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# INVESTIGATING OF THE FORMATION EXTRUSION WELDS IN ALUMINUM EXTRUSION

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## ABSTRACT
*Aluminum extrusion profiles contain two types of extrusion welds which are seam weld (longitudinal joint) and charge weld (transverse joint). Seam welds are occured during the hollow profile extrusion; the billets' material is divided into separate metal streams by the bridges of the die which support a mandrel, and then these metal streams are welded in welding chamber behind the bridges. However charge welds are occured at the die ports between metals from consecutive billets' materials (it is often termed billet to billet extrusion). The metallurgical and mechanical properties of extrusion weld zones in a profile may have been different from main material's in the same profile. When the desired conditions have not been provided, the poor joints, brittle fractures and surface roughness may occur. For this reason investigating the formation mechanism of the welds, the metallurgical and mechanical properties of the weld zone are important. In this study seam weld and charge weld zones of samples, provided by Sistem Aluminium Company and On-At Aluminium Company, have been investigated. After these investigations some results about extrusion welds are obtained .*
**Keywords:** Aluminum extrusion, extrusion welds, seam weld, charge weld, longitudional joint transverse joint.

## 1. INTRODUCTION
Aluminum extrusion is a plastic deformation process; the billet is placed into a container and compressed by the stam force, then the metal is ejected through the die orifices. A schematic extrusion process is shown Figure 1.

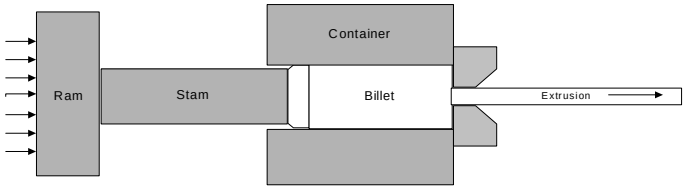



*Figure1. Schematic Extrusion Process*

Aluminium extrusions is very popular material as they are used many applications, such as, window and door frame systems of commericial and domestic buildings, prefabricated houses/building structures, roofing and exterior cladding, shop fronts etc. Furthermore, aluminium extrusions are also used in mass transport for airframes, road rail vehicles and in marine applications [1].

## 2. EXTRUSION WELDS

In generally, extrusion products are called two types; solid and hollow profiles. Extrusion welds frequently occured in both solid and hollow profiles. Therefore, having understood that the extrusion welds and their formation mechanism are very important for their quality and strength.

There are two types extrusion welds; seam weld (longitudional joint) which occurs in hollow shape profiles and charge weld (transverse joint) which occurs in both solid and hollow shape profiles.

### 2.1. Seam Welds (Longitudional Joints)

Seam welds are occured during the hollow profile extrusion; the billet's material is divided into seperate metal streams by the bridges of the die which support a mandrel, and then these metal streams are welded in welding chamber behind the bridges. Figure 2 shows the steps of a hollow profile shape with seam welds.

Figure 2a, which is the first step, shows the metal currents which are divided as the number of ports on the die surface. In the second step each metal current forms two small currents which flow tangentially through the core under the mandrel consoles (Figure 2b). In the welding chamber metal current, coming from the two parts are forced to come together. Therefore the forward points of these currents contacts closely necessary for welding primarily. If the section of structure which will be extruded includes more than one hollow, one extrusion step to the other side is necessary for filling the area among the cores with beams (figure 2c). In the last step (figure 2d) the section which has inner cores and it gets its last shape [2].

Sufficient width of welding chamber should be necessary for supplying the exact metal feeding and optimum pressure conditions in the welding chamber. However welding chamber should be narrow for optimum die resistances. The dimensions of the welding chamber should be prepared proper to these situations [2,3]. Moreover, the study, prepared by Duplancic and Pirgin [4] has shown that mechanical properties of seam welds heal by increasing the pressure of welding chamber.

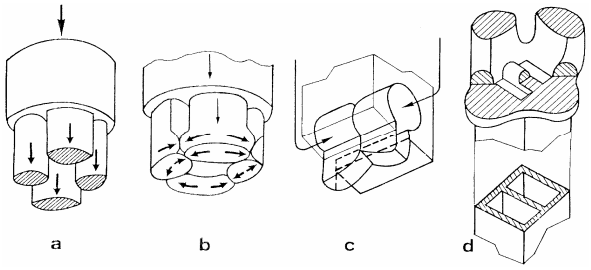



*Figure2. Successive steps in extrusion of hollow shape; a) into ports, b) filling the welding chamber, c) into the gap between the cores. d) extrusion of the hollow shape [2]*

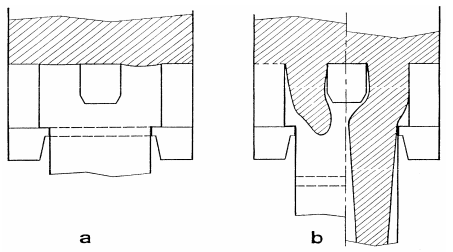



*Figure3. Charge weld; a) upsetting of a new billet, b) charge welding in progress[2]*

### 2.2. Charge Welds

Charge welds (Figure 3) are occured at the die ports between metals from consecutive billet's material (it is often termed billet to billet extrusion or continuous extrusion). When the desired conditions have not been provided for the continuous extrusion, poor welding, brittle fractures and surface roughness may occur. For this reason investigating the formation mechanism of the welds, the metallurgical and the mechanical properties of the weld zone are important.

## 3. SPECIMENS AND TESTS

The specimens used for charge welds have been provided by On-At Aluminum Company and the specimens used for seam welds have been provided by Sistem Aluminum Company.

Charge welded specimens which were produced under various extrusion conditions and with different geometries in order to untertake the stretching test. Most of the specimens have passed the stretching test successfully. But, it was observed that some of the specimens were disrupted from the welding

sections, as it seen some of them in Figure 4. Also the pictures of the microstructure of these specimens taken from the welded and normal zones are seen in Figure 5

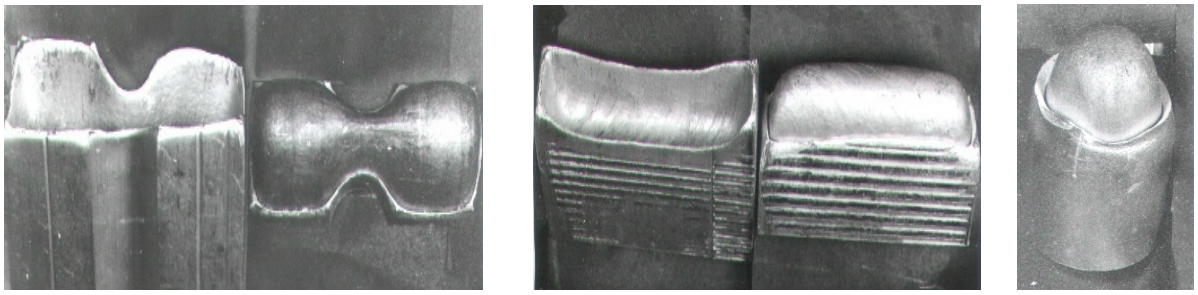
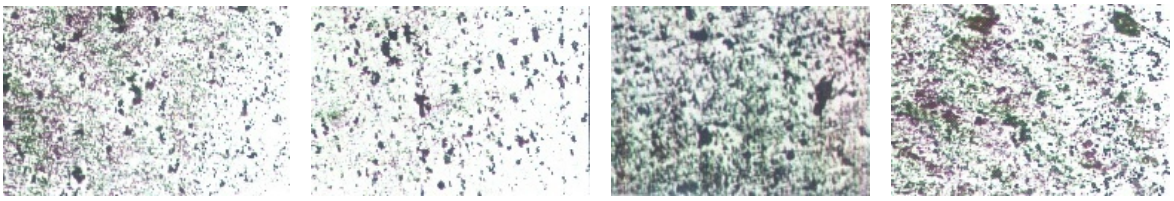
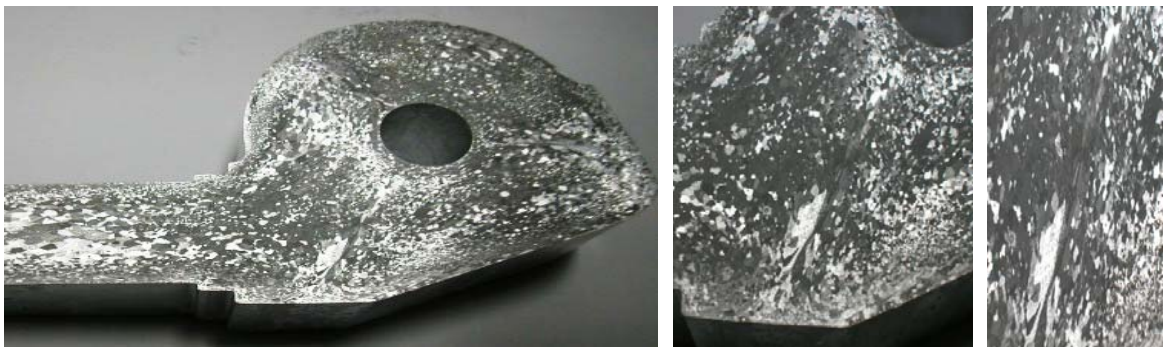


*Figure4. Separated charge weld zones*

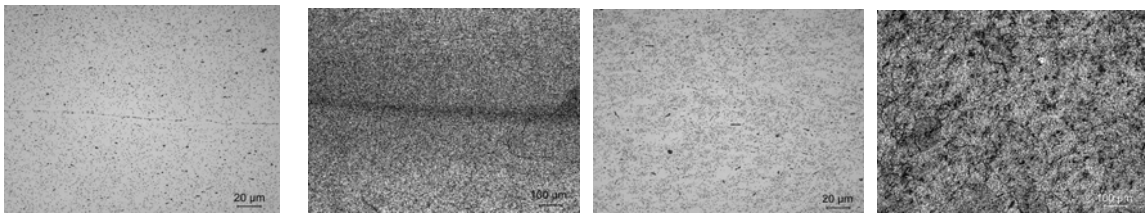


a b c d

*Figure5. Microstructure of charge weld specimens (100µm): a-b, on the outer the charge weld; c-d, on the charge weld point*



*Figere6. Seam weld specimen*



a b c d

*Figure7. Microstructure of seam weld specimen: a-b, on the weld lines; c, on the boundary weld line; d, on the outer of the weld*

Seam-welded specimen primarily has been prepared macro etching and the locations of the seam zones are obtained. Then the specimens for macrostructure investigation were prepared with especially for taking the material from the seam zone to get the seam line clearly visible. Figure 6 shows macro structure of the seam welded specimen and its seam zones with different zooms. The weld seam are clearly seen in Figure 7(a,b), and the seamless zones are seen in Figure 7(c,d).

For macrostructure investigation, specimens are undergone to emery application (320, 500, and 800), then they are etched with 32%HCl, 32%$HNO_3$, 32% distillate water, and 4%HF solution between 30 and 45 seconds. In addition microstructure specimens were undergone to emery application (320, 500,

800, and 1200), then they were polished with 3 micron diamond paste, and 0.5 micron colloidal silicon. These specimens were etched in 0.5 %HF solution between 30 and 60 seconds.

## 4. DISCUSSION

It is interesting to note that charge-welded specimens, which were prepared in various extrusion conditions, were dirupted charge-welded ends interface exactly during the stretching tests. One of the reasons of this can be lubricants, and pollutions mentioned before. In the extrusion process container and die-tools are separated from each other after the stroke. Then new billet is pressed after the extrusion residual are cut, and process is resumed. If the cut application is not done well, billets, which haven't necessary metallurgic properties, aren't used, and entering pollutions to die core isn't prevented, products with desired properties can't be obtained. Also in charge welding, this situation is more sensitive. Because charge welding commonly forms the weakest part of the profile. In addition, in order to get a good charge joint a sufficient pressure occurrence on that sections necessary. One of the reasons of weak disrupt in charge joints can be this.

After the microstructure of charge welded specimens investigated, in weld zone occurrence of the Mg2Si precipitates in macro levels are seen. In the same specimens the microstructure of the main body of the metal had more bulky $Mg_2Si$ precipitates with respect to microstructure, formed in the typical aluminum AA6xxx alloy extrusion. It should be expressed that precipitation of $Mg_2Si$ in macro levels isn't a desired situation in aluminum extrusion. An important reason of reaching high temperatures in extrusion process and trying to cool quickly after the extrusion process completed, is providing the precipitation of $Mg_2Si$ in micro level. However in charge welded specimens mentioned above any micro precipitations haven't been observed.

For microstructure images of the seam welds, investigation have been done on the seam weld line, on zone without weld, and on seam boundary zone. $Mg_2Si$ precipitates are seen as a string on the sew weld line although they are seen in the other zones. The reason of this can comes from the formation nature of the seam welds. If the mechanism of the seam welds formation is remembered, firstly billet material divides into different metal current by means of ports, then these metal currents flows through each other, and die exit and adhere. This adhesion is a solid metal adhesion and passing of the separated surfaces in to each other is difficult. So the reason of alignment of $Mg_2Si$ precipitations on the seam line is probably based on this. On the other hand, in the all zones the precipitations are occurred in micro sizes which is a desired condition.

## 5. CONCLUSIONS

As a result of metallographic investigation of charge and seam welded specimens produced in different extrusion conditions it was seen that if the desired producing conditions aren't provided in the extrusion process, the disruption can even occur exactly charge welds' voids. Also tight alignment of $Mg_2Si$ precipitates on a tiny line where the seam line locates in the seam welds. But micro level of these precipitates shows that metallurgic structures of the seam welds are good. The contradiction of these situations shows how the extrusion conditions are important.


## 6. ACKNOWLEDGEMENTS:

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