MICROSTRUCTURAL IMPROVEMENTS OF ALUMINUM MAGNESIUM ALLOYS BY ADDING TITANIUM

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The number of efforts aimed at improving casting and mechanical properties of aluminum alloys is increasing year by year worldwide [1][2]. Although scientists around the world achieved incredible results and their work is applied in different industries, the ecological aspects of aluminum production and use remained not fully understood and still is being developed through machine learning and artificial intelligence models to optimize the sustainability of nthe industry [3]. One of the solutions in making these alloys more reliable and at the same time more durable and ecologically sustainable is to minimize the porosity of the alloys.

This work focuses on the identification of changes in microstructural characteristics of aluminum-magnesium alloys when adding modifying element titanium.

Microstructure of the materials has been carried out with optical microscopy, and the results were exported to the excel documents. Overall, 4 samples were analyzed on the porosity and shrinkage of the materials. The magnesium content in the alloy remained the same, being equal to 10% and titanium percentage was chosen to be 0.2, 0.3, and 0.4%. Each sample's microstructure area was chosen according to the 'worst' part of the area and were discussed accordingly.

The magnification range was defined to be 2.5x, 5x, 10x, and 20x to observe a large scale of the porosities or shrinkages of the specimens. The following are the images of the base alloy Al-Mg with 10% magnesium content.

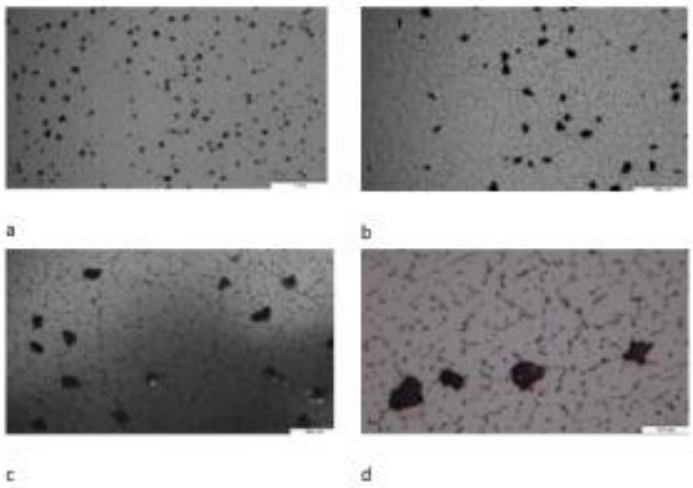


Figure 1. Microstructure of Al-Mg alloy before etching.

As can be seen from figure 1, the sample has many porosity lines which in turn can cause a defect during the casting and treatment processes.

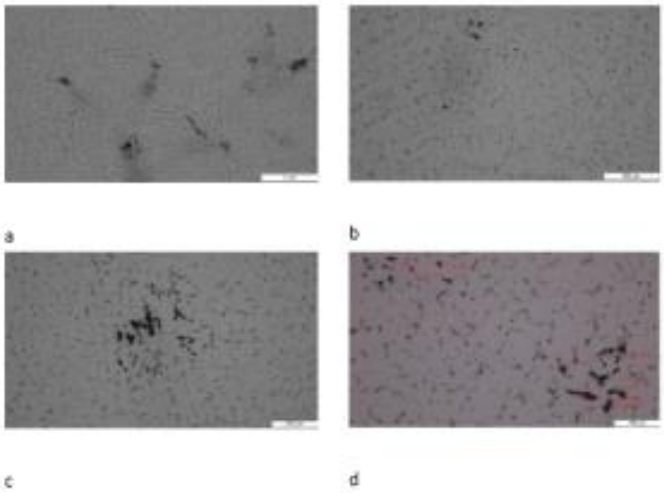


Figure 2. Microstructure of Al-Mg alloy alloyed with 0.2% of titanium.

Titanium addition (0.2%) led to the minimization of the number of porosities, yet leading to some shrinkages in some areas (figure 2).

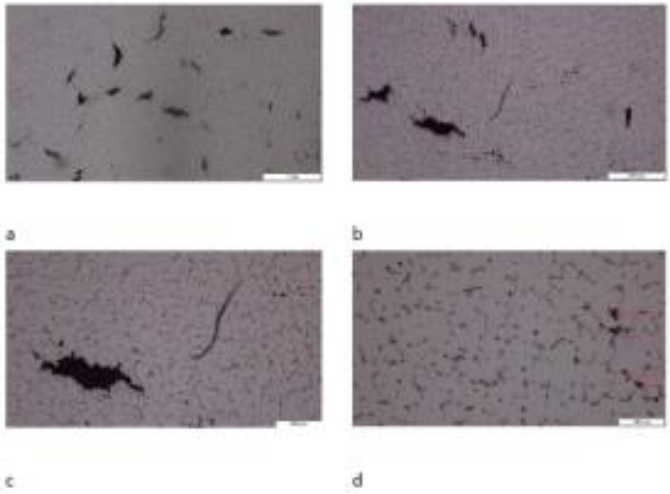


Figure 3. Microstructure of Al-Mg alloy alloyed with 0.3% of titanium.

0.3% of titanium, however, as can be seen from the figure 3, had a negative effect on the alloy and the area and the length of the shrinkage is noticeably higher in those with the addition of 0.2% titanium. It should also be noted that the amount of area defined as shrinkage areas is lower than in the base alloy.

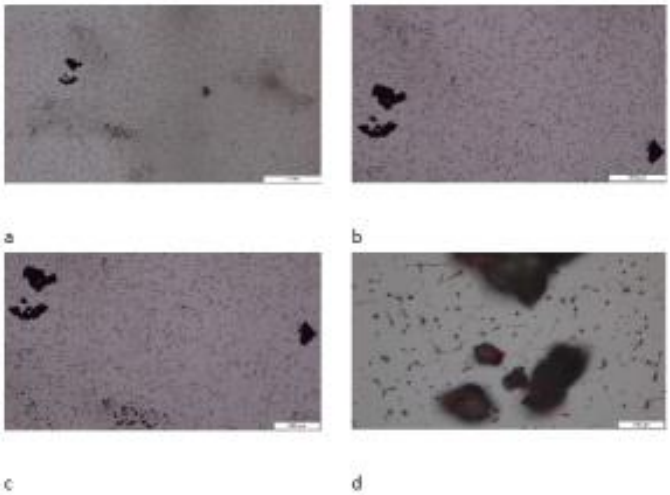


Figure 4. Microstructure of Al-Mg alloy alloyed with 0.4% of titanium.

Finally, it can be noticed that in the figure 4 shown the alloy microstructure when adding 0.4% of titanium a number of porosities in some areas. In this scenario, we can see that further addition of titanium (from 0.3% to 0.4%) changed the type of the defect.

In conclusion, the optimal amount of titanium is 0.2%, which results in some shrinkage but no porosity. However, considering the amount of porosity in the base alloy and in the alloy with the first addition of titanium (Figure 2), the addition of titanium had a positive effect in terms of minimizing defects. Although further addition of titanium generally led to a better result in material porosity (Figure 4) compared to the base alloy, it should also be noted that the trend of the element's influence decreased from 0.2% to 0.4%. The greatest amount of shrinkage was found in the alloy with 0.3% titanium.

Literature:

1. Bhardwaj, A. R., & Purohit, R. (2026). Aluminum alloys in sustainable manufacturing: A review. *Sustainable Materials and Technologies*, e02028.

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3. Lin, Z., & Yang, C. (2026). Artificial Intelligence Design of Sustainable Aluminum Alloys: A Review. Computers, Materials & Continua, 86(2).