# Analysis and Optimization of Extrusion Process using Hyperworks

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*Abstract*— Minimizing the amount of scrap generated in an aluminum extrusion process. An optimizing method is constructed based on Simulation Analysis approach. In present thesis the Simulation approach is presented to optimize the amount of Scrap generated during Aluminum extrusion process. The model applied to real data obtained from an existing extrusion factory. Results from using the suggested model provided substantial reductions in the amount of scrap generated. Using sound simulation analysis approaches contribute significantly in reducing waste and savings when compared to the existing nonscientific techniques.

***Key words:*** Aluminium, Extrusion, Hyperxtrude

## I. INTRODUCTION

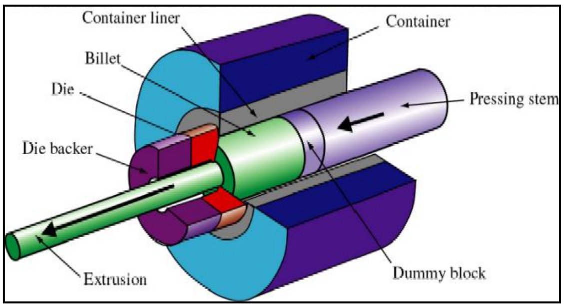
Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed or drawn through a die of the desired cross-section. The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections, and to work materials that are brittle, because the material only encounters compressive and shear stresses. It also forms finished parts with an excellent surface finish.

Extrusion may be continuous (theoretically producing indefinitely long material) or semi-continuous (producing many pieces). The extrusion process can be done with the material hot or cold.

### A. *Commonly extruded materials:*

Include metals, polymers, ceramics, concrete, play dough, and foodstuffs. The products of extrusion are generally called "extrudates"

### B. *Direct Extrusion:*




## II. LITERATURE SURVEY

Henry Valberghas done FEA analysis on unlubricated direct and indirect extrusion of aluminium alloys. Two identical axisymmetric DEFORM 2D FEM models were made, one for direct extrusion and one for indirect extrusion

Amin Farjad Bastani, Trond Aukrust) has done work on isothermal extrusion of aluminium. Transient finite element simulation of the extrusion process have been performed over 20 press cycles using the 3D finite element software Altair HyperXytrude 9.0 and 2D finite element software ALMA 2π.The best combination of process parameters for isothermal extrusion has been found and represented as so called isothermal maps for each phase of the press cycle.

**M. Noorani-Azad, M. Bakhshi-Jooybar** In this paper two types of dies are used for forward extrusion first is conical die and other is curved die. The effect of die profile on the variation of stress and load in the cold forward extrusion of aluminum has been studied. The aim of this research is the reduction in deformation load, improvement in the metallurgical properties of the product and increasing in the die life by means of an optimum die profile. By using the finite element software ABAQUS, the optimum die angle for the conical die in the same condition is determined .The finite element and experimental load –displacement curve have been determined. In the proposed work the optimal die profile is rod cold extrusion of aluminum with work hardening is obtained by using slab method. ABAQUS is used to obtain the optimum angle for a conical die in similar conditions. The results illustrate that the required load in the optimum curved die is significantly less than that in the optimum conical die. This implies that although manufacture of curved die profile is more difficult compared with the manufacture of conical die it will reduce the forming load and therefore, will increase the productivity of the production process.

**Irena Nowotynska, Andrzej Smykla** Composite billet with circular section sleeve in hard core vice versa used in the experiment. Investigations of the flow during extrusion were carried out using grid distortion method. Before extrusion the composite is first split in the two equal halves .The sample are cut by wire EDM and also by hack show .The square grid were inscribed on to the longitudinal symmetrical plane. The two billets were then reassembled together and extruded simultaneously .In all cases the process was stopped after 50% of the initial billet length was extruded and were pushed out of the container and split. The grid distortion was recorded and analyzed. Shape of the die has an influence on the plastic zones, which are formed during the extrusion process .Additionally in the case of the convex die there is a very substantial metal flow in the radial direction of sleeve material. This kind of metal flow is c characterized by more uniform velocity profile for the material passing through the die outlet.

Good assessment of a finished product means satisfactory surface condition, proper bonding of composite e components and appropriate property distribution within its section .The above condition will be fulfilled if the difference between flow velocity of core and sleeve material is as small as possible .The increase of die angle over 90 degree reduces composite layer outflow, especially sleeve material resulting in better bonding of composite .In the case of convex die metal flow is in a radial direction toward the die opening which has special significance in the case of extrusion of two different material. It follows then that sleeve material may slow down and pressed to the core material. As a result there may be better velocity equalizing of out flowing layers, providing a durable bonding of components.

Selective use of convex dies with specific geometry for specific layer composite results in better equalization of relative velocities of particles in a die outlet, thus justifying their use for extrusion process.

## III. OBJECTIVES:

- Minimizing the amount of scrap generated in an aluminum extrusion process.
- In present thesis simulation approach is presented to optimize the amount of Scrap generated during Aluminum extrusion process.
- The model applied to real data obtained from an existing extrusion factory.
- Apply simulation analysis approaches for calculating scrap amount in kg.
- Results comparison from existing conventional with simulation analysis method.

## IV. MATERIALS AND METHODS:

### A. *Aluminum Profile Production:*

Aluminum profile production (extrusion) process passes through several stages starting with castings where logs are produced; the logs are next cut into standard billets and are put into extrusion machine to manufacture profiles of different shapes and sizes. The extruded aluminum profiles are placed in the aging furnace in order to increase their durability and strength. Next, the profiles are polished thoroughly and depending on request are either sent for paining, or anodizing before shipping to the customer. In **Fig. 1**, the detailed process is presented for a specific extrusion company.

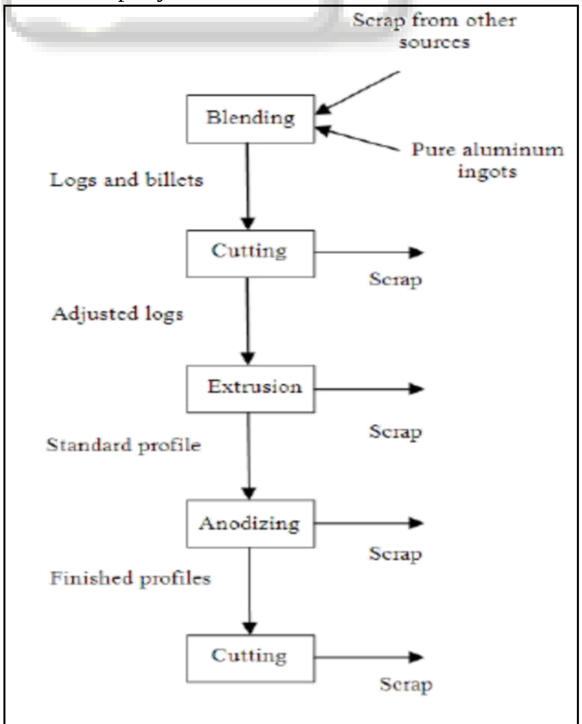



Fig. 1. Aluminum profile production process

### B. *Existing Process parameter:*

The Process parameters used in Existing Company are as follow.

- Alloy type: Aluminum (6063)
- Extrusion Ratio: 86
- Billet Length: 650 mm
- Billet Dia: 181 mm
- Ram speed: 6 mm/s
- Die Length: 152 mm
- Die Dia : 101mm
- Billet Weight: 45 Kg.
- Billet Temp: 540℃
- Die Temp: 410℃
- Die Material: Hot Die Steel H-13

### C. *Scrap Data:*

- Above process parameters are used in the Extrusion factory.
- Total Scrap per one Billet = **1.80 kg**

### D. *Problem faced in existing Extrusion Company:*

- Scrap generated is more.
- Time and cost for removing scrap is high.
- Product quality is poor.
- Productivity is reduced.

### E. *Proposed optimization method:*

- Using HyperXtrude 11.0 based on simulation analysis it is possible to calculate the Traverse weld length.
- The transverse weld length indicates the region where scrap generated.
- It is possible, with the Hyper view to calculate the amount of scrap generated.
- We can calculate the scrap amount in Kg.
- By changing various process parameters it is possible to predict scrap amount.
- Using Simulation analysis method we can reduce the amount of scrap generated.

### F. *Selection of process parameters:*

- Using Design of Experiment (DoE) concept 3 main parameter are considered for the impact on Scrap which are as follow.
  - Ram Speed,
  - Billet Temperature,
  - Die Temperature
- Existing Parameter set are as follow,
  - Ram Speed = 6 mm/Sec,
  - Billet Temperature = 540℃
  - Die Temperature = 410℃

### G. *DOE (Design of Experiment) method:*

- Using Design of Experiment (DoE) combination is derived with 5% variation on the parameter set.
- Following **Table 1** represents the various changed parameter set.
- Total combination = 2 * 2 *2 = 8 Simulation Analysis.

| Simulation Analysis | Ram Speed (mm/Sec) | Billet Temp ( ℃ ) | Die Temp(℃ ) |
|---|---|---|---|
| 1 | 5.7 | 513 | 390 |
| 2 | 6.3 | 513 | 390 |
| 3 | 5.7 | 567 | 390 |
| 4 | 6.3 | 567 | 390 |
| 5 | 5.7 | 513 | 430 |
| 6 | 6.3 | 513 | 430 |
| 7 | 5.7 | 567 | 430 |
| 8 | 6.3 | 567 | 430 |

Table 1: Experiment list table

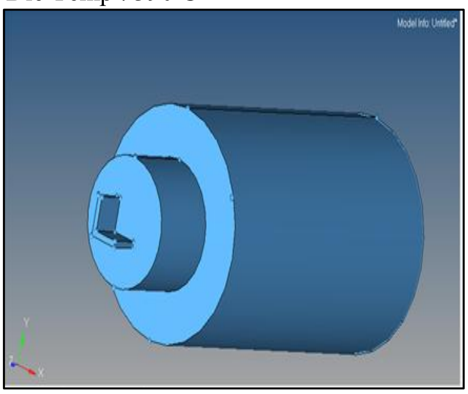
## V. SIMULATION ANALYSIS:

### *A. Steps:*

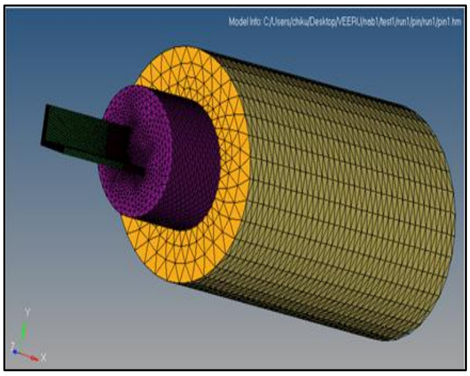
1) Standard L profile section is used for simulation analysis.
2) Using HyperXtrude 11.0 based on simulation analysis it is possible to calculate the Traverse weld length.
3) Generated Mesh file for simulation analysis.
4) Setting up the parameter for identifying Traverse weld length.
5) The transverse weld length indicates the region where scrap generated.
6) It is possible ,with the Hyperview to calculate the amount of scrap generated
7) We can calculate the scrap amount in Kg.
8) By applying various process parameters we can predict scrap amount.
9) Using Simulation analysis method we can reduce the amount of scrap generated.
10) There are 3 process parameters are changed for various Simulation analysis.
11) Total combination = 2 * 2 *2 = 8 Simulation Analysis.

The following data and process parameters are used in analysis.

- Ram speed: 5.7 mm/s
- Billet Temp : 513℃
- Die Temp : 390℃

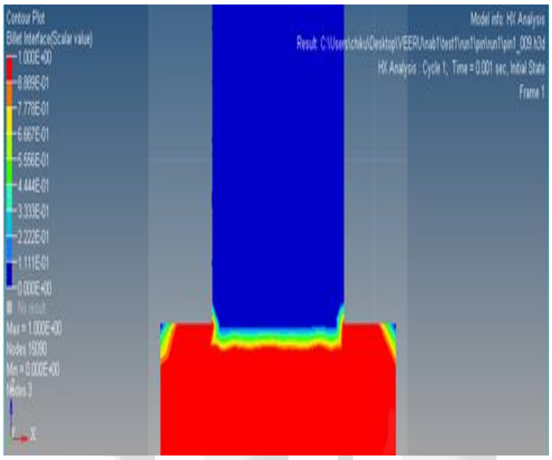


Model for Simulation

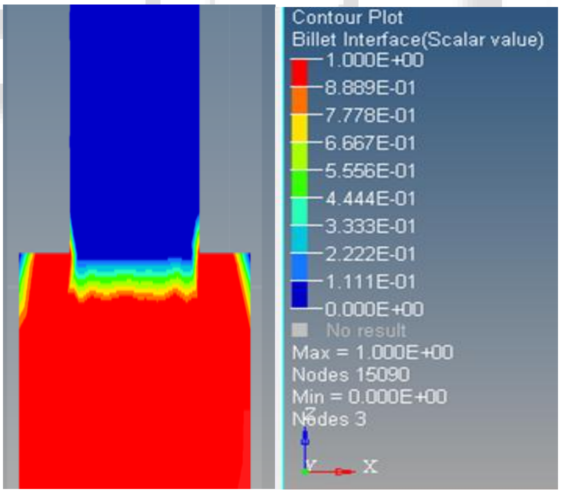


Meshing

### *B. Results obtained during Hyper View Simulation analysis:-*



Billet Interface




## VI. RESULT INTERPRETATION:

1) The High portion shows new Billet material.
2) The Low portion shows old Billet material.
3) The intermediate value indicate possible billet interface where a mixed of old and new billet exist.
4) So if we calculate area of mixed region we can predict possibilities of scrap.
5) And by fundamental equation we can calculate weight of scrap in Kg.

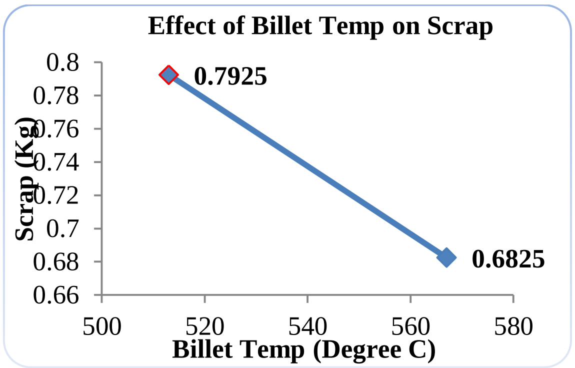
## VII. RESULT & DISCUSSION:

Following are the result generated for 8 simulation analysis.

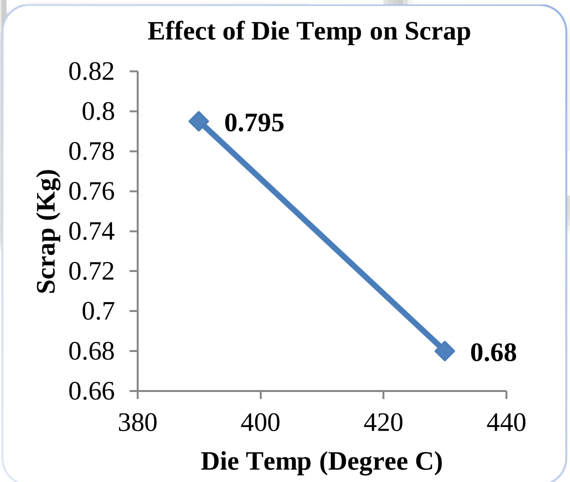
| Simulation Analysis | Ram Speed (mm/Sec) | Billet Temp ( ℃ ) | Die Temp ( ℃ ) | Scrap (Kg) |
|---|---|---|---|---|
| 1 | 5.7 | 513 | 390 | 0.98 |
| 2 | 6.3 | 513 | 390 | 0.83 |
| 3 | 5.7 | 567 | 390 | 0.69 |
| 4 | 6.3 | 567 | 390 | 0.68 |
| 5 | 5.7 | 513 | 430 | 0.68 |
| 6 | 6.3 | 513 | 430 | 0.68 |
| 7 | 5.7 | 567 | 430 | 0.68 |
| 8 | 6.3 | 567 | 430 | 0.68 |

Table2: Result

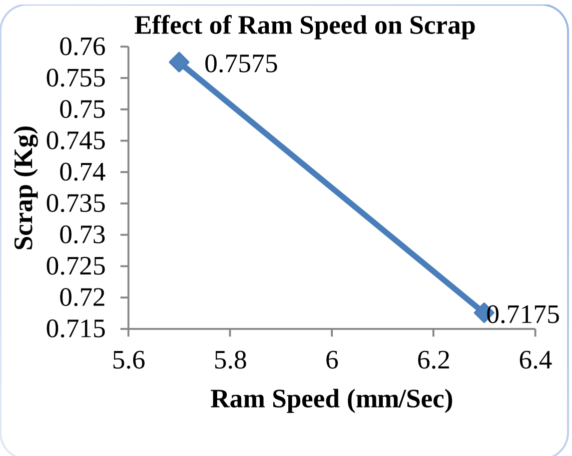
### A. *Result1: Effect of billet temp on scrap*




### B. *Result2: Effect of Die temp on scrap*




### C. *Result3: Effect of Ram speed on scrap*




When comparing the total amount of scrap generated as shown in **Table 2**, it is found that scrap using conventional method are more. The total scrap generated produced using the conventional procedure is around **1.80 kg** (average per Billet) whereas it is around 40-60% less using the suggested simulation analysis optimization method.

## VIII. CONCLUSION

1) The aluminum extrusion process produces a sizable amount of scarp; this mainly attributed to the techniques used and the lack of modern scientific experience of the staff.
2) In order to reduce the large amount of scrap, a thorough evaluation of the exiting cutting method should be carrying out.
3) In addition to reduce scrap, an effective an optimal simulation analysis method will contribute to efficient uses of time and other resources.
4) For example the use of the Analysis simulation tool (HyperXtrude) developed, the reduction of the amount of scrap generated ranged from 40-60% and this constitutes large saving.
5) Efficient scientific approaches and tools should be used in the different processes within industries; Simulation Analysis techniques are one of the strong tools that produce good results.
6) It is recommended that the extrusion company should substitute the existing methods with more cost effective approaches which are based on Simulation Analysis.

## REFERENCES

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[2] H. Sano, Y Yoshida Dept. of material science and engineering, Nagoya University Japan.
[3] Henry Valberg Norwegian University of science and technology, dept. of engineering design and material, Trondheim, Norway.
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