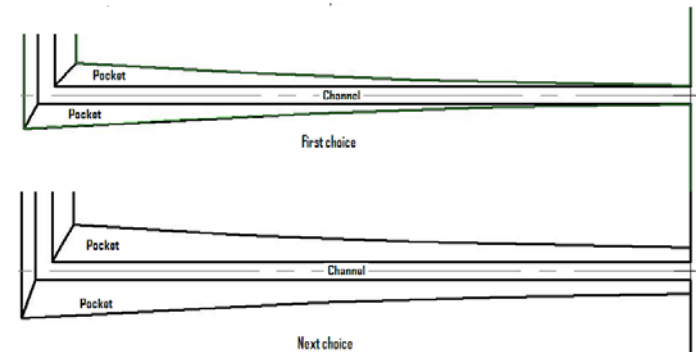
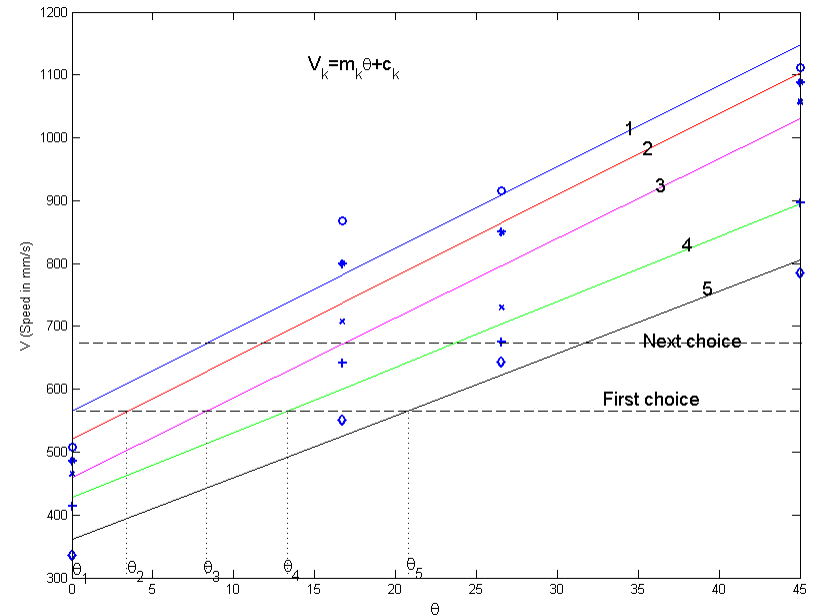
Die optimization

Geometry considered



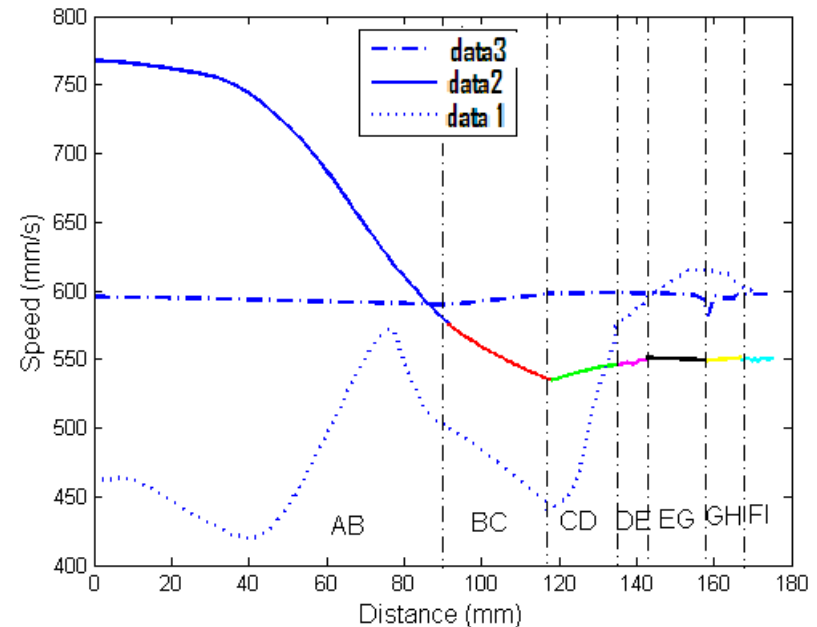
Proposed new design method

1. After dividing channel into n elements, we run at least three simulations with different pocket widths but every element has equal width value and note flow velocity across each element.
2. We use each element's velocity changes with θ which is obtained from the first step to calculate m and C of equation $V=m\theta+C$ by using linear regression. Then for each element we pick respective θ values for which their velocity equals the velocity of the first element (starting from $\theta = 0$).
3. We formed the outer boundary of the pocket by joining mid points of outer boundary of each element for the respective θ value by using spline. We repeat this process (step 2 and 3) for various different velocity ($\theta > 0$) of the first element until velocity variation along the channel is within a tolerance level.



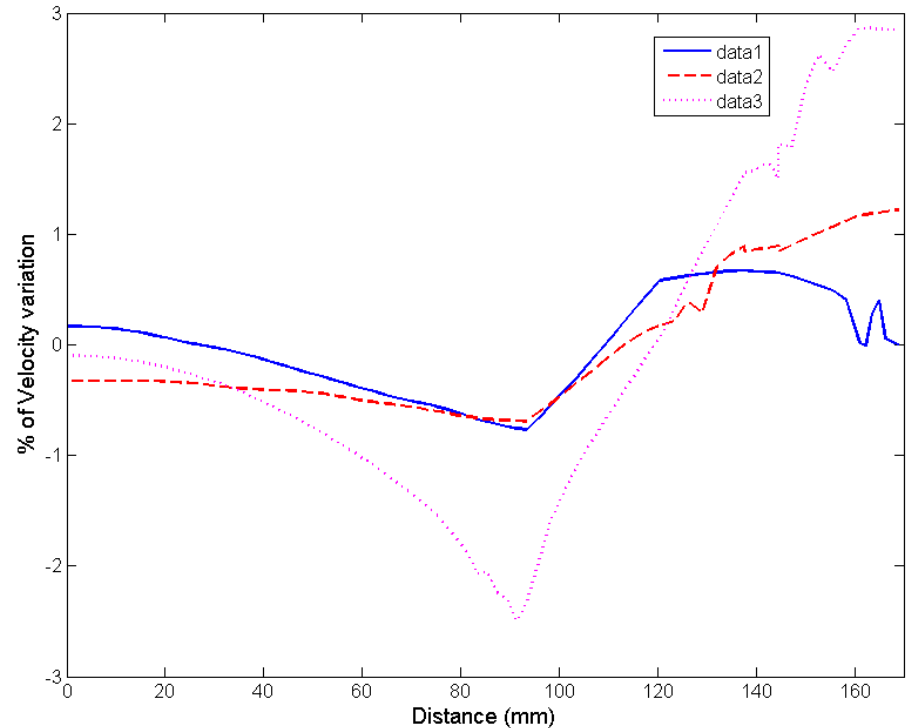
Comparison of velocity variation along die channel

- Data1 - Original
- Data2 - without pocket, but move to die axis
- Data3 - Optimal geometry

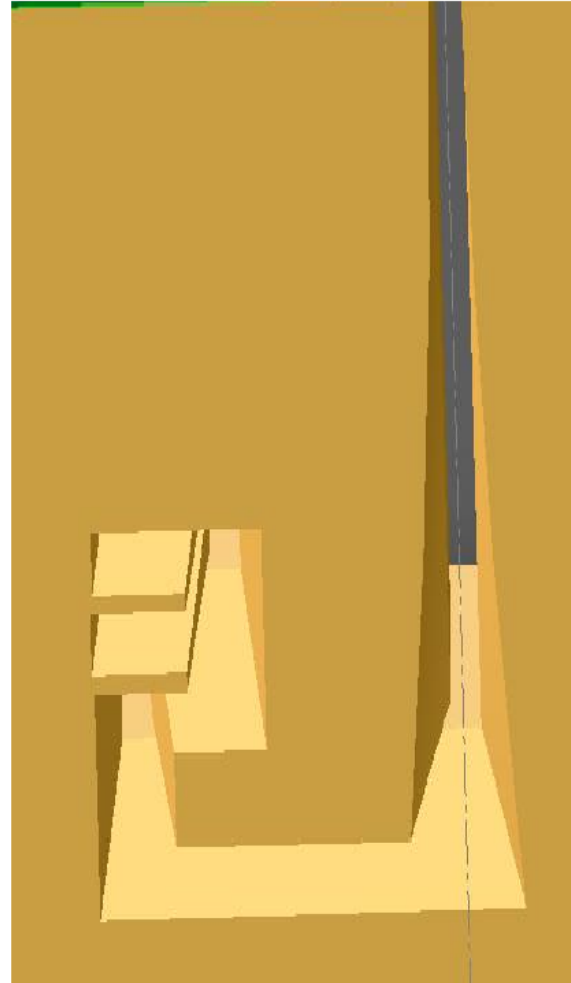
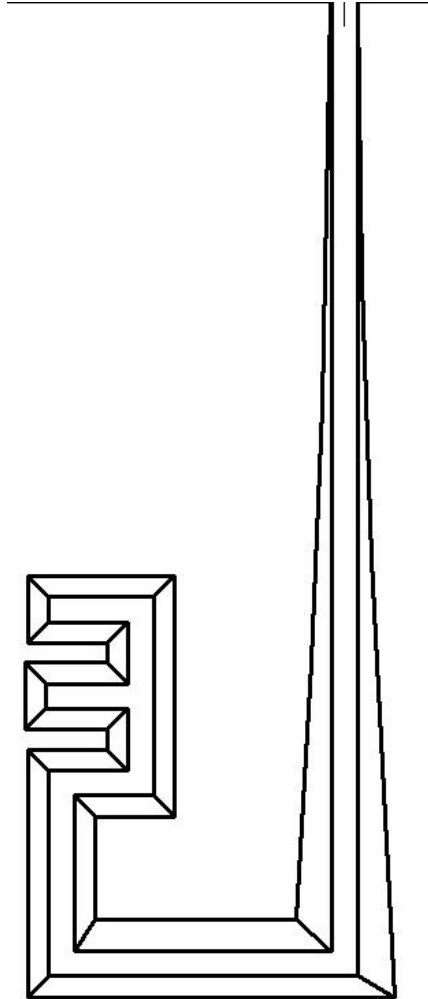


Comparison of velocity variation along die channel with optimal pocket geometry for other process conditions

- Data1
 $T_0=400^{\circ}\text{C}$, $v=25\text{mm/s}$
- Data2
 $T_0=400^{\circ}\text{C}$, $v=50\text{ mm/s}$
- Data3
 $T_0=450^{\circ}\text{C}$, $v=25\text{mm/s}$

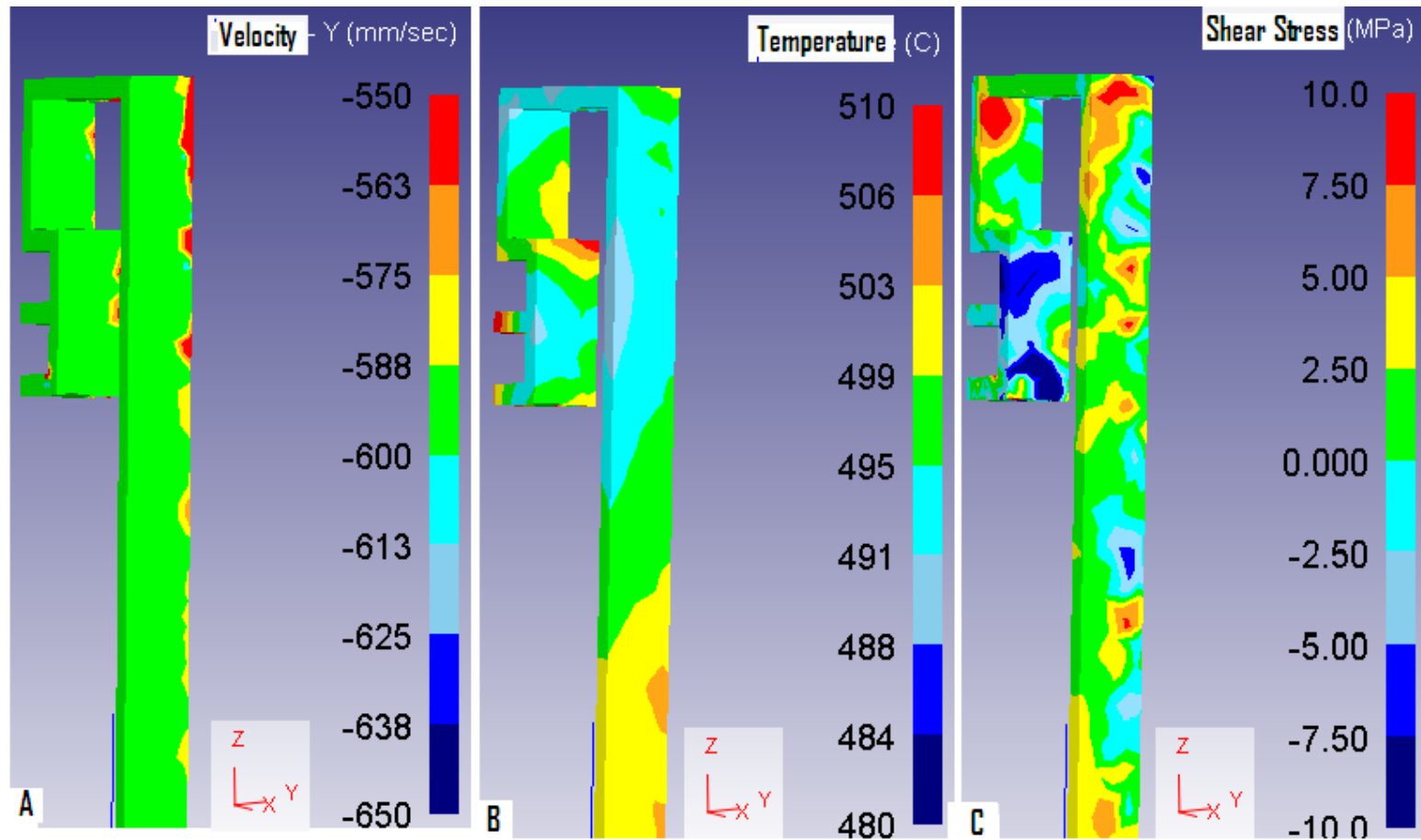


Optimal pocket geometry



Optimal pocket

Velocity, Temperature, Shear stress



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- Fang G., Zhou J., Duszczek J., and Wu. X. K, Key Engineering Materials, V367, 63-70, 2008.
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- Peng Z., and Sheppard T., Materials Science and Engineering A, V407, 89-97, 2005.
- Yuan Z., Li F., and He Z., Journal of Materials Science and Technology, V24, 256-260, 2005.