

INVESTIGATION OF NICKEL ALUMINIUM
BRONZE (NAB) METALS CAST AND ITS
PROPERTIES

MOHD NASUHA BIN AB HALIM

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science

A handwritten signature in black ink, appearing to be 'D.' with a flourish, positioned above a horizontal line.

(Supervisor's Signature)

Full Name : IR. DR. MOHD RASHIDI BIN MAAROF
Position : SUPERVISOR
Date : 30 APRIL 2022

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citation which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.



(Student's Signature)

Full Name : MOHD NASUHA BIN AB HALIM
ID Number : MMD 20002
Date : 30 April 2022

INVESTIGATION OF NICKEL ALUMINIUM BRONZE (NAB) METALS CAST AND ITS PROPERTIES

MOHD NASUHA BIN AB HALIM

Thesis submitted in fulfillment of the requirements
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Dedication

I dedicated this to my wife and my children, my parent and my siblings

My supervisor and those who guided and motived me for completing this study

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In the name of Allah, Most Gracious, Most Merciful;

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ABSTRAK

Terdapat tiga jenis gangsa aluminium iaitu gangsa aluminium binary, gangsa aluminium nikel kompleks dan gangsa aluminium silikon yang bermula daripada penambahan kecil aluminium ke dalam tembaga. Ianya bermula daripada penyelidikan terdahulu yang menemui peningkatan kekerasan aloi kuprum tanpa menjejaskan sifat kebolehtempanannya. Menghasilkan aloi NAB boleh membawa kepada penyerapan gas oksigen dan hidrogen sewaktu peringkat pencairan dan mewujudkan kesan kecacatan pada sifat mekanikal dan fizikal aloi NAB. Cabaran lain juga wujud apabila produk mempunyai bentuk yang kompleks yang mengakibatkan kepelbagaian kadar penyejukan semasa pemejalan dan mengakibatkan ketidakseragaman pada struktur mikro. Aloi kuprum yang digunakan dalam kajian ini adalah aloi Nikel Aluminium Gangsa (NAB), yang terdiri daripada beberapa unsur-unsur seperti Cu, Al, Fe, dan Mn. Daripada literatur yang terdahulu, ubahsuai struktur mikro aloi NAB telah terbukti akan meningkatkan kualiti aloi bagi aplikasi automotif dan marin. Sampel adalah rod penyambung enjin yang dibentuk menerusi acuan menggunakan teknik tuangan pasir. Komposisi telah disediakan mengikut piawaian ASTM B148 UNS95800 dan dicairkan menggunakan relau aruhan induksi sehingga suhu 1100°C, kemudian dituangkan ke dalam acuan tuangan pasir dengan agen penyahgas sebanyak 1.1%. Sampel memejal pada suhu ambien. Kemudian spesimen dipotong kepada 3 bahagian mengikut ketebalannya. Kajian diteruskan dengan menyasat sifat, struktur mikro, struktur dendrit, dan kakisan menggunakan perkakasan mikroskop optik, SEM, FESEM, EDS, dan XRD. Berdasarkan dari keputusan, mikrostruktur menunjukkan kuantiti DAS dan SDAS seunit luas menjadi lebih tinggi disebabkan oleh masa pemejalan yang lebih lama. Suhu leburan adalah lebih tinggi apabila ketebalan meningkat disebabkan oleh jumlah tuangan yang lebih tinggi. Saiz dan dimensi mikro struktur juga berubah. Ini akhirnya menghasilkan sifat yang lebih baik, seperti kekerasan yang lebih tinggi dan rintangan kakisan yang baik. Permukaan patah juga mendedahkan butir struktur dendritik dan sempadan ira. Kemudian, spesimen telah direndam dalam air laut dalam kajian rintangan kakisan. Perubahan dalam jisim spesimen, nilai pH, dan TDS air laut yang digunakan telah diukur. Analisis data mendedahkan bahawa spesimen belum terkakis sepenuhnya untuk tempoh rendaman, kerana terdapat sedikit variasi fasa dalam jisim spesimen. Nilai pH dan TDS menunjukkan perubahan, tetapi perubahan ini adalah minimum secara perbandingan. Kesimpulan penyelidikan menunjukkan bahawa kesan penyahgasan pada ketebalan rongga yang bersifat mekanikal NAB pada bahagian yang lebih tebal menahan haba pendam lebih lama dan kadar penyejukan yang lebih perlahan yang menghasilkan kekerasan mikro yang lebih rendah, menghasilkan saiz ira yang lebih besar, DAS dan SDAS yang lebih besar dan kemungkinan untuk mempunyai kadar kakisan yang lebih tinggi berbanding bahagian yang lebih nipis. Berdasarkan hasil kajian ini, aloi NAB sangat sesuai digunakan dalam aplikasi maritim dengan kadar kakisan yang lebih rendah dan sifat mekanikal yang lebih baik.

ABSTRACT

There are three major types of aluminium bronze which is Binary Aluminium Bronze, complex nickel aluminium bronze and silicon aluminium bronze which start from a small addition of aluminium into copper which started from the discovered previous researcher that resulting an increase of hardness of copper alloy without affecting its malleability. Producing NAB alloy can lead to the absorption of gaseous such as oxygen and nitrogen during solidification stage and create a defect on properties and physical to NAB alloy. Another challenge is also present when a product has a complex shape resulting in a variety of cooling rates during solidification and resulting to non-uniformity of the microstructure of the product. This study inspects the effect of thickness during the metal casting process on the microstructure of copper alloy products toward to its properties, microstructure and corrosion. The copper alloy used in this project is Nickel Aluminium Bronze (NAB) alloy, which consists of elements such as Cu, Al, Fe, and Mn. From the previous literature, adjustment of NAB alloy microstructure has been proven to improve the quality toward to properties in automotive and marine applications. The sample is shaped like a connecting rod and fabricated using the sand casting technique. The composition was prepared according to the ASTM B148 UNS95800 standards and melted using an induction furnace at 1100°C, then poured into a sand casting mould with a 1.1% degassing agent. The sample solidified at ambient temperatures, and then the specimen from the NAB alloy sample was cut into 3 sections according to its thickness. The study is continued by investigating the properties, microstructure, dendrite structure, and corrosion by optical microscope, SEM, FESEM, EDS, and XRD. Based on the results, the microstructure morphology shows a quantity of DAS and SDAS per unit area becomes higher due to a longer solidification time. Casting cavity's temperature is higher as the thickness increases due to higher casting volume in the melting state. The size and dimension are affected as well. This eventually results in better properties, such as higher hardness and good corrosion resistance. The fracture surface also reveals intergranular fracture between the dendritic structure and grain boundaries. Later, the specimens were immersed in seawater in the corrosion resistance study. Changes in the specimen mass, pH and TDS values of the seawater used were measured. The data analysis revealed that the specimens were not fully corroded for the immersion period, as there were phase variations in the specimen microstructure. The pH and TDS values show changes, but these changes are minimal comparatively. The conclusion of research shown that effect of degassing on different cavity thickness of NAB mechanical properties on thicker which is holding longer latent heat and slower cooling rate that produces part produces lower microhardness, larger grain size, larger DAS and SDAS and possibility to have a higher corrosion rate compared to thinner part. Based on this research, NAB alloy are very suitable to be use in maritime application with its lower corrosion rate and improved mechanical properties.

TABLE OF CONTENT

	Title Page	Page
DECLARATION		i
SUPERVISOR'S DECLARATION		ii
STUDENT'S DECLARATION		iii
ACKNOWLEDGEMENT		vi
ABSTRAK		vii
ABSTRACT		viii
TABLE OF CONTENT		ix
LIST OF TABLES		xii
LIST OF FIGURES		xiv
LIST OF SYMBOLS		xviii
LIST OF ABBREVIATION		xix
LIST OF APPENDIES		xxi
CHAPTER 1: INTRODUCTION		
1.1	Project Background	1
1.2	Problem statement	3
1.3	Objective	4
1.4	Scope of Study	5
1.5	Structure of The Dissertation	5
CHAPTER 2: LITERATURE REVIEW		
2.0	Introduction	7
2.1	Nickel Aluminium Alloy (NAB)	8
2.2	Sand Casting	10
2.3	Solidification of Sand-Casting Product	11

2.3.1	Growth Morphology in Sand Casting	15
2.3.2	Dendrite Arm Spacing (DAS)	18
2.3.3	Effect of Thickness on Dendritic Structure	19
2.4	Nickel Aluminium Bronze Microstructure	21
2.4.1	Effect of Casting Cavity Thickness on Grain Size	23
2.4.2	Effect of Casting Cavity Thickness on Shape Factor	24
2.5	Effect of Cavity Thickness on Degassing	25
2.6	Effect of Thickness on Shrinkage Porosity/ Properties/ Corrosion/ Power of Hydrogen and Total Dissolved Solids	26
2.7	Summary	27

CHAPTER 3: METHODOLOGY

3.1	Introduction	29
3.2	Flow Chart	29
3.3	Pattern and Mould Preparation	32
3.4	Melting	34
3.4.1	Preparation of NAB Alloy	34
3.4.2	Melting	36
3.4.3	Tapping and Degassing	37
3.5	Specimen Preparation	37
3.5.1	Sample Preparation for Tensile Test	37
3.5.2	Sample Preparation for Hardness Test	38
3.5.3	Specimen Preparation for Corrosion Experiment	39
3.6	Specimens Preparation Microstructure Analysis	41
3.6.1	Specimen Preparation for Microstructure Observation	41
3.7	Microstructure Analysis, Dendritic Analysis, and Phase Analysis	43

CHAPTER 4: RESULTS & DISCUSSION

4.1	Introduction	46
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4.2	An Analysis of General NAB Properties	47
4.3	An Analysis of General NAB Microstructure	50
4.4	The Effect of Product Thickness on NAB Microstructure's Average Shape Factor and Grain Size	54
4.5	The Effect of Product Thickness on NAB Dendritic Structure DAS and SDAS	60
4.6	The Effect of Product Thickness on Corrosive Environment	69
4.7	Corrosion Rate Analysis	72
	4.7.1 Mass of Specimen	72
	4.7.2 Corrosion Rate	73
	4.7.3 pH Value	76
	4.7.4 Total Dissolve Solid Value	77
CHAPTER 5: CONCLUSION		
5.1	Conclusion	80
5.2	Recommendation	81
REFERENCES		82
APPENDICES		93

LIST OF TABLES

Table 1.1	Influence of alloying elements	1
Table 2.1	Chemical Composition Nickel Aluminium Bronze – Cast (ASTM C95800 B148)	9
Table 2.2	Mechanical Properties of Nickel Aluminium Bronze – Cast (ASTM C95800 B148)	9
Table 2.3	Physical Properties of Nickel Aluminium Bronze – Cast (ASTM C95800 B148)	9
Table 2.4	The metal reactivity series, shows the arrangement of the appropriate reactivity of metal against oxygen. The top-down arrangement indicates reduces catalytic reactivity	26
Table 3.1	Specimens preparation and its repetition prepared for post-process test	33
Table 3.2	Composition of NAB alloy according to ASTM B148-C95800 and the actual average weight of an element, including physical appearances	34
Table 4.1	Thickness vs micro-hardness vs DAS size	49
Table 4.2	General micrograph of NAB microstructure (b), (c) and (d) compared to the schematic (a)	51
Table 4.3	Image of NAB connecting rod and its microstructure captured by optical microscope (magnified at 100x). Highlighted in the red square is a sample from the product edge. Meanwhile highlighted in the green square is a sample from the middle of the product (Relative to x-x)	55
Table 4.4	Shows the average shape factor and grain size of the big end section at the edge and middle points	55
Table 4.5	The average shape factor and grain size of the Beam section at the edge point and middle point	57
Table 4.6	The average shape factor and grain size of small end sections at the edge and middle points	57
Table 4.7	Linear trendline equation of shape factor from edge point to middle point on the big end, beam, small end	58

Table 4.8	Linear trendline equation of average grain size from edge point to middle point on the big end, the beam, and the small end	60
Table 4.9	Table show an image of casting a nickel aluminium bronze connecting rod and its microstructure captured by a Scanning electron machine at 1000x. On the NAB product highlighted in the red square is a sample from the edge of the product meanwhile highlighted in the green square is a sample from the middle of the product	61
Table 4.10	The average value of dendrite arm spacing and secondary dendrite arm spacing of big end section at edge point and middle point	62
Table 4.11	The average dendrite arm spacing and secondary dendrite arm spacing of small end sections at the edge point and middle point	63
Table 4.12	Linear trendline equation of average size of dendrite arm spacing (DAS) from edge point to middle point on the big end, beam, small end	65
Table 4.13	Linear trendline equation of average size of secondary dendrite arm spacing (SDAS) from edge point to middle point on the big end, the beam, and the small end	65
Table 4.14	Composition of corrosion element on corrosion specimen	71
Table 4.15	Mass loss of corrosion testing (immersion)	72
Table 4.16	Corrosion rate of different sections of connecting rod	73
Table 4.17	pH value of seawater electrolyte at a different section of connecting rod after 123 days immersion test	77
Table 4.18	TDS value of seawater electrolyte at a different section of connecting rod after 123 days immersion test	78

LIST OF FIGURES

Figure 1.1	Diagram of connecting rod I-Beam	3
Figure 1.2	Porosity trapped between dendritic structure	4
Figure 2.1	Cu-Al-5 wt.% Ni-5wt.% % Fe phase diagram	10
Figure 2.2	Cooling curve of pure metal during casting	12
Figure 2.3	(a) phase diagram for a copper-nickel alloy system and (b) associated cooling curve for 50%Ni-50%Cu composition during casting	13
Figure 2.4	(a) Characteristic grain structure in the casting of pure metal, showing randomly oriented grains of small size near the mould wall, and large columnar grains oriented toward the centre. (b) The characteristic grain structure in an alloy casting shows segregation of alloying components in the centre of the casting.	14
Figure 2.5	Illustrated the growth morphology begins from the group of atoms touching the mould wall and forming nano-sized crystallites from a molten metal called nuclei and continued growth to larger crystalline and finally form a grain. The solid is an embryo if its radius is less than the critical radius and is a nucleus if its radius is greater than the critical radius.	16
Figure 2.6	The transition in growth morphology. The growth morphology changes from planar to cellular, to dendrite as compositionally induced undercooling increases	16
Figure 2.7	(a) if the liquid is undercooled, a protuberance on the solid-liquid interface can grow rapidly as dendrite. The latent heat of fusion is removed by raising the temperature of the liquid back to the freezing temperature. (b) Scanning electron micrograph of dendrites in steel (15x magnification)	17
Figure 2.8	(a) The Formation of a raft of dendrites to make grains. (b) Relationship between Dendrite Arm Spacing, Grain Size, and Local Solidification Time of Alloy Al-4.5%Cu	19
Figure 2.9	Secondary dendrite arm spacing. Linear intercept measurement method and three-dimensional representation. Source: Tailoring	20

Properties to Represent HPDC Tensile and Fatigue Behavior in Al-Si Cast Alloy

Figure 2.10	Shown an SDAS vs distance from the centre of a specimen to mould wall where is (A. mould temperature 35°C, B. mould temperature 200°C, and C. mould temperature 400°C) and micrograph of a specimen from centre to wall mould	21
Figure 2.11	(A) Schematic micrograph of NAB alloy (B) Micrographic phase structure of nickel aluminium bronze at 500x	22
Figure 2.12	(a) Effect of the shape factor of primary α -Al phase on ultimate strength and elongation of a semi-solid slurry of Al-Si-Mg-Fe alloy in as-cast condition, (b) Globule formation during stirring in the semi-solid range, structure evolution in rheocasting	25
Figure 3.1	Flowchart of experimental activities throughout the study	31
Figure 3.2	Connecting rod shape dimension (mm) and cut specimens according to area and segment	32
Figure 3.3	Sand muller machine used to mix the greensand assortment	33
Figure 3.4	Connecting rod pattern sand mould in cope and drag halves	34
Figure 3.5	Illustration of crucible volume	35
Figure 3.6	The Graphite Crucible coated with Zircon Flour Binding using Sodium Silicate and Colloidal Silica	36
Figure 3.7	Melting of NAB alloy using T.S. Induction Furnace	36
Figure 3.8	Tensile test shape dimension (mm) of NAB alloy according to ASTM E-8	38
Figure 3.9	Instron 1195 Universal Testing Machine	38
Figure 3.10	Vickers machines, Matsuzawa MMT-X7 for microhardness	39
Figure 3.11	Schematic diagram of immersion test	40
Figure 3.12	Methyl-methacrylate liquid and the LECOMAT™ Pressure Vessel	42
Figure 3.13	(a) Grinding process using abrasive paper, (b) Polishing process and, (c) Etching process	43
Figure 3.14	(a) Optical microscope OLYMPUS BX53 series, and (b) FEI QUANTA 450, SEM & EDS combo machine	44
Figure 3.15	FESEM machine JEL JSM-7800F	45

Figure 3.16	Bruke D8 ADVANCE	45
Figure 4.1	Schematic representation of Daihatsu ED-10 engine connecting rod with metal casting part from the fabricated mould	46
Figure 4.2	No-necking of NAB sample after a tensile stress test	47
Figure 4.3	FESEM images of the fracture surface due to the effect of degassing addition	48
Figure 4.4	Gas porosity (arrows) inside alloy's microstructure	53
Figure 4.5	Microstructure image capture at 100x. (a) Microstructure at big end section at edge point. (b) Microstructure at the big end at the middle point	56
Figure 4.6	Chart of average shape factor (a) and average grain size (b), from edge point to the middle point of the big end part	56
Figure 4.7	Microstructure image capture at 100x. (a) Microstructure of beam section at edge point	56
Figure 4.8	Chart of average shape factor (a) and average grain size (b), from edge point to the middle point of beam part	57
Figure 4.9	Microstructure image capture at 100x. (a) Microstructure of small end section at edge point. (b) Microstructure of small end at the middle point	57
Figure 4.10	Chart of average shape factor (a) and average grain size (b), from edge point to the middle point of the small end part	58
Figure 4.11	Scanning electron micrograph of big end section which is shown numerous dendrite arms spacing and secondary dendrite arms spacing, 1000x. (a) Micrograph at the edge of the big end section, and (b) micrograph at the middle of the big end section	62
Figure 4.12	Chart of average dendrite arm spacing (a), and average secondary dendrite arm spacing (b), from edge point to middle point of the big end section	62
Figure 4.13	Chart of average dendrite arm spacing (a), and average secondary dendrite arm spacing (b), from edge point to middle point of the big end section	63

Figure 4.14	Chart of average dendrite arm spacing (a), and average secondary dendrite arm spacing (b), from edge point to middle point of the big end section	63
Figure 4.15	Chart of average dendrite arm spacing (a), and average secondary dendrite arm spacing (b), from edge point to middle point of the big end section	64
Figure 4.16	Chart of average dendrite arm spacing (a), and average secondary dendrite arm spacing (b), from edge point to middle point of the big end section	64
Figure 4.17	Micrograph of the beam section of the SEM microstructure result (middle point)	67
Figure 4.18	EDS result of the beam section of connecting rod (middle point)	68
Figure 4.19	Beam section of the SEM microstructure result (edge point)	68
Figure 4.20	EDS result of the beam section of connecting rod (edge point)	69
Figure 4.21	First day of Immersion Test	70
Figure 4.22	After 60 days Immersion Test	70
Figure 4.23	Precipitated elements covering the immersed specimen	70
Figure 4.24	Mass loss of selected component thickness	72
Figure 4.25	Micrograph of corroded area. The red rectangle was magnified to 4000x	74
Figure 4.26	Micrograph of magnified corrosion film	74
Figure 4.27	Corrosion film XRD analysis	75
Figure 4.28	pH value of the initial and final day of immersion test	77
Figure 4.29	Dendritic structure after immersion test	79

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