EFFECTS OF GATING SYSTEM DESIGN ON TENSILE PROPERTIES OF CAST ALUMINIUM 6063 ALLOY

Oyetunji Akinlabi[1)]*, *Adedeke Ayodele*[1)]
[1)] *Department of Metallurgical and Materials Engineering, Federal University of Technology, Akure, Nigeria*

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*Corresponding author: *email:* akinlabioyetunji@yahoo.com, *Department of Metallurgical and Materials Engineering, Federal University of Technology, Akure, Nigeria*

Abstract
The effects of gating system design on the tensile strength properties of cast Al-Mg-Si alloy component were studied, with gating sprue diameters of 10 mm and 12 mm respectively for pressurized and non-pressurized systems. A match plate pattern was made for channels and mould cavity preparation, while the pouring temperature is at 680^0C maintained as the optimum temperature. The variation with respect to increasing ingate of 1 to 3 was observed, the resulting castings from the gating system were compared for tensile strength using instron tensile test machine. The non-pressurized system with reduced turbulence and increasing cross sectional area towards the mould cavity, had finally increased the tensile strength. The result shows that 2-ingate pressurized gating system with 10 mm sprue diameter designed type has improved tensile strength. While the non-pressurized system with reduced turbulence and increasing cross sectional area towards the mould cavity, had finally increase the tensile strength.

Keywords: Gating system, Pouring Temperature, Tensile Strength, Gravity, Pressurized and Non-pressurized; Foundry

1 Introduction

Gating system is the assembly of channels which facilitates the molten metal to enter into the mould cavity [1-3]. There're two types of gating systems depending on the choke area: non-pressurised and pressurized [4]. A non–pressurised gating system having choke at the sprue base, has total runner area and ingate area higher than the sprue area. In this system, there is no pressure existing in the metal flow system and thus it helps to reduce turbulence, a typical gating ratio is 1:4:4. In the case of pressurised gating system normally the ingates area is the smallest, thus maintaining a back pressure throughout and generally flows full and thereby, can minimize the air aspiration even when a straight sprue is used. It provided higher casting yield since the volume of metal used up in the runners and gates is reduced. A typical gating ratio is 1:2:1 [5,6].
One of the important features of mould cavity is the gating system [7,8]. The gating system is composed of pouring basin, sprue, runner, gate and riser. The function of sprue and runner is to allow the molten metal to completely fill the cavity of casting component. However, uniform flow of the molten metal is required to avoid entrapment of air, metal oxidation and mould erosion [9,10].
This research investigate the effects of designed gating systems components such as varied sprue diameters of 10 mm and 12 mm with increased in-gate number of 1 to 3 on the tensile properties

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of Aluminum alloy produce through sand casting technique. The main goal is to improve the quality of resulting casting with minimal damage.

2 Methodology

2.1 Chemical Composition

The material used for this experimental work was aluminium alloy 6063. Spark analysis was done to obtain the chemical compositions of the alloy at Nigalex (Nigeria Aluminium Extrusions) Limited and the result presented in **Table 1**.

Table 1 Chemical Composition of Al-Mg-Si (6063) Alloy

Element	Al	Si	Mg	Fe	Cu	Mn	Cr	Ni
Weight [%]	98.66	0.4498	0.4620	0.2425	0.005	0.0162	0.005	0.000
Element	Zn	Ti	Be	Ca	Pb	V	Zr	Sn
Weight [%]	0.0002	0.006	0.000	0.000	0.0337	0.007	0.0011	0.000

2.2 Casting

Match plate pattern was made for channel and mould cavity preparation. The aluminium alloy was melted in a crucible furnace at a pouring temperature of 680 $^{\circ}$C [11,12] into the prepared sand mould, afterwards the castings is left for 24 hrs. for solidification; and thereafter removed from the mould for fettling. Rods of 20 mm in diameter by 200 mm in length were produced [13-15].

2.3 Machining

The as-cast aluminium alloy was machined to tensile samples using student 2500 centre lathe into dimensions of 5 mm in diameter and 40 mm gauge length as shown in Fig. 1. In accordance with [16].

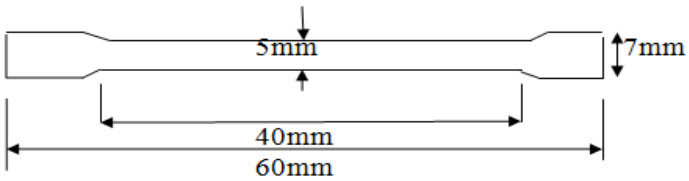

Fig. 1 Tensile Sample

2.4 Tensile Test

Room temperature uniaxial tensile test were performed on round samples machined from the aluminium cast alloy. Each test piece was clamped on the tensometer capable of producing a load-extension graph on attached graph paper. A graphical result of the applied load against extension was obtained from the auto graphic reading drawn by the Hounsfield tensile testing machine, and from which the maximum load was obtained and corresponding stress calculated [16].

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3 Results and Discussion

3.1 Effect of Different Ingates on the Tensile Properties of Pressurized and Non-pressurized Gate systems

From **Fig. 2**, it was observed that the control sample has decreased tensile strength of (89.8 $N.mm^{-2}$ and 83.3 $N.mm^{-2}$) for sprue diameters of 10 mm and 12 mm respectively, in comparison to increased numbers of 2-3 ingates for the pressurized; and non-pressurized gating systems with improved tensile strength properties as show in **Fig. 3-5**. True stresses for pressurised 2-ingate has (171.1 $N.mm^{-2}$ and 83.1 $N.mm^{-2}$) and 3-ingates has (132.6 $N.mm^{-2}$ and 126.1 $N.mm^{-2}$), while tensile strength for non-pressurised gating system for 3-ingates has (135.9 $N.mm^{-2}$ and 150.4 $N.mm^{-2}$) for 10 mm and 12 mm sprue diameters respectively are presented in **Table 2**.

Table 2 True Stresses for Tensile Test Samples

Samples	Sprue diameter [mm]	True stress [$N.mm^{-2}$]	Designed components
A1	10	132.6	Pressurised gating system with 3-ingates
A2	12	126.1	Pressurised gating system with 3-ingates
B1	10	171.1	Pressurised gating system with 2-ingates
B2	12	83.1	Pressurised gating system with 2-ingates
C1	10	89.8	Pressurised gating system with 1-ingate
C2	12	83.3	Pressurised gating system with 1-ingate
D1	10	135.9	Non-pressurised gating system with 3-ingates
D2	12	150.4	Non-pressurised gating system with 3-ingates

The result is in accordance with [17] work on influence of gating system design on tensile properties of $AlSi_7MgO_3$ alloy, which the experimental research shows little improvement of the tensile strength based on design gate system. And the increase in the higher casting yield is provided by the molten metal inflow into the mould cavity for the pressurized gating system whereby a back pressure is maintained which reduces air aspiration, and for the non-pressurized gating system that help reduces turbulence [18, 19].

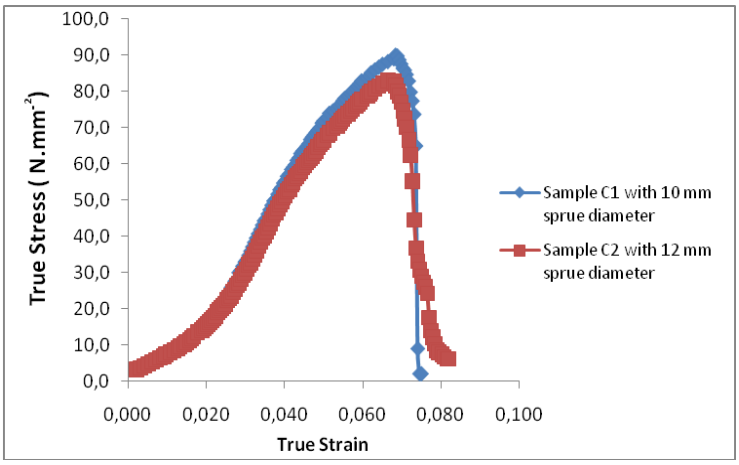

Fig. 2 Variation of True Stress with True Strain for Aluminium 6063 under Horizontal Top Feeding System for Control Samples with 10 mm and 12 mm Sprue Diameters

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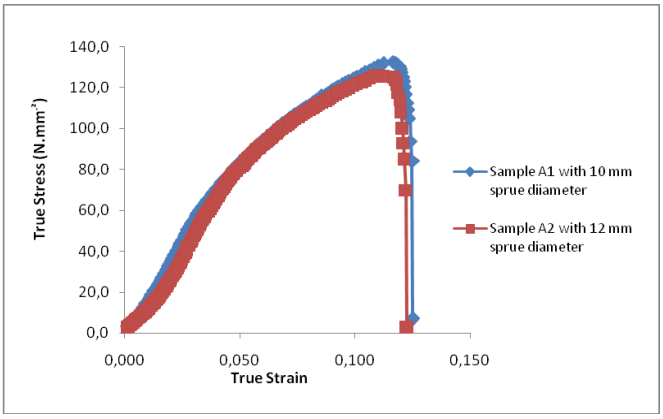

Fig. 3 Variation of True Stress with True Strain for Aluminium 6063 under Pressurised Gating System with Three(3) Ingates for Samples with 10 mm and 12 mm Sprue Diameters.

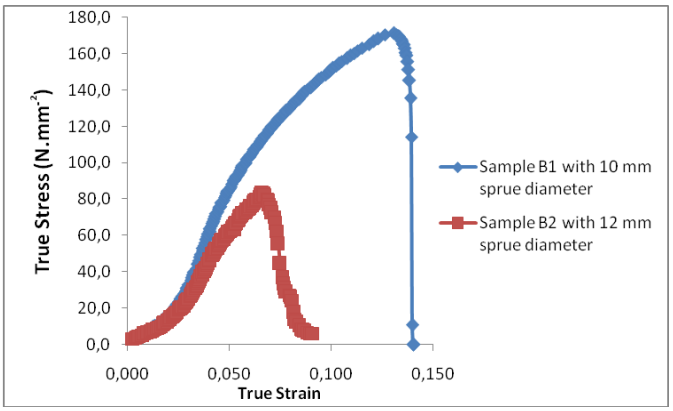

Fig. 4 Variation of True Stress with True Strain for Aluminium 6063 under Pressurised Gating System with Two(2) Ingates for Samples with 10 mm and 12 mm Sprue Diameters

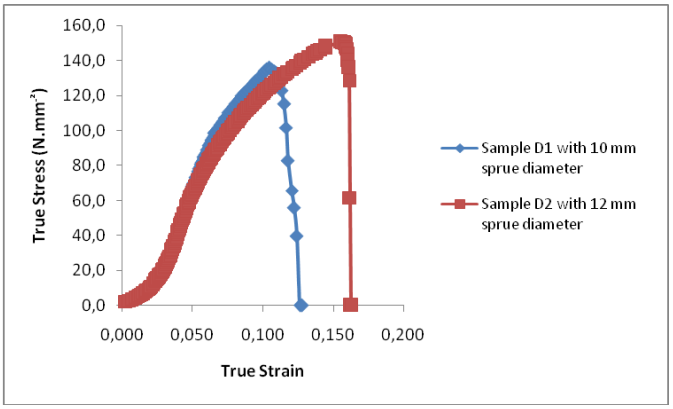

Fig. 5 Variation of True Stress with True Strain for Aluminium 6063 under Non-Pressurized Gating System with Three(3) Ingates for Samples with 10 mm and 12 mm Sprue Diameters.

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3.2 Effect of Different Sprue Diameters on the Tensile Properties of Pressurized and Non-pressurized Gate systems

Fig. 6, shows graph for the effect of different sprue diameters for tensile strengths from produced castings for the pressurized and non-pressurized gate systems. The control sample with 10 mm and 12 mm sprue diameters under horizontal top feeding system produced casting with reduced tensile strength of 89.8 N.mm^{-2} and 83.1 N.mm^{-2} respectively, in comparison to gating systems design with runner component (as shown in **Fig. 2**).

The samples with 10 mm sprue diameters under pressurized gate systems had increased tensile strengths, whereas the non-pressurized system has increase tensile strength for 12 mm sprue diameter as depicted in (**Fig. 5**).

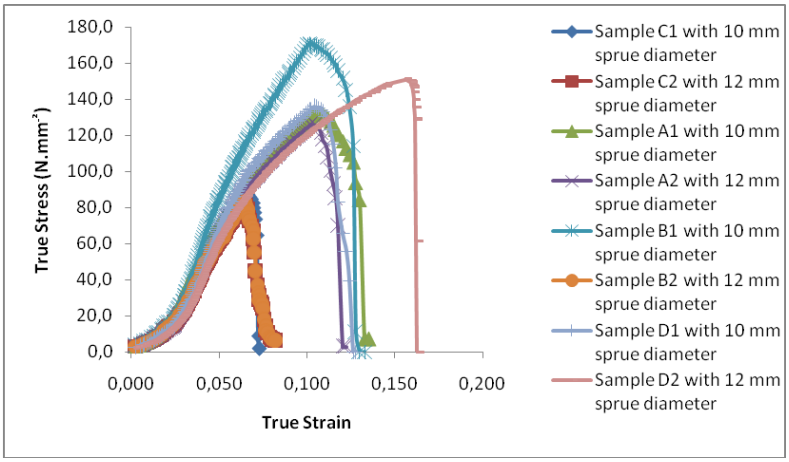

Fig. 6 Variation of True Stress with True Strain for Aluminium 6063 under both Pressurized and Non-Pressurized Gating Systems for Samples of Different Sprue Diameters

3.3 Effect of Different Sprue Diameters on the UTS of Cast Alloy Samples Produced from Pressurized and Non-pressurized Gate system

Fig. 7, shows that the 10 mm sprue diameters for the cast alloy samples for pressurized gating system has better increased tensile strengths, and in the contrary the 12 mm sprue diameter for non-pressuurized gate system had finally increased tensile strength. However, the average UTS for the cast alloy samples with 10 mm sprue diameters under pressurized designed systems tend to have improved tensile strengths of 132.6 N.mm^{-2} and 171.1 N.mm^{-2} for 3-ingates and 2-ingates system design respectively. While the 12 mm and 10 mm sprue diameters for non-pressurized gate systems had UTS of 150.4 N.mm^{-2} and 135.9 N.mm^{-2} respectively (as shown in **Fig. 5**).

4 Conclusions

The effect of gating system design on tensile strength of cast aluminium alloy was studied. Hence, the following conclusions were drawn:

a) Increase in number of ingates for gating systems design has effect on the tensile strength of produced castings as expected.

b) For improved tensile strength properties for gating systems the ratio of the runner component to the sprue diameter should be considered double for pressurized systems.

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c) The sample with 10 mm sprue diameter with 2-ingates has the highest average UTS of 171.1 N.mm^{-2} under the pressurized system, while the non-pressurized system had finally increased tensile strength.

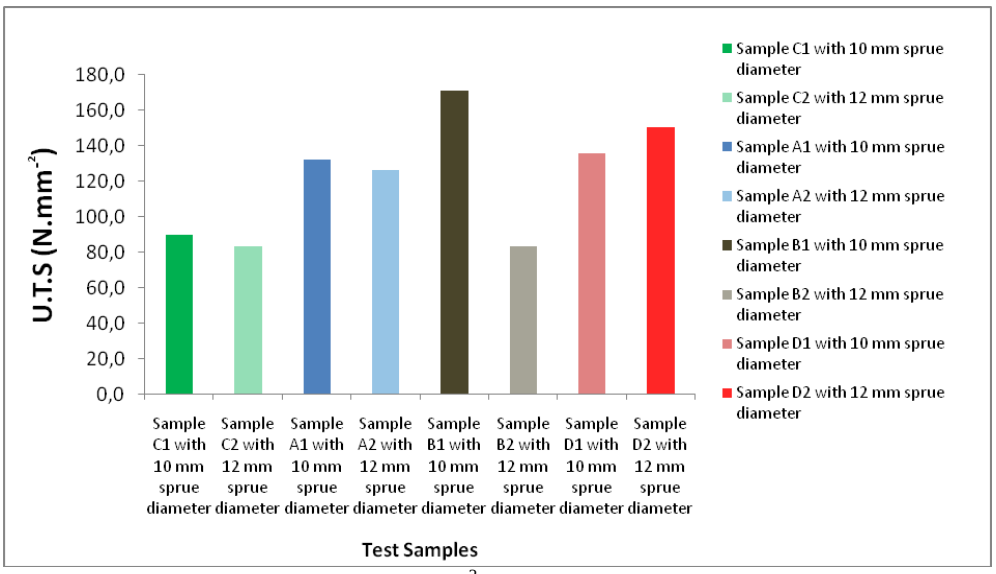

Fig. 7 Variation of Average UTS (N.mm^{-2}) for Aluminium 6063 under both Pressurized and Non-Pressurized Gating Systems for Samples of Different Sprue Diameters

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