CHARACTERIZATION OF THE DENDRITIC SPACING AND ASPECT OF THE FRACTURE OF THE SOLIDIFICATION OF ALUMINUM ALLOY IN MOLD OF STEEL AND COPPER[1]

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Abstract

This work it is made a study of the effect the different matter of the mold in the structures of solidification the alloy and a influence in the property with the characterization the dendritc spacing. The alloy Al-10%Cu, was solidified directionaly with heat extraction in copper and steel mold, whose purpose was to evaluate mold that leads to obtaining the smallest secondary dendritic spacing. Tensile tests were performed, and analyze the fracture by scanning electron microscopy – SEM. The samples for the test of traction were removed from positions of the central ingot. In solidification alloy done in order covers the dendritics spacings are smaller in relation to the order made in steel. The appearance of the fracture suggests that the fracture traveled the path between dendritas, where the matrix of aluminum don't has deformation. The presence of Al_2Cu eutetic with defects from the presence of oxygen and impurities in the alloy are probably the cause of the weakness.

Key words: Alloys; Fracture; Dendritc spacing.

CARACTERIZAÇÃO DO ESPAÇAMENTO DENDRÍTICO E ASPECTO DA FRATURA DA SOLIDIFICAÇÃO DE LIGA DE ALUMÍNIO EM MOLDE DE AÇO E COBRE

Resumo

Neste trabalho é realizado um estudo da influência do molde na estrutura de solidificação da liga e suas propriedades através da caracterização do espaçamento dendrítico. A liga Al-10%Cu, foi solidificada unidirecionalmente, com extração de calor em moldes de aço e cobre, cujo objetivo foi avaliar que molde leva a obtenção do menor espaçamento dendrítico secundário. Foram realizados ensaios de tração e analise da fratura por microscopia eletrônica de varredura – MEV. Os corpos de prova para o ensaio de tração foram retirados de posições centrais do lingote. Na liga solidificada no molde feito em cobre os espaçamentos dendríticos são menores em relação ao molde feito em aço. O aspecto da fratura sugere que a fratura percorreu o caminho entre as dendritas, onde a matriz de alumínio não sofreu deformação. A presença do eutético Al_2Cu junto a defeitos oriundos da presença de oxigênio e impurezas na liga são provavelmente as causas da fragilidade.

Palavras-chave: Ligas; Fratura; Espaçamento dendrítico.

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1 INTRODUCTION

Aluminum alloys find a wide variety of uses because of its remarkable combination of characteristies such the low density, the high corrosion resistence, high electrical heat conductivity and excelent mecanical properties.(1-4) However, the alloys of aluminum possess those qualities, for the added elements, the size of grains formed by the solidification type that they influence in the property of the alloy.(5)
The mechanical properties of the alloys depend to the solidification spped, this for her time is certain by secondary dendrite arm spacing (SDAS).(6) The dendrite spacing is one of the main structural parameters that it is influenced strongly by the material of the mold and directionally solidified.(1,5,7,8) The unidirecional solidification studies a influence the dendritic spacing.(9,10) Thus a number of workers have studied the effects of the secundary dendrite arm spacing (SDAS) on the behaviour of the mecanical properties.
The main objective of the present work was to study the effect the material of the mold behaviour in secundary dendrite arm spacing (SDAS) with respect to the mecanical properties.

2 EXPERIMENTAL WORK

Commercial aluminum added with 10% copper, solidified using the unidirectional solidification technique.
The end-chill apparatus used consisted of steel and copper with 63mm thickeness to promote directional solidification. The mold was made in insulating material was used to reduce heat losses from the metal/air surface.
The specimens produced were in the form of ingot. The ingots cut the specimen dimensions by a tensiom test according to ASTME-8M-97(11) standards from the selected transverse sections of the directionally solidified specimens at 20 mm, 37 mm, 52 mm from the metal/mold interface.
Tensile tests were conducted at spped 100mmm/min temperature of 25ºC, an load 220N and relative humidity 70,00%, the tension test according to NBR-6810-1991 standards. After by characterization by tensile test, the fracture surfaces was observed, by scanning electron microscope - SEM.
, and then they were sectioned along the tensile axis and polished by using the standard metallographic techiniques and etched with an acid solucion caustic solucion (10g NaOH+90ml H_2O of) Metals Handbook, ASM, (1999) for eight minutes. The microstructure for micrograph examination and evoluction of the dendritic spacing was characterized by scanning electron microscope - SEM.
The tests were carried out an more than thirty-two specimens, having different material from either the type mold.

3 RESULTS AND DISCUSSION

3.1Results of the Chemical Analysis

The mecanical compositions of the alloys are shown in Table1. Were obtained samples of the thirty-two prepared alloys. The Table 1 displays the main elements.

Table 1 - Presents the chemical composition of the used elements.

	Al	Mg	Si	Cu	Fe	Mn	Zn	B	Outros
Al	<99.73	0,0018	0,0518	0,0015	0,158	0,0018	0,0027	0,0003	>0,0006
Cu	-	-	-	99,90	0,0095	-	-	-	-

3.2 Tensile Properties and SDAS

As show in Figure 1 and 2, the graph tension and elongation for the different conditions studied in the present work. The strength and elongation of materials decreases with distance growth from the metal/mold interface too both types the mold.
However the tension is higher for sample by mold with copper in relation to the mold with of steel.

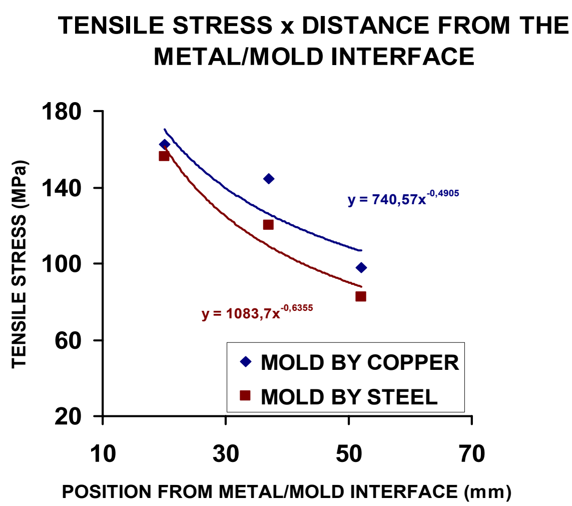

Figure 1 – Effect of distance from the metal/mold interface and type the mold.

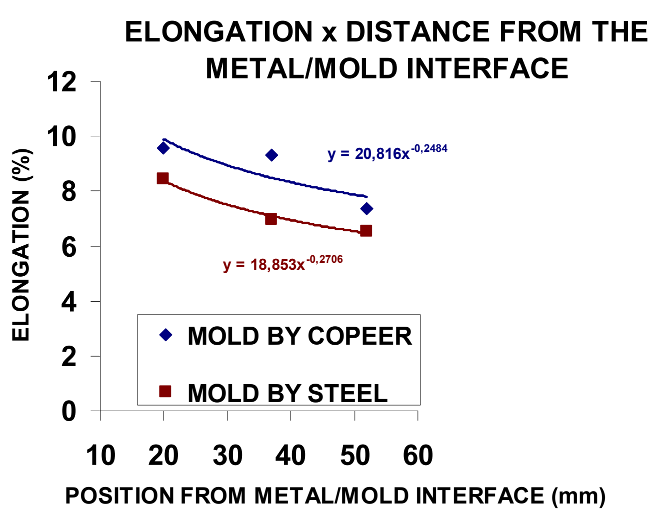

Figure 2 – Effect of distance from the metal/mold interface and type the mold.

Table 2 show the comparisons between secondary dendrite arm spacing (SDAS) for solidification with end-chill of steel end copper.

Table 2 –Relationship of secondary dendritic spacing with the position in that they were measured distant of the interface metal/mold.

Mold/interface	7 mm	14 mm	20 mm	Increase
Copper 63 mm	13,33	17,07	23,00	200 X
Steel 63 mm	15,60	19,20	25,00	200 X

The SDAS decreased from about 48 µm from about 43 µm (section at 20 mm) and 66 µm from about 60 µm (section at 37 mm). Figures 3 and 4 reveals pattern of structure microscopically the (SDAS) for both end-chin (steel and copper).
Figure 3 shown the photo micrographic of distance from the metal/mold interface for mold by copper.

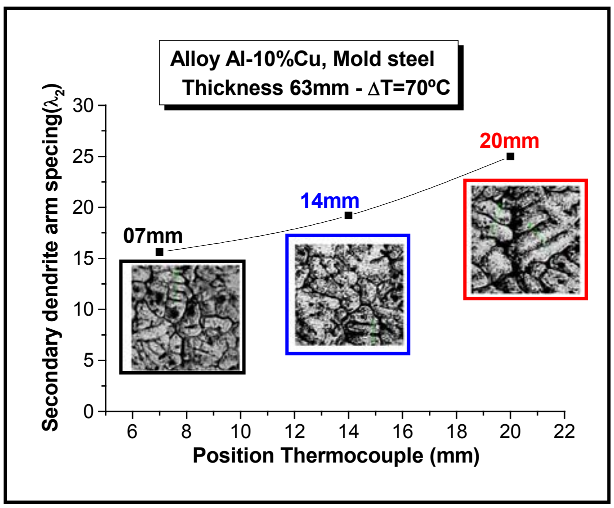

Figure 3 - Graph for alloy solidified in mold of steel 63 mm, with the Image of microscopy showing the dendritic growth.

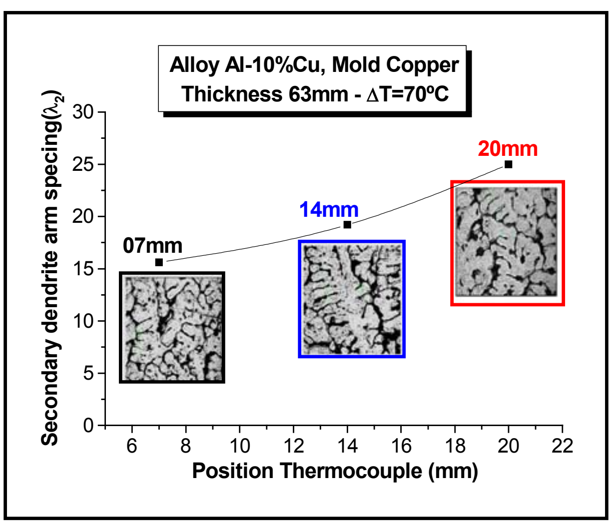

Figure 4 - Graph for alloy solidified in mold of copper 63 mm, with the Image of microscopy showing the dendritic growth

Comparisons with tensile properties shows the alloy with larger SDAS (Figure 3) (mold of steel) present lower ductility. However the alloy with small SDAS (Figure 4) (mold of copper) present height ductility.
This result is most the influence of the growth the SDAD during initiate to end the unidirectional solidification.

3.3 Fractography

Upon examining the fractures surfaces of the test specimens, present multiple crack paths are created upon tensile test.

Figure 5 – Shape of fracture surface the specimens. a) sample by mold with copper b) sample by mold with steel.

In Figure 6 shows a typical surface of a brittle fracture created during the fast fracture.

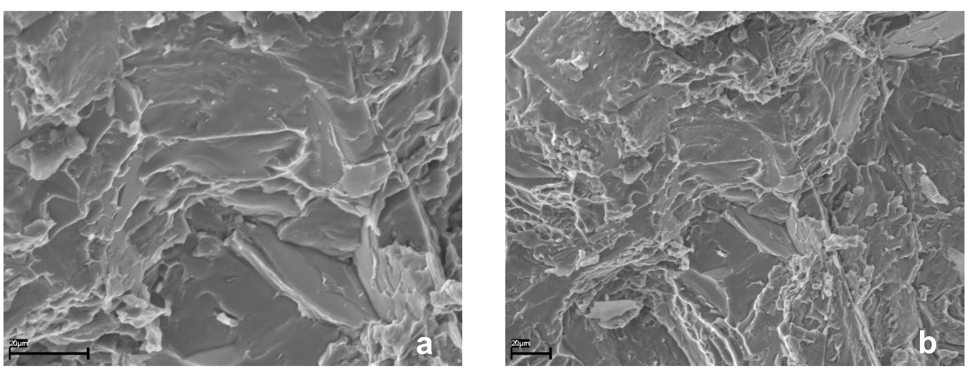

Figure 6 – Brittle fracture surface a) mold with copper SEM 400 x b) mold with steel SEM 400x.

The fracture surfaces present the difference much smaller for both materials solidify by two type mold (Figure 7). This leads to suggest that fracture surface is promoted by the combined effect of coarse grains and an enrichment of segregation elements.

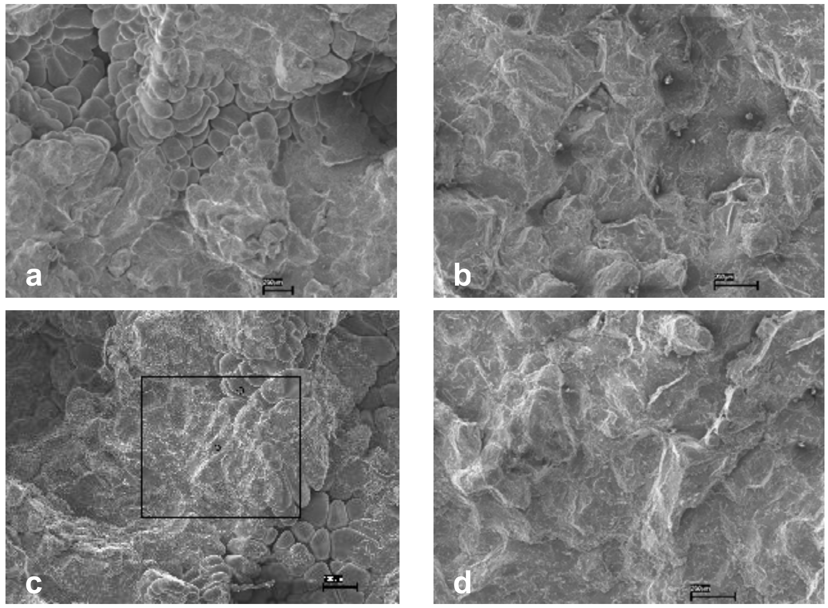

Figure 7 – Image of a tensile specimen; a) sample by mold with copper SEM,1000x. b) sample by mold with steel SEM,1000x; c) aspect of the surface the sample by mold with copper SEM1000x; d) detail of c)SEM 1000x.

Figure 8 shows a fracture surface of base metal. The surface present a structure, clean with phases constitution the eutectic structure (Al_2Cu). Observe the base metal (α) of aluminum permanence intact. Whereas eutectic structural (Al_2Cu) precipitates with excess an interdendritic regions and are thought to be responsible for further embrittlement.

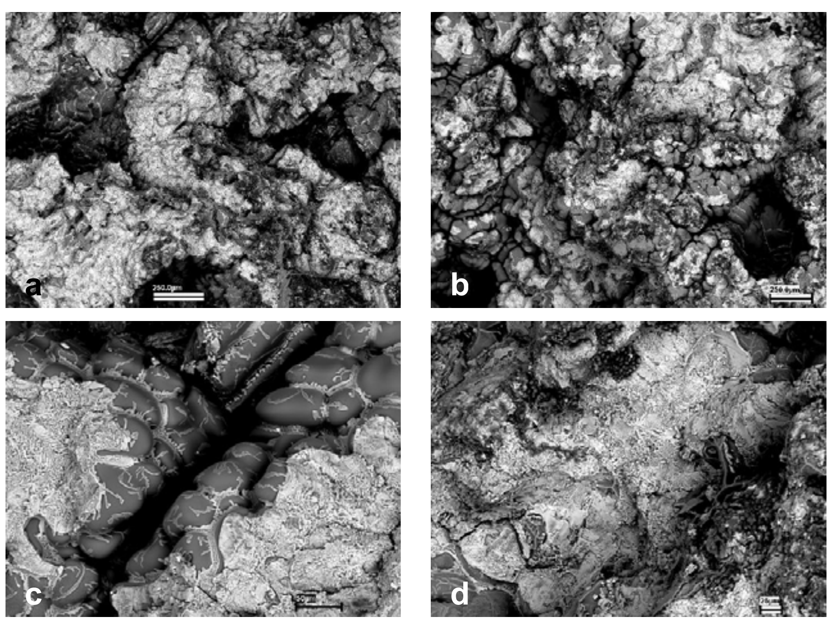

Figure 8 – Fracture surface of base metal a) mold with copper, SEM 5000x; b) mold with steel,SEM 5000x; c) detail of sample showing the type eutectic structure with am base metal; c)detail of a) SEM 250 x;d) detail of d)SEM 500x.

4 CONCLUSIONS

The mold consisted of copper produce in alloy structure with narrow secondary dendrite arm spacing (SDAS). In alloy, with small SDAS the mechanical properties is satisfactory in relation to the mold with of steel.

The aspect of the fracture surface apparent fragility. The phases eutectic structural (Al_2Cu) combined with coarse grains is probably responsible for embrittlement.

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