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DEVELOPMENTS AT TEMPERATURE CONTROL IN ALUMINUM EXTRUSION PROCESS

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ABSTRACT
Aluminum extruding companies aim to carry out their products cheaper, more quick, and more qualitative in the concept of continuously developing technology, and quality. For these reason they refer to some new arrangements to reach their goals. One of the important goals of producer companies is temperature control during the production process which is made possible with the developed thermal cameras on which were come applied for recent years. However controlling the temperature variations which is composed by continuous heat formation and heat passages is more difficult for many extruders. If the heat can be taken into control during the extrusion process, important gains can be obtained from the viewpoint of reaching higher quality, and efficiency in production. In these study, the factors affecting the extrusion temperature are investigated for the aim of production quality and efficiency. Also flowcharts and schematic process diagram for temperature control have been formed. In addition, recent developments about the subject is reviewed.
Keywords: Aluminum extrusion, temperature control, exit temperature, extrusion productivity.

1.INTRODUCTION
Aluminum is valuable material because of its lightweight, strength, formability, ductility, durability, corrosion resistance, conductivity and recyclability.
One of the known methods of the plastic forming applicable to aluminum, and its alloys is extrusion method.
Since the components with the complex shape made of various alloys can be formed by extrusion method, aluminum extrusion is used for many applications, such as, window and door frame systems, fabricated houses, building structures, roofing and exterior cladding, transport, road and rail vehicles, marine applications, aerospace etc [1].
Extrusion process is a plastic deformation process which is put into practice with compressing the billet through the die core by stam force (Figure 1).

2. EXIT TEMPERATURE
In the extrusion process additional heat increase occurs because of working under the big loads, and frictions. Exceptionally in some conditions, initial billet temperature is high and extrusion speed, and extrusion ratio is low. In this case, exit temperature can fall down. Figure 2 shows the variation of exit temperature against stroke time in different tests, carried out in Sistem Aluminum Company. Also Figure 3 shows the heat generation, and heat conduction in an extrusion process.

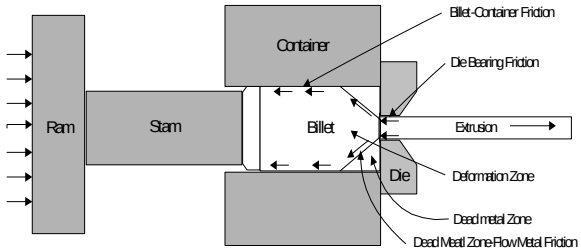

Figure1. Schematic Extrusion Process

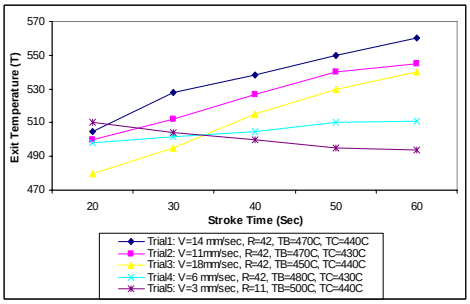

Figure 2. Different exit temp. with changed the extrusion parameters; T_B: Beginning billet temp., V: Ram velocity, R: Extrusion ratio, T_C: Beginning container temp.

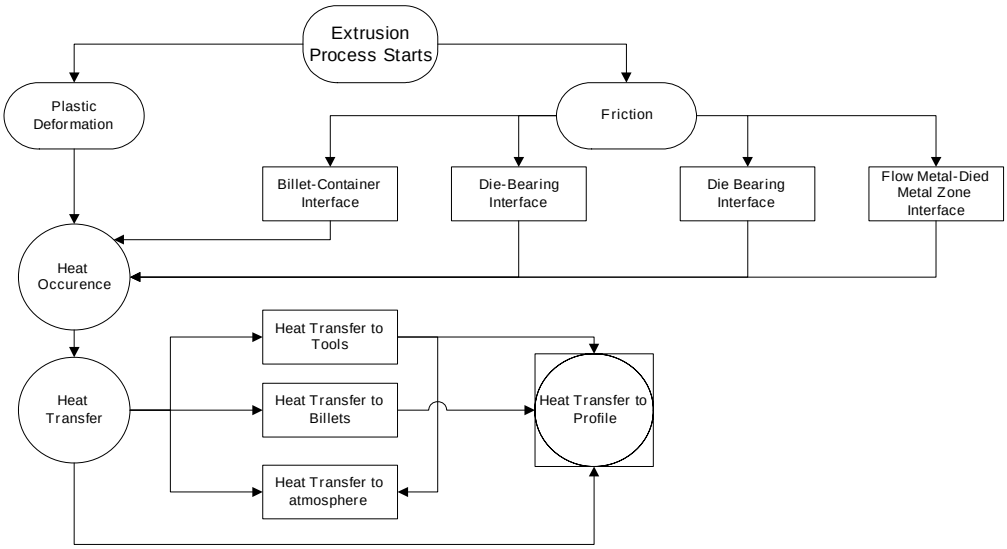

Figure 3. Heat formation and heat transfer in extrusion process

In the extrusion process, which is a complex application, a lot of factors effect to the exit temperature. The main factors are billet temperature, billet length, extrusion ratio, billet container interface friction, die bearing interface friction, flow metal-dead metal zone interface friction.

Billet temperature: It affects the exit temperature directly. In addition billet temperature generally increases along the extrusion stroke. For this reason billet is heated in different temperatures along its length in a lot of industrial extrusion applications. Figure 4 shows schematically a preheater and a billet with the different temperature regions.

Billet length: As the billet length increases, friction path also increases, so that heat generation causes a significant increase the exit temperature.

Extrusion Ratio ($R=Ao/A_1$): Exit temperature increases when the extrusion ratio (the ratio of billet section area to profile section area) is high. The reason of this is being high of the deformation amount in the high extrusion ratio comparing to the low extrusion ratios.

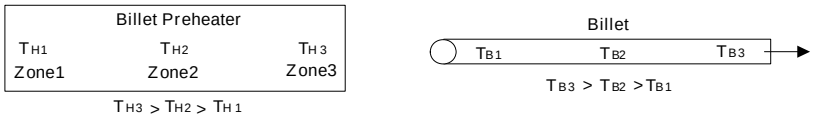

Figure 4. Heating a billet with different temperatures (T_H: billet heater temp., T_B: billet temp.)

Billet-Container Interface Friction: Heat which is formed by friction, occurred between the billet, and container during the extrusion process, also increases the exit temperature.

Die-Bearing Interface Friction: The frictions in the die-bearing increase the heat temperature directly. For this reason bearing length should be as short as possible.
Flow Metal-Dead Metal Zone Interface Friction: Friction increases as the dead metal zone increases. The length of the dead metal zone is associated with the die design.
Ram Velocity: In the situations where the ram velocity is high, the heat which is formed by frictions both in die bearing interface and between the billet and container, increases. This high heat formation, occurred on the surface can't be transferred the center (from surface) because there is no enough time for heat transfer. For this reason in the high extrusion speeds there may be deformations, occurred in the dimensions of hot tearing in the profile surfaces. But, in the low extrusion speeds, heat transfer from surface to the center is easier.

3. EXIT TEMPERATURE CONTROL

Controlling the exit temperature by knowing the directions of heat generations, and heat transfer during the extrusion process is important for not only production quality, but also efficiency. Figure 5 shows the exit temperature control in an extrusion press schematically. Also in Figure6, a flow chart of temperature control is shown.

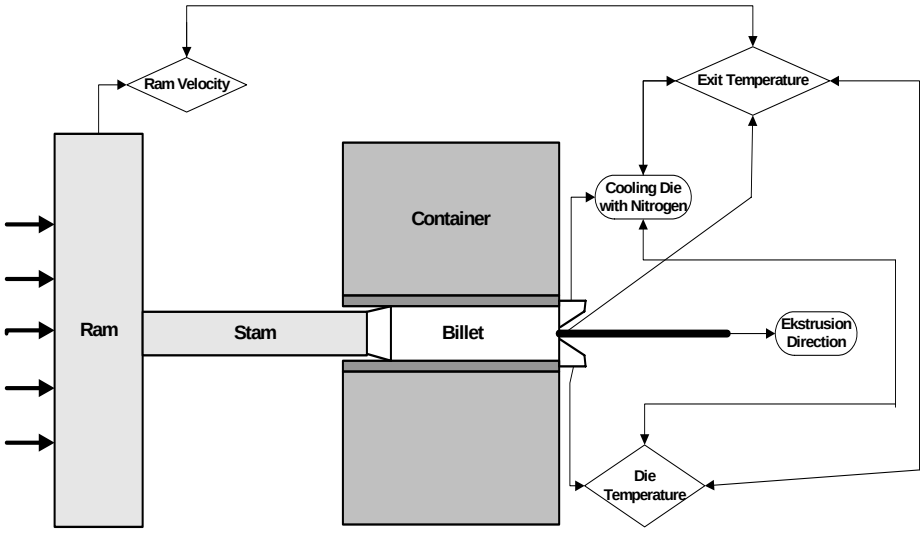

Figure 5. Exit Temperature Control in an Schematic Extrusion Press

If the heat generations can be taken under the control during the extrusion process, important gains can be achieved:

- Uniform surface quality
- Dimensional stability
- Fixed metallurgical and mechanical properties
- Higher productivity due to higher extrusion speeds and low stroke times

The grain size is very important in an extrusion product. In some researches, it is shown that grain size is affected by extrusion temperature changing [2-5].

4. RESEARCH AND DEVELOPMENTS

With the developed pyrometers, temperatures of billet, die, container and exit temperature can be measured continuously and easily. So extrusion process can be executed in a constant exit temperature by making feedback.
There have been a lot of studies and developments about isothermal extrusion in recent years.
Optalex that is a closed-loop control system for isothermal extrusion developed a system that measures profile exit temperature, billet temperature, die temperature and it is enable a press to be run at a near ±3% constant exit temperature by controlling the some parameters, such as, ram speed, billet

temperature, die temperature, die cooling with nitrogen. It is reported that their isothermal extrusion system improves the productivity 10% - 20% and the scrap reduction 2-5% by Optalex [6].
Biswas and Repgen [7] developed a computer aided software (CADEX) for calculation of extrusion parameters. The researchers' aim was to optimize productivity of the extrusion. They reported the extrusion time can be reduced by an average of 10% [8]. Pandit and Buchheit [9] developed a control signal processing system on isothermal extrusion. They reported that productivity increased up to enhanced the product quality [8]. Pandit et al. developed [10,11] an automation system for production optimization in aluminium extruder plants based on temperature measurement and control. They reported that long term tests in industrial extruders have proved that automation system MoMAS yields increased productivity and more uniform quality.

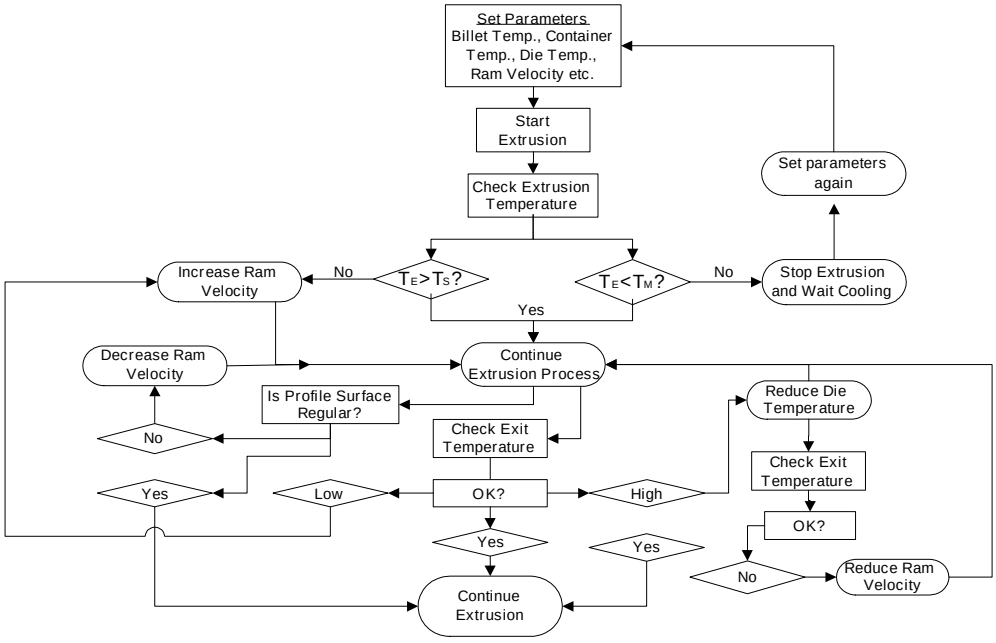

Figure 6. A Flow Chart of Temperature Control in Extrusion Process

5. CONCLUSION

This study can be a basic and orientative study from the viewpoint of exit temperature, which is one of the important subjects in the extrusion for small, and medium scaled enterprises. The process schemes can be a simple and efficient method for controllability of the output temperature. The prepared process schemes can be modified and used successfully by some extrusion companies because these schemes have the simplicity, orientation, and flexibility properties.

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