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Analysis of Riser Variations in Recycled Aluminum Sand Casting on Hardness Values

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Abstract

In this study, we will discuss the process of casting used aluminum metal. Used aluminum is one of the industrial wastes that can be converted into products using the casting method. This study aims to obtain a good casting material with good hardness values and minimal defects. The research will focus on the results of castings by analyzing the visuals and hardness values of the specimens. The research design is a pre-experimental type of One-Shot Case Study by conducting treatments whose results will be directly observed and analyzed descriptively. The treatment given is to increase the number of risers in recycled aluminum castings. Variations in the number of risers are 1 riser, 2 riser, and 3 riser. Each variation has 3 specimens, so there are 9 specimens in the study. The data from the test results contained a fairly large porosity value for each riser variation. The hardness value that has been tested using the Rockwell hardness tester obtained the highest hardness value occurs in the 2 riser variation, namely 27.69 HRA and the lowest hardness value occurs in the 3 riser variation, namely 21.56 HRA. Thus, for casting used aluminum with a casting pattern as in this study, it is best to use 2 risers.

Keywords: Casting, Sand Molding, Riser, Scrap Alumnium, hardness test

1. Introduction

Metal casting is a method that is widely used to produce engineering tools or objects and objects for everyday life. Most metal tools or equipment are processed through smelting and casting processes, so metal casting has an important role in the production process of metal-based equipment or objects [1].

Khoerur et al conducted a study on the channel system model in the foundry, namely with 3 variations of the channel system model, from the results of the study it was found that porosity defects occur mostly in parts that are far from the channel system. The presence of air that is still trapped in the mold cavity causes more porosity defects. The part close to the duct system has a slight porosity defect because the trapped air can exit directly from the duct. Air in the mold cavity can exit through the riser and inlet. The final solidification level is located in the center of the casting away from the riser and inlet. The longer the freezing rate, the lower the hardness value [2].

The casting results will produce engineered objects in the form of scrap with a high level of hardness and good structure. For this reason, researchers will examine the effect of the number of risers on the casting process. The presence of more than one riser causes air trapped in the mold cavity to easily escape through the riser. The use of recycled aluminum material or scrap aluminum as a casting material aims to reprocess items that are not new anymore.

Dhimas Wicaksono conducted a research on Riser Analysis on casting propellers from used aluminum. The research was conducted by making 3 variations of the tubular riser with variation A not using a riser and variations to B and C using a diameter of 7 mm and 15 mm with a length of 10 mm with used aluminum casting raw materials (recycled) at a pouring temperature of 7000 C. The results of the study shows that the larger the riser, the smaller the shrinkage rate. In testing the microstructure, the

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value of cast defects varies with each variation. In hardness testing, the Riser variation did not significantly affect the hardness level of the used aluminum, but it greatly affected the shrinkage rate and the porosity of the specimen [4].

Rachmadi Norcahyo and Indra Sidharta conducted research on aluminum casting using a simulation method with finite element software, then a casting experiment was carried out to determine the phenomena that occurred during the casting practice. The castings used are in the form of a cube measuring 75 mm × 75 mm × 75 mm with a bottom-horizontal gating system. To determine the effect of the wall thickness of the exothermic riser in overcoming shrinkage defects, an ordinary riser with a cylindrical shape with a diameter of 49 mm and a height of 75 mm was compared with an exothermic riser with the same diameter. The exothermic riser wall has a thickness starting from 5 mm and is added every 2 mm until shrinkage defects do not occur again in the castings. From this study, it was found that increasing the wall thickness of the exothermic riser will result in the aluminum being melted longer. So that the molten metal will be able to fill the castings well [5].

Krisnawan conducted a study by providing variations in the size of the riser (addition channel), namely with three variations of the diameter and height of the riser. The largest percentage of shrinkage occurred in variation 1, with the smallest riser diameter and the largest riser height. While the smallest shrinkage percentage occurred in variation 3, namely with the largest riser diameter and the smallest riser height. Based on this research, it can be concluded that the function of the channel system is very important, not only affecting the structure, but also the hardness value of the castings [6].

The casting that is mostly done in the small-scale or home industry is casting with sand molds [8]. The biggest advantage of the sand mold is that almost any metal can be poured into the sand mold and there are no restrictions on the size, shape or weight of the parts [7]. Casting is a process of making components or objects by means of menus

1.1 Sprue System

The Sprue system is a sprue that serves as the passage of metal flow that is poured into the mold cavity which has several parts including: pour cup, Sprue flow, conductor, and inlet [8]. Some parts of the duct system are: pour cup, duct (Sprue System), checker or reservoir, runner , riser (adder), and inlet (ingate) [9].

1.2 Riser

Riser (addition sprue) is a channel that functions to accommodate excess liquid metal which is Scrap as a liquid metal reserve and feeder in case of shrinkage in castings [13]. The riser is a channel that compensates for the shrinkage process in the freezing of the castings, so the riser freezes it must be slower than the casting [9]. The effective riser Scrap is a conical truncated riser with an upper diameter of 25mm and a lower diameter of 10mm, with a length of 60mm [10].

1.3 Scrap aluminum

Aluminum is a non-ferrous metal that has many advantages, including corrosion resistance, light density, good formability, and good castability [11]. The physical properties of aluminum are shown in Table 1 and Table 2.

Table 1: Physical properties of aluminum

Properties,	**Aliminum Purity(%)**	
	99.996	**>99.0**
Density (20^0C)	2.6989	2.71
Melting pint	660.2	653-657
Specific Heat (Cal/g.^{0}C)(100^0)	0.226	0.2297
Electrical resistance temperature coefficient	0.00429	0.0115
Coefficient of expansion (20-100^0C)	$23.86x10^{-6}$	$23.5x10^{-6}$
Crystal Type. Grid constant	Fcc.a=4.013kX	Fcc.a=4.04kX

(Surdia dan saito, 200:134)

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Table 2: Mechanical properties of Aluminum

Properties,	Aliminum Purity(%)			
	99.996		>99.0	
	Dianil	75% cold rolling	Dianil	H18
Tensile Strength (kg/mm^2)	4.9	11.6	9.3	16.9
Creep strength (0.2%)(kg/mm^2)	1.3	11.0	3.5	14.8
Extension (%)	48.6	5.5	35	5
Brinel Hardness	17	27	23	44

(Surdia dan saito, 200:134)

1.4 Visual inspection

Visual inspection is carried out to see the number of cast failures or cast defects that occur, then from the results of this visual inspection the types of failures that occur are grouped to find out what types of failures are often encountered in each cast object [12].

1.5 Hardness

Hardness is a criterion used to express the intensity of resistance of a material to deformation caused by other objects. There are three types of hardness testing [8], namely: stress testing, scratch testing, and resilience testing.

Hardness testing is a process whose purpose is to determine the resistance of a material to deformation in the local area or material surface, namely plastic deformation. Plastic deformation is a condition of a material which when given a force, the microstructure will not return to its original shape [13]. The purpose of this study was to determine the effect of the number of risers on recycled aluminum castings on casting defects and the hardness value of the material.

Table .3: Properties of metal in casting [2]

Type of Metal	Tensile strength (Mpa)	Ductility (%)	Hardness (BHN)
Ferrous			
Gray cast iron	110-207	0-1	100-150
White cast iron	310	0-1	450
Steel	276-2070	12-15	110-500
Non ferrous			
Aluminum	83-310	10-35	30-100
Copper	345-689	5-10	50-100
Magnesium	83-345	9-15	30-60
Zinc	48-90	2-10	80-100
Titan	552-1034	-	158-266
Nickel	414-1103	15-40	90-250

2. Research Methodology

In order for research to be more focused, it is necessary to have a clear research flow. This research flow describes the research process from beginning to end. The flow of this research is made to make it easier to carry out research and what process to do. For more details on how the flow in this research can be seen in Figure 1.

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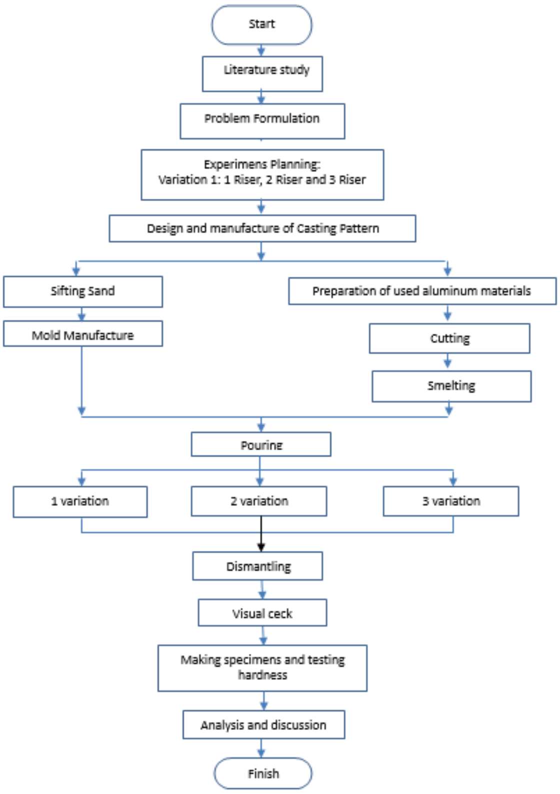

Figure 1: Research flow chart

This research is a type of pre-experimental research which has 2 variables, namely the number of risers in recycled aluminum casting as an independent variable or treatment (X), hardness as the dependent variable or result (O). There are variations in the independent variable or X, namely A1, A2, and A3. A1 is 1 riser, A2 is 2 risers, A3 is 3 risers. The research framework is shown in Figure 2.

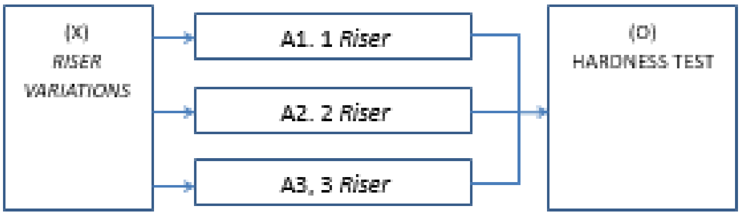

Figure 2 : Research framework

The increasing number of risers also affects the mechanical properties of the castings, one of which is hardness. The faster the freezing rate, the greater the hardness.

2.1 *Hardness Test*

The increasing number of risers also affects the mechanical properties of the castings, one of which is hardness. The faster the freezing rate, the greater the hardness.

2.2 *Research of Material*

The material used in this research is scrap aluminum. The used aluminum used in this research is used beverage cans, aluminum brake pads and others.

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3. Result and Discussion

In this study, hardness testing used the Rockwell hardness tester. The Rockwell tester is easy to use and the hardness value can be quickly determined. The type of Rockwell test equipment used is a digital one, so that the hardness value of the material can be immediately known. The Rockwell hardness tester used is shown in Figure 3.

Figure 3: Rockwell hardness tester used

Hardness test specimens from 3 casting results using variations of 1 riser, 2 riser and 3 riser were made 3 specimen samples each. Thus, the number of specimen samples tested for hardness was 9 specimens. For each specimen, 3 positions of hardness were taken. The hardness test specimen tested using the Rockwell test equipment is as shown in Figure 4.

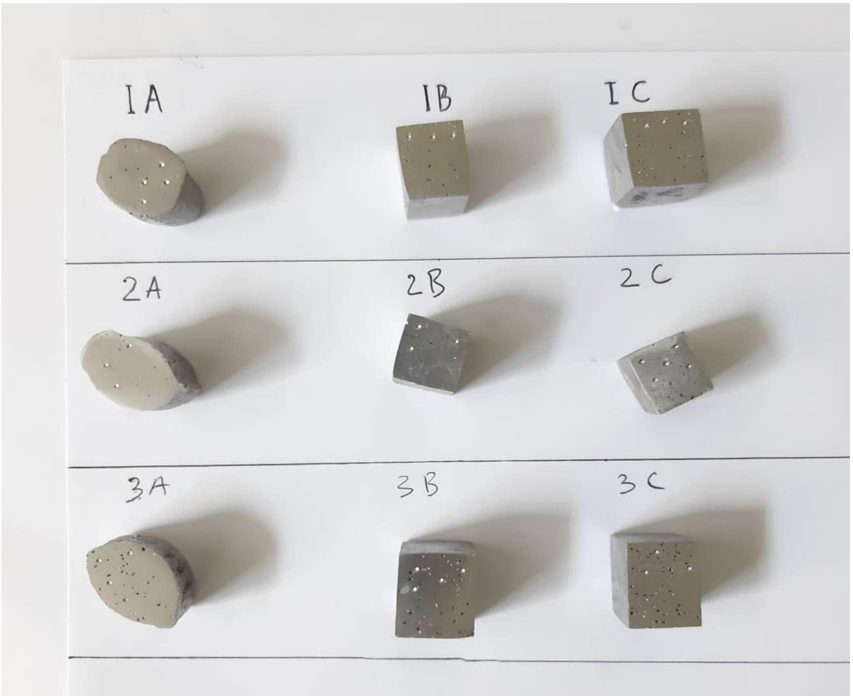

Figure 4: Hardness Test Specimen

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The results of tests that have been carried out on 9 specimen samples can be seen in table 4.

Tabel 4.1: Hardness test results using Rockwell test method

No Spesimen	Hardness value (HRA)				Average	Information
	Number	Point 1	Point 2	Point 3		
Specimen 1	A	17,2	26,9	29,1	24.40	Ø small
	B	46,3	17,0	28,5	30.60	Ø medium
	C	24,1	16,3	14,8	18.40	Ø large
Specimen 2	A	33,6	37,2	32,9	34.57	Ø small
	B	26,1	25,7	31,5	27.77	Ø medium
	C	20,5	24,6	17,1	20.73	Ø large
Specimen 3	A	20,2	14,2	21,5	18.63	Ø small
	B	27,8	34,5	34,1	32.13	Ø medium
	C	10,4	17,5	13,8	13.90	Ø large

To see the hardness value in the variation of 1 riser, 2 riser and 3 riser on parts that have different diameters on the results of used aluminum casting can be seen in Figure 5.

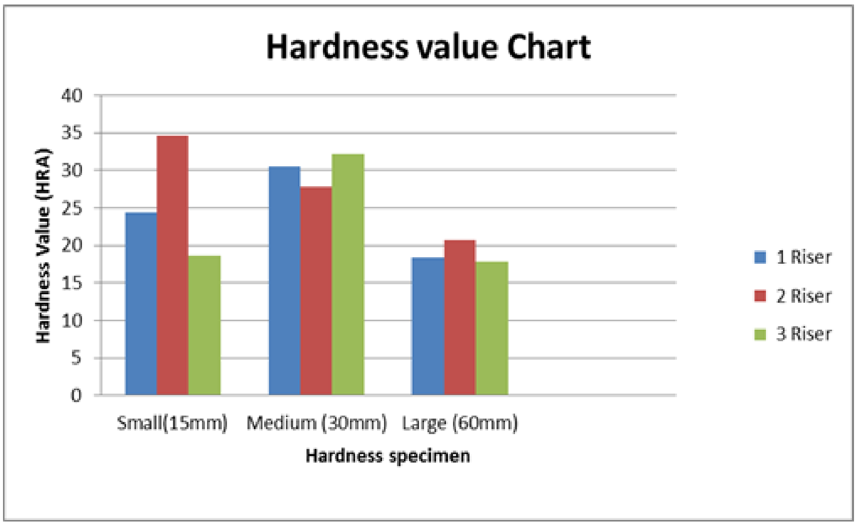

Figure 5 : Hardness value

From figure 5 it can be seen that the hardness value in each variation has a different value. For specimens with small diameter (15mm), the highest hardness value occurred in specimen variation 2, namely 34.57 HRA, while the lowest value was found in specimen variation 3 riser, namely 18.40 HRA. In the medium diameter (30mm) specimen, the highest hardness value was found in the 3-riser variant, 32.13 HRA, and the lowest was in the 2-riser variation, 27.77 HRA. In large diameter specimens (60mm), the highest hardness value occurred in the riser variation specimen, which was 20.73 HRA and the lowest value occurred in the 3-riser variation specimen, namely 13.90 HRA.

From the graph it can also be seen that there is an increase and decrease in the value of hardness in each variation, but in the second variation it tends to decrease, especially in small diameters, this can be caused by the presence of porosity and contaminants in the aluminum liquid originating from used materials. These contaminants cause the tip of the indenter to hit during the hardness test, so that its hardness is much different from the others. In future research, it will be focused on anticipating the occurrence of porosity and minimizing contaminants.

From the three variations of the riser, it can be seen that the hardness values are almost the same. To see the best hardness value of the three riser variations, an average value of all test objects was made for each riser variation. The average value of the three variations of the riser can be seen in Figure 6.

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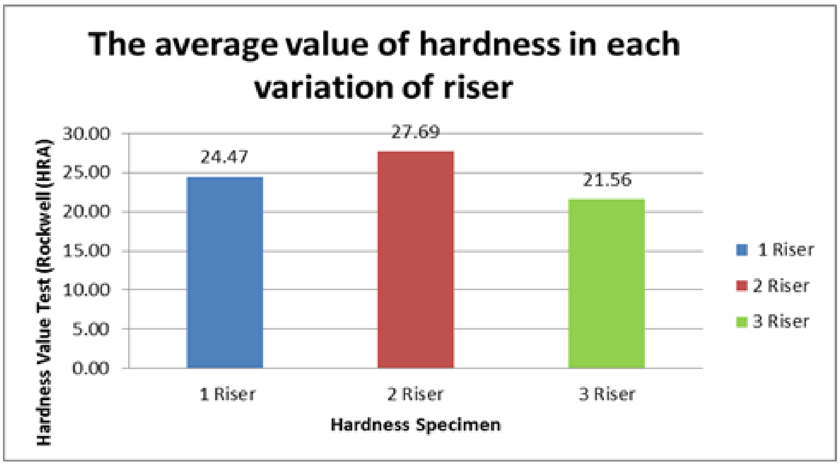

Figure 6: Average hardness test values

From figure 6, it can be seen that the average hardness value was obtained for the specimens with a variation of 1 riser, namely 24.47 HRA, specimens with a variation of 2 risers, namely 27.69 HRA and specimens with a variation of 3 risers obtained a value of 21:56 HRA. So that the highest hardness value occurs in the test object with a variation of 2 risers. Thus, of the three variations of the riser used in this study, the one with the best hardness value is to use 2 risers. This difference in hardness values indicates a riser effect on the hardness value. In hardness testing, the Riser variation did not significantly affect the hardness level of the used aluminum, but it greatly affected the shrinkage rate and the porosity of the specimen [4].

The effect of porosity and contaminants on the specimens resulted in different hardness test results. some of the contaminants in the test specimens are visible and some are invisible, so there will be a possibility that the indenter of the test equipment will press on the position of the contaminant so that its value will be much different compared to the others. But overall, the test results obtained values have almost the same phenomena or variations. Thus, using 2 risers is the most effective in this casting process.

For comparison, the Rockwell hardness value of 27.69 HRA is equal to 69 HBVN on brinel hardness (https://www.engineersedge.com/hardness_conversion.htm). Based on Table 2, the material properties of aluminum show that the Brinel hardness (HBVN) of Aluminum is 30-100. So that the aluminum from this casting has a fairly good hardness of 69 HBVN. Thus the results of this used aluminum casting can be used to make products with high economic value, besides that it can help reduce industrial waste

4. Conclusion

From the results of the tests that have been carried out, the porosity values are still quite large in each riser variation. The porosity of the three risers has non-significant differences, so it can be concluded that the cause of porosity is not only the influence of the number of risers but also the influence of impurities or other particles that are not soluble in the casting. Meanwhile, the highest hardness value occurred in the 2 riser variation, namely 27.69 HRA and the lowest hardness value occurred in the 3 riser variation, namely 21.56 HRA. risers. This difference in hardness values indicates that there is a riser effect on the hardness value. Thus, using 2 risers is the most effective in the process of casting used aluminum.

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