



24th ABCM International Congress of Mechanical Engineering
December 3-8, 2017, Curitiba, PR, Brazil

COBEM-2017-1302

INFLUENCE OF PRESSURE ON MICRO STRUCTURE AND MECHANICAL PROPERTY OF ALLOY AL-0,35% Si-0,40% Mg MANUFACTURED BY SQUEEZE CASTING PROCESS

Regina de Moura Bernardo

Reginamourabernardo@gmail.com

Diego Ferreira de Lima

Diegoferreira_09@hotmail.com

Fernando Tadeu de Araújo Filho

fernandotdearaujo@live.com

Ronaldo Marques de Oliveira Filho

Ronaldomarques_filho@hotmail.com

Claudio Alves de Siqueira Filho

Technology Center - Federal University of Paraíba, Castelo Branco, s/n, CEP 58051-900, João Pessoa – Paraíba, Brazil.

Siqueira@ct.ufpb.br

Abstract. In the "Squeeze Casting" process the liquid metal is placed in a mold and subjected to a permanent pressure applied through a hydraulic press until complete solidification. The high pressure used in the process causes a refining of the microstructure to occur, which results in an improvement of the mechanical properties in general. In addition, solidified parts by means of this technique present superior weldability, better surface finish, better responses to the heat treatment, among other benefits. The present work has the objective of analyzing the influence of pressure in the microstructure and microhardness Vickers, in the Al-Si-Mg alloy. For this purpose, the composition Al-0.35% Si-0.40% Mg by mass, solidified by the squeeze casting process using pressures of 0 MPa, 50 MPa, 100 MPa and 150 MPa, was used with the pressing time of 5 seconds. It has been generally observed that with increasing pressure there is a decrease in secondary dendritic spacing and consequently an increase in micro hardness values.

Keywords: Squeeze Casting, Microstructure, Microhardness.

1. INTRODUCTION

The foundry is considered an ancient technology, being today one of the most used processes in the production of metallic components, for a wide field of applications. It is estimated that about 90% of all existing utensils, equipment and tools incorporate castings. (FERREIRA, 1999)

Currently there are several different processes to obtain a cast, each with its characteristics and potentialities. However, the traditional requirements demanded by industry are no longer enough. The technological development that the industries have been experiencing in recent years leads to the search for increasingly light castings, with immediate use, more perfect and without the need for so many subsequent finishing operations. (HAJJARI et al., 2008)

The process that provides a product with the aforementioned characteristics is squeeze casting. In this technique the liquid metal is placed in a mold and subjected to a permanent pressure applied through a hydraulic press until complete solidification. (H HU, 1998)

The high pressure used in the process causes a reduction in the degree of micro-segregation and a refined microstructure, which results in an improvement of the mechanical properties, such as an increase in microhardness. In addition, solidified parts by means of this technique present superior weldability, better surface finish, improved electrical conductivity and also have better responses to the heat treatment. The technique is economical, simple and has great potential for automation and high production rates. (MT ABOU, 2003)

The production of alloys has had a significant increase since the 20th century due to the increased world demand for ferrous and non-ferrous products. Aluminum alloys are widely used and among the non-ferrous are the most produced, followed by copper, magnesium and zinc alloys, easily produced by squeeze casting technique. Recently, this technique has been well studied for use in the manufacture of metal matrix composites, especially aluminum, magnesium, zinc and silicon alloys. (ROHATGI, 1998) (DORCI, 1998).

Thus, the present work aims to analyze the influence of the pressure in the microstructure and mechanical properties (Vickers microhardness) of the Al-0.35% Si-0.40% Mg alloy solidified by the squeeze casting process.

2. EXPERIMENTAL PROCEDURE

For the preparation of the alloys, the pure metals were weighed with proportions relative to Al-0.35% Si- 0.40 Mg, by mass. The heavy metals were placed in the silica carbide crucible and placed in the muffle furnace for casting and homogenization of the alloy analyzed. After casting, the alloy was cast at 722 ° C, which corresponds to 10% above the *liquidus temperature* (656.2 ° C). Such temperature was monitored by a type K thermocouple. At the casting temperature, the alloy was cast in a steel ingot 1020 and brought to the electro-hydraulic press to obtain the solidified ingots under pressure, according to Figure 1. The press time was 5 seconds and the pressures varied from ambient, 50 MPa, 100 MPa and 150 MPa.



Figure 1. Hydraulic press used to obtain ingots.

Figure 2 (a), (b), (c) illustrates schematically, how the slices were made in the specimen to obtain a sample for the accomplishment of the microstructural and microindentations analyzes. (a) The ingots were sectioned longitudinally. (b) Cross sections with 20mm, 40mm, 60mm and 80mm measurements were made from the base to the top of the ingot. (c) Representation of the sample used for microstructure and microhardness analysis.

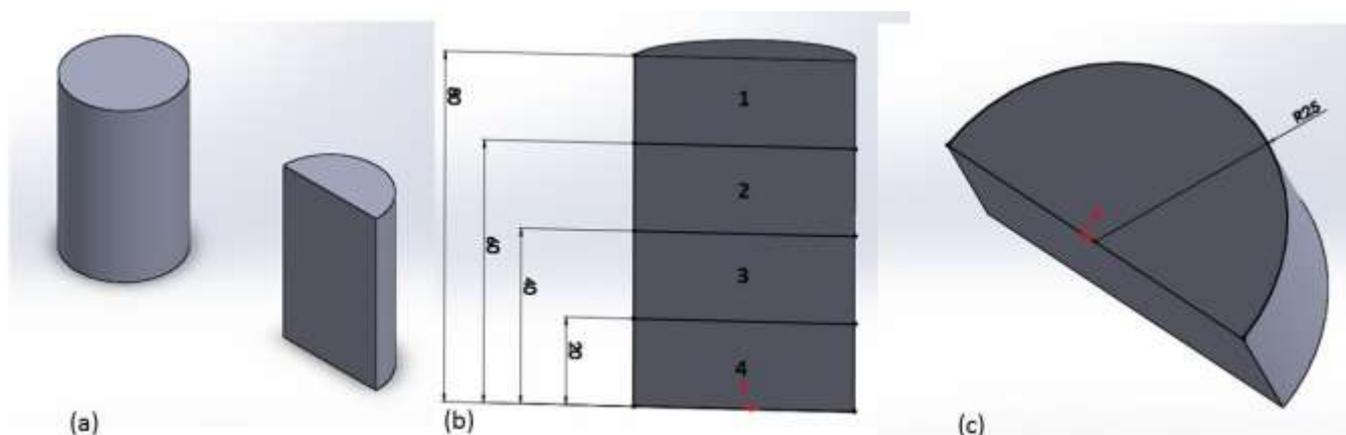


Figure 2. (a) Longitudinal cut, (b) transversal cuts, (c) schematic of the samples used.

After the cuts the microstructure was revealed through mechanical sanding, water cooled. After sanding the pieces were polished, using 92% ethyl alcohol and 3µm diamond paste and attacked for 20 seconds with 10% HF (hydrofluoric acid).

Measurements of the secondary dendritic spacings were then performed. Figure 3 shows schematically the positions where the spacing measurements were taken, being 5 mm, 13 mm and 23 mm from the metal / mold interface to the center of the ingot. Twenty measurements were taken at each position and an overall mean of the values of the secondary dendritic spacing for each piece was made, since the entire structure was refined not varying much the values of the secondary dendition spacing between them, which can be observed in figure 4 representing the macrostructure of a sample solidified at ambient pressure.

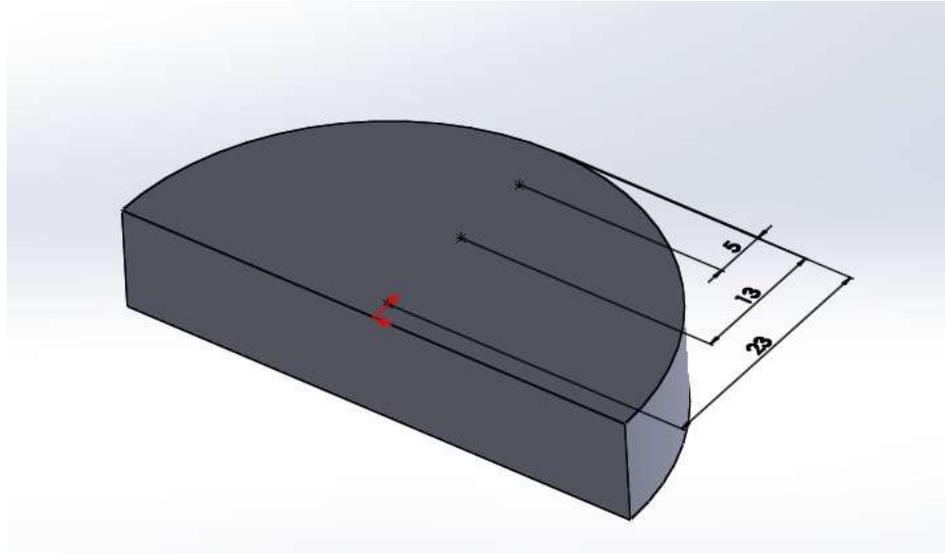


Figure 3. Schematic of the positions used for measurements of secondary dendritic spacing and Vickers microhardness.



Figure 4. Macro-structure of an alloy sample Al-0.35% Si- 0.40% Mg solidified at ambient pressure.

In order to perform the Vickers microhardness, the same samples and the same positions as in Figure 3 were used. Six indentations were performed per region, totaling 18 indentations per sample and an overall average of these values for each part. In this test a load of 100 gf (gram force) was used, with a time of 5 seconds.

In Figure 5 we observed a sample solidified at 50 MPa, where it can be observed how the indentations were performed to obtain the Vickers microhardness values in the samples. The indentations were always performed avoiding grain contours, so that no influence occurred in the Vickers microhardness values.

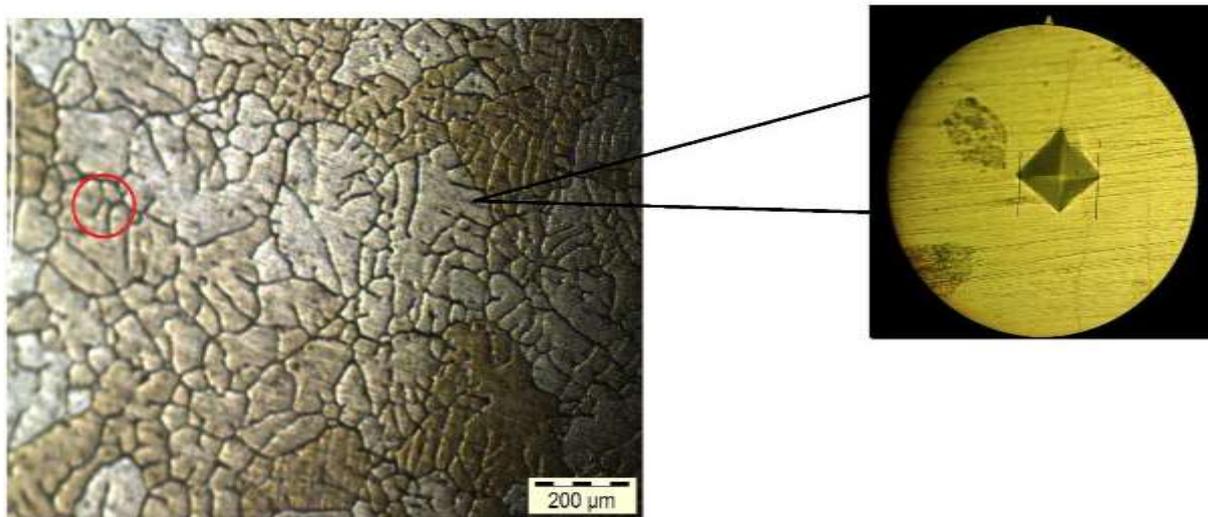


Figure 5. Indentation in an alloy sample Al-0.35% Si-0.40% Mg solidified at 100 MPa.

3. RESULTS AND DISCUSSIONS

Figure 6 shows the graph of the secondary dendritic spacing (λ_2) as a function of the pressure. It is observed that the increase in pressure caused a decrease in the secondary dendritic spacings. At the pressure of 100 MPa, a lower value was observed for the secondary dendritic spacing.

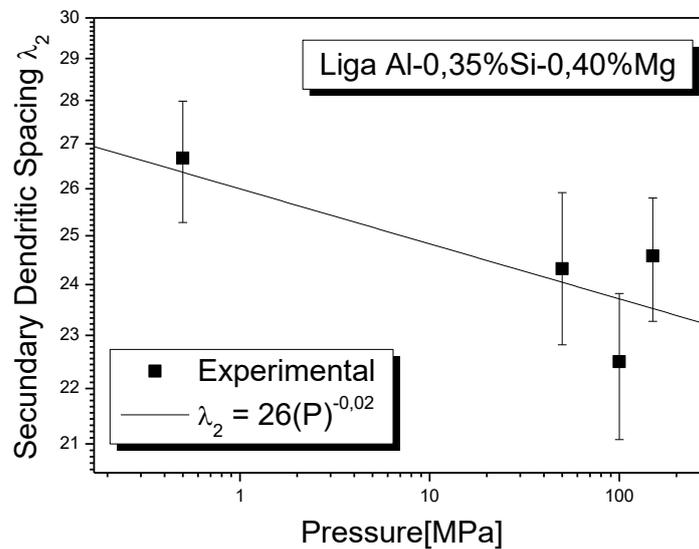


Figure 6. Evolution graph of the secondary dendritic spacing as a function of pressure.

In Figure 7 (a), (b), (c), (d) we can see images of the secondary dendritic spacing (λ_2) of the solidified parts at ambient pressure, 50 MPa, 100 MPa and 150 MPa, respectively. Analyzing this image it is noticed that as the pressure increases the secondary dendritic spacing decreases, which does not match the graph.

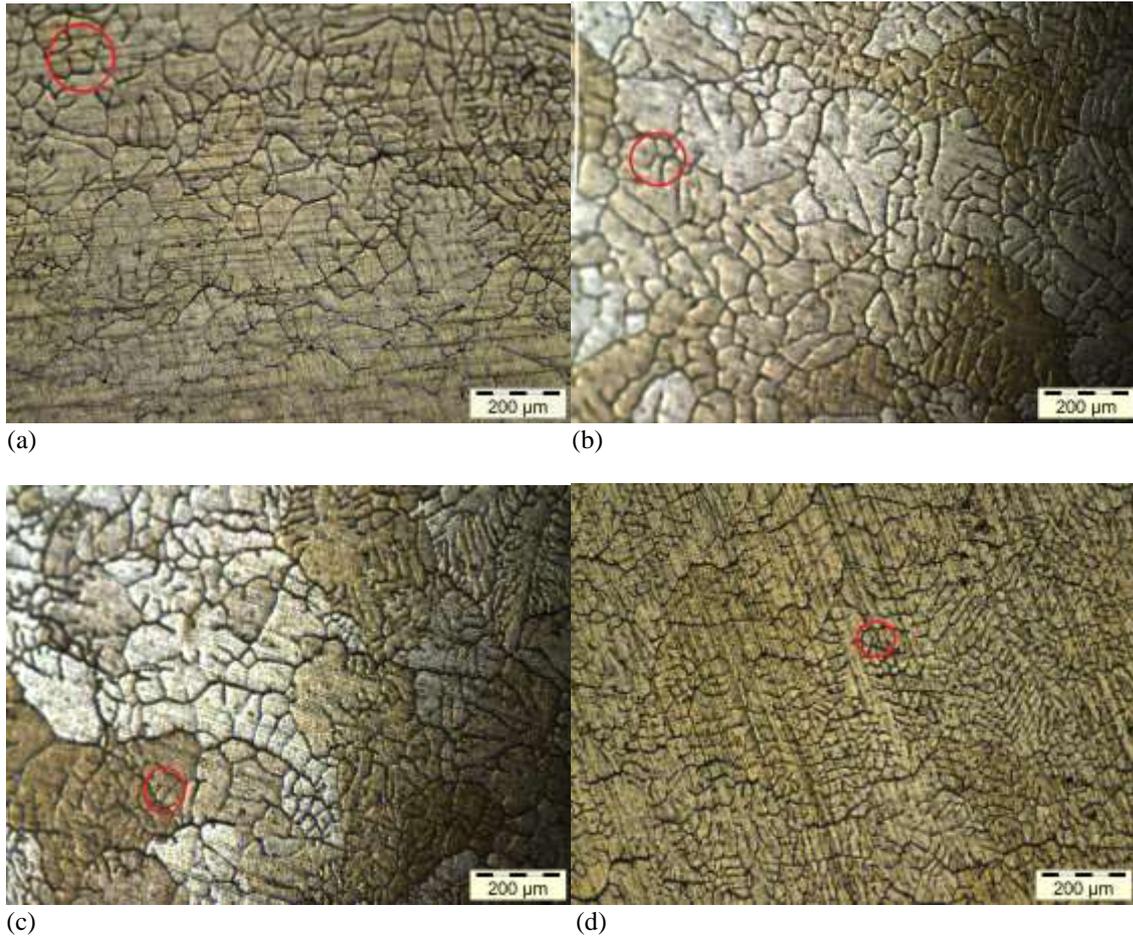


Figure 7. Secondary dendritic spacing (λ_2) of the solidified parts at ambient pressure, 50 MPa, 100 MPa and 150 MPa, respectively.

A variação da microdureza Vickers em relação à pressão é apresentada na figura 8. Nota-se que ocorreu um aumento nos valores de microdureza Vickers em função do aumento da pressão. Nas ligas processadas a pressão de 100 MPa observou-se um maior valor de microdureza, que se deve ao menor valor de espaçamento dendritico secundário apresentado à pressão de 100 MPa.

The variation of the Vickers microhardness in relation to the pressure is shown in figure 8. Note that an increase occurred in the Vickers microhardness values with an increase in pressure. A higher microhardness value was observed in the alloys processed at 100 MPa, due to the lower secondary dendritic spacing presented at a pressure of 100 MPa.

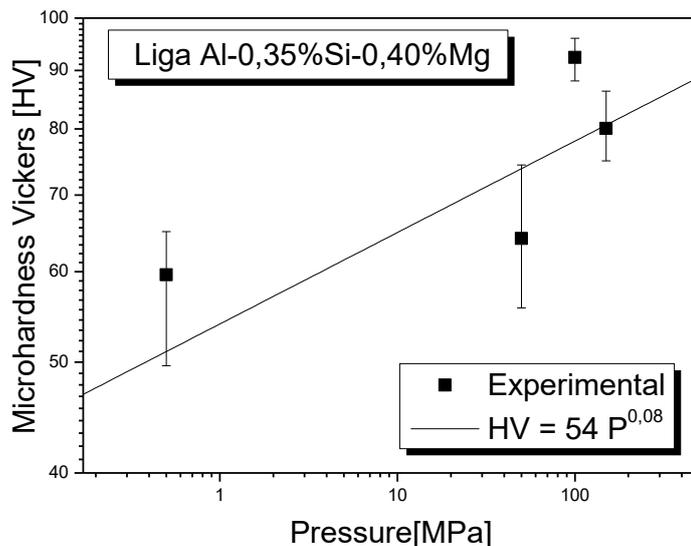


Figure 8. Graph relating Vickers microhardness and pressure.

Figure 9 shows the graphical representation of the correlation between the microstructures and the Vickers microhardness. It is observed that as the secondary dendritic spacing increases the microhardness tends to decrease.

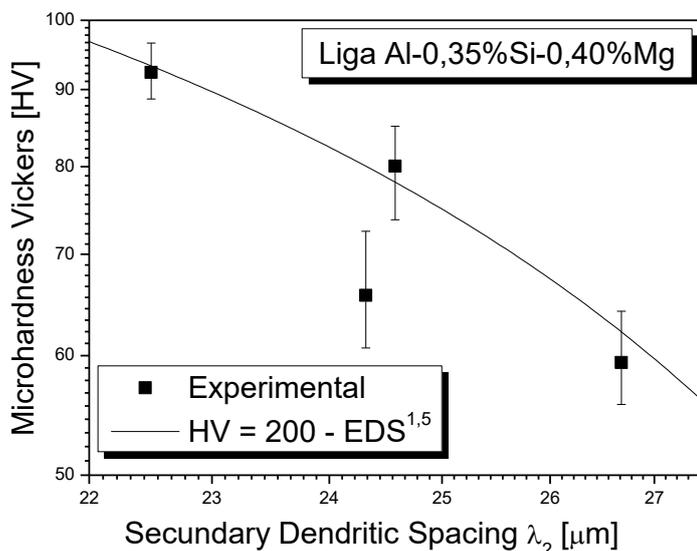


Figure 9. Graph of microstructure correlation with Vickers microhardness.

4. CONCLUSIONS

In general, in both the microstructure and the Vickers microhardness, the pressure variation played an important role. In the microhardness the pressure caused a decrease of the secondary dendritic spacings, in addition to leading to an increase in the Vickers microhardness values. It is worth mentioning the behavior of the alloys manufactured at 100 MPa, which obtained lower values of dendritic spacings and higher values of microhardness, which shows a better behavior of the alloys fabricated at this pressure.

5. REFERENCES

- Ferreira, J. M. G. de C., Tecnologia da Fundição, Fundação Calouste Gulbenkian, pp. 505-516, 1999.
- E. Hajjari, M. Divandari, (2008) "An Investigation on the Microstructure and Tensile Properties of Direct Squeeze Cast and Gravity Die Cast 2024 Wrought Al Alloy", Materials and Design, Vol. 29, pp. 1685–1689.
- HU H. Squeeze castings of magnesium alloys and their composites. J Mater Sci 33, pp. 1579-1586, 1998.
- Abou El-Khair MT. Microsegregation and improved methods of squeeze casting 2024 aluminium alloy. J Mater Sci Technol 2003.
- Rohatgi, P., Cast Metal-Matrix Composites – squeeze casting, IN.: American Society for Metals: ASM Handbook, vol 15, "Casting", 9a edition, pp. 840-842, 1988.
- DORCIC, J. L, VERMA, S. K., Squeeze Casting, IN.: American Society for Metals: ASM Handbook, vol 15, "Casting", 9a edition, pp. 323-327, 1988.

6. RESPONSIBILITY NOTICE

The authors Bernardo, R.M; Lima, D.F; Araujo, F.T; Oliveira Filho, R.M; Lima, R.A and Siqueira, C.A are the only responsible for the printed material included in this paper.