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Properties of seam welds produced with different extrusion parameters

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ABSTRACT

Purpose: This study focuses to investigate the effects of different extrusion parameters on microstructural properties of seam (longitudinal) welds in aluminum extrusion profiles.

Design/methodology/approach: To realize the study, it is studied on a hollow extrusion profile type which has seam weld zones. The experimental profile was produced in different temperatures, billet temperatures and ram speeds by a real extrusion press which has a capacity of 1460 tones. These parameters are some of the most important parameters in an extrusion process.

Findings: Some structural differences are occurred between having the different extrusion parameters both seam welds and without weld regions, when the experimental results are observed. In addition, it was observed commonly the structure of the material had a change through re-crystallization with increasing temperatures. This situation decreases the significance of seam weld lines. Moreover, the grain size is getting smaller with increasing ram speed as it is shown in microstructural figures.

Research limitations/implications: Also some structural differences in seam welds may occur for having the other extrusion parameters without temperature and speed. But, the other extrusion parameters are not used in this study. Therefore, effect of some other important parameters such as pressure, extrusion ratio can be investigated in future.

Practical implications: In application, seam welds occur on hollow profiles. This study demonstrates that some extrusion parameters effect to microstructure of seam welds.

Originality/value: It is shown that different microstructural properties take place due to the process parameters variations and natural of extrusion method in the extrusion production. They cause also variations on structural features.

Keywords: Mechanical properties; Seam weld; Extrusion; Aluminum; Microstructural properties; Longitudinal weld.

PROPERTIES

1. Introduction

Producing of the profiles which have hollows by the porthole dies, containing mandrel and welding chamber [1-5]. Porthole die extrusion has a great advantage in the production of hollow sections, which are difficult to produce by conventional extrusion with a mandrel on the stem [6-9]. Using a porthole die extrusion long hollow profiles can be produced without respect to the length of the mandrel.

In the recent years, the researches focused on investigation of microstructural characterization and mechanical properties of the extrusion welds and normal extrusion regions (without weld) depending different extrusion conditions and parameters [10-18].

Therefore, this study attempted to investigate of microstructure of seam welds in aluminum extrusion by different billet temperatures, profile exit temperatures and ram speeds.

2. Experimental works

For experimental works, the profiles also containing the transverse weld, used in the study are obtained from the real producing process.

2.1. Material

In experimental study, AA6063 alloy type among the aluminum alloys, which is common preferred one, is used. AA6063 allows producing the profiles which have complex geometry on account of the fact that it can get good plastic shape.

2.2. Production

Production of experimental profile has been carried out in the MEIUREY modeled press, which has the capacity of 1460 tones. The experimental profile is shown in Fig.1 and its extrusion ratio is 5.

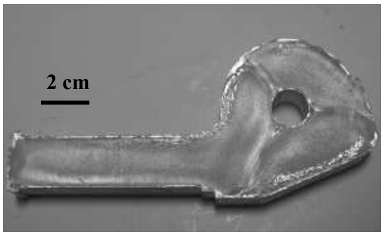


Fig. 1. The experimental profile's section

2.3. Micro structures tests

At first, cutting process of specimens is implemented with Struers SECOTOM-19 device sensitively (without deformation of the section, which will be investigated). Specimens which have been cut, was done abrasion process. For abrasion process was used Struers ROTOPOL-25 device. Holding the specimens and applying force to them is implemented with Struers ROTOFORCE-4 device.

Abrasion process is implemented by 120, 180, 240, 600, 1200, 2500 and 4000 grit abrasives under 20N strength. After abrasion process was completed, the specimens were polished by 3μm MD Mol abrasive with 1μm diamond paste. For finally polishing, colloidal silica was used.

After this process the specimens were etched by Keller solution [20] for 40-60 seconds and investigated under with ZEISS optic microscope.

3. Results and discussions

The micro structure of the specimen, which is etched with the Keller solution, in the Fig. 2, shows the magnesium silicide (Mg2Si) precipitates which are arranged and condensed. The Mg2Si precipitates are dissolved in 500-520 ^{o}C into an aluminum solution. Therefore, the extrusion producers want to work mostly practically and try to keep the exit temperature over 500 ^{o}C. The purpose is to work over 500 ^{o}C and make the Mg2Si precipitates to dissolve, and to make Mg and Si to be dispersed by creating Mg2Si in round micro form, together with the cooling and then heating process, also is to make the Mg2Si to disperse homogenously in the structure of the aluminum. But in the Fig. 2 it is easily understood that this situation isn't realized. The Mg2Si precipitates are stacked in the structure, around the welding line, in a non homogenous way. This results from being too low of billet temperature and the exit temperature. The Mg2Si dispersion isn't realized in the purposed level because of the low temperature and an undesired occurred structure. Also the investigation of Fig. 3 shows that the Mg2Si composites, which belongs to the non welding-normal zone are formed, and these are in macro form. As it is seen in the figure, these Mg2Si precipitates are placed in the grain boundary (the grain boundaries are a little distinctive). On the other hand, Akaret [19] claimed that the welding zones have artificial grain structure. According to Akaret, the term grain, determines an interface between the two metal volumes which distance are in inter-metallic level. The suspended electrons can easily pass through this kind of interface as they can do through any grain boundary. The coherence which is created as a result of this is a perfect coherence. But, in this kind of artificial grain boundaries, there is no extreme Mg2Si precipitate, and there is a concentration on the seam weld zone, and around the seam weld zone which shows that the perfect coherence isn't occurred. However, as it is distanced from the seam weld zone, it is seen that the precipitate concentration of the Mg2Si is evaluating towards the normalization level. This situation shows that there is a formation of a worse structure than the normal structure, in the seam weld zone.

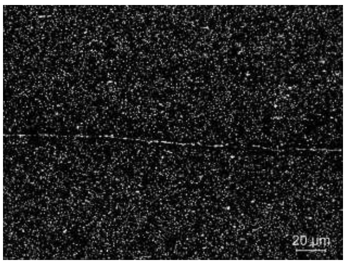
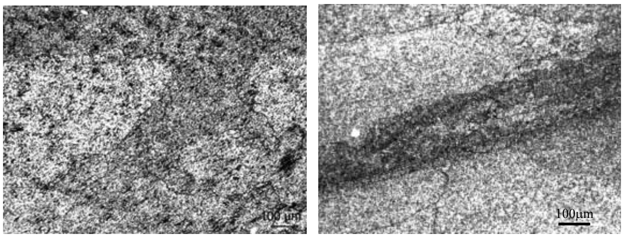


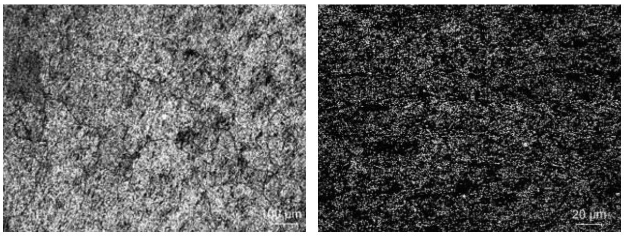
Fig. 2. Seam weld region (in dark) T_B=430^{o}C, V_R=10mm/s, T_E=440^{o}C

The seam weld region in Fig. 4 has a very interesting and diverse structure. Seam weld region seems like to be divided into two different lines. The reason of this occurring like that couldn't be found. In conclusion the information related to the reason of this case is useless. The common belief is that the extrusion process is complex and sometimes unpredictable structures may occur. Thus precipitates of Mg2Si are leaned and dense onto seam weld region and precipitates of Mg2Si are not seen in anywhere except in this seam weld region. The first reason of having that much of Mg2Si dense in a specific region is having not enough process temperature which is required to dissolve Mg2Si. The second reason is having the limit of artificial grains argued by Akaret, which occurred badly in welding region in this specimen. Moreover doubling the lines in weld region may have various surface layers, consisting of the limit of artificial grains badly, faulty and leaky stick. However, it is considered as a low probability. The quickness of the ram speed has aggravated the bad coherence. Another interesting case is that the grain boundaries can be slightly seen. This shows that the re-crystallization is started.



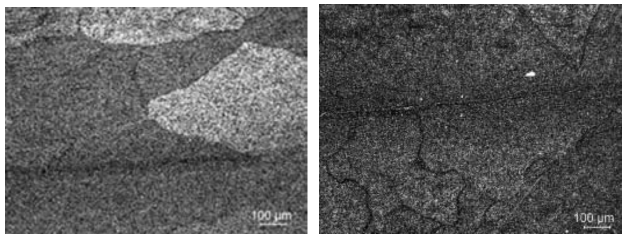
Figs. 3 and 4: Fig. 3. The microstructure of normal zone T_B=430^{o}C, V_R=10mm/s, T_E=440^{o}C; Fig. 4. Seam weld region T_B=450^{o}C, V_R=15mm/s, T_E=475^{o}C

The Fig. 7 shows that the re-crystallization in the seam weld zone is in a specific level. However, the structure started to get better and the concentration of the Mg2Si precipitate in decreased in the seam weld.



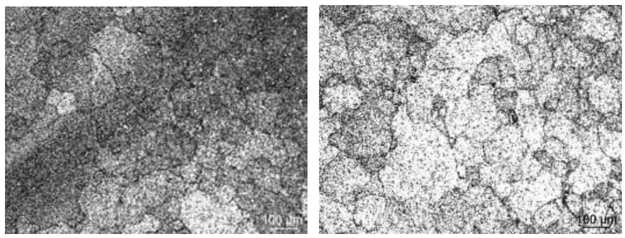
Figs. 5 and 6: Fig. 5. The normal region (in near of the seam line) T_B=450^{o}C, V_R=15mm/s, T_E=475^{o}C; Fig. 6. The normal reion (no-weld) T_B=450^{o}C, V_R=15mm/s, T_E=475^{o}C

In the Fig. 8, it is seen big and small re-crystallized grains. The movement of the structure of the re-crystallized grains to the seam weld line shows that this is the best seam weld structure between all of them. But, the welding line still isn't clear. In the seam weld zone, even if the necessary temperature occurring for the re-crystallization appears, the quickness of the ram speed, cause a clear and distinctive welding line. On the other hand even the Mg2Si precipitate is more concentrated in seam weld zone bad precipitate distribution isn't seen. This situation is reasoned from high amount of the Mg2Si precipitate. But, the production parameters played efficient role in this case.



Figs. 7 and 8: Fig. 7. Seam weld region T_B=470^{o}C, V_R=15mm/s, T_E=500^{o}C; Fig. 8. Seam weld region T_B=490^{o}C, V_R= 15 mm/s, T_E=520^{o}C

When the values in Figs. 9 and 10 are examined, it is determined that the temperatures of the billet and the profile exit are the highest temperatures measured in this experiment and the ram speed has an average value at the same time. Thus, the reason of having a high level of re-crystallization is the producing temperatures. High producing temperatures caused re-crystallization even in the seam weld region. Re-crystallized structures can be seen in the micro structure of the specimens, etched by the Keller solution. The penetration of the re-crystallized structure to the seam weld region due to high temperatures can be seen in Fig. 9. The micro structure of the re-crystallized specimens belonging to normal region (un-welded region) can be seen in Fig. 10.



Figs. 9 and 10: Fig. 9. Seam weld region T_B=510^{o}C, V_R=6mm/s, T_E=560^{o}C; Fig. 10. The normal region (in near of the seam line) T_B=510^{o}C, V_R=6mm/s, T_E=560^{o}C

On the other hand, when the Fig. 9 is examined, it can be seen that the precipitates of Mg_2Si are dispersed more uniformly than in all other structures. Therefore, the structure appeared in the experiment profile produced with the mentioned parameters is a more homogeneous and desired structure type.

4. Conclusions

As the results of the microstructural specimens are examined by considering the production parameters, the following conclusions are obtained:

- Increases in both ram speed values and the temperatures of the billet, and the profile exit leads the seam weld region to transform into a thin significant line, and these re-crystallized grains are closely leaned onto this line.

- With the help of getting increased both ram speed values and the temperatures of the billet and the profile exit, the precipitates of Mg_2Si on the seam line became less intensive and a more homogeneous structure which conforms precipitate is formed.

Acknowledgements

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