The Enhancement of Micro Grinding Process By Using NdFeB To Seize Material Dust

by

Ahmad Fadhil Hafiz Bin Mohd Ali

A project dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical Engineering)

JULY 2008

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CERTIFICATION OF APPROVAL

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Approved by,

____
(Assoc. Prof. Dr Patthi Hussain)

ABSTRACT

By the substitution of ferrite to NdFeB materials, the process of seizing material dust in micro grinding process will be faster. Magnetic, chemical, corrosion, mechanical and magnetisation properties of the different materials are described and compared to enable the replacement. The concept design of magnetic steel attachment is to build a close steel attachment that can be adhered to pressure vessel so that the material dust will not be plunged out to the environment work. The sample of bonded NdFeB magnet is prepared by mixing the NdFeB powder with 5% of epoxy binder. NdFeB magnet also undergoes Scanning Electron Microscope (SEM) and X-Ray Diffraction (X-RD) test for further analysis. The final test would be the micro grinding process is operated with NdFeB bonded magnet placed at the base of the steel attachment.

ACKNOWLEDGEMENT

In the name of Allah, thanks to God, the most merciful and the most gracious for giving me a tireless strength to complete this Final Year Project (FYP). Firstly, I would like to show my gratitude to my beloved parents, Mohd Ali Bin Osman and Siti Ngesah Bt Jayus, who gave me support and motivation encouragement throughout the whole project. Moreover, truthful and honest thanks to my FYP supervisor, AP Dr. Patthi Hussain for his supervision, understanding, information and ideas and subsequently assisted me to carry out route of the project within 1 year. I would like to express my appreciation to UTP technical staff from mechanical and electrical engineering department for assisting me throughout my FYP. They are Mr Muhammad Anuar, Mr Irwan, Mr Faisal and Mr Isnain. Last but not least, I would like to portray my gratitude to UTP for giving me chance to undertake this momentous final year research project. This FYP course is really a big exposure to produce well rounded students whereby students can apply their knowledge and lesson from the courses taken towards accomplishing a specific goal.

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CHAPTER 1

INTRODUCTION

1.1 Background Studies

Material verification project is a project to validate and verify mechanical and chemical properties of equipment such as pipeline and pressure vessel. The process of micro grinding sampling is to grind the surface of the vessel to get the material dust for further material verification process. [2] Most of grinding processes are performed on pressure vessel. This task has been executed because of some of data losses during transition of people or management from one company to another company. Other reasons that can be considered are material age and its applicability to be used for latest data management. The use of conventional micro grinding process is not comprehensive because of the limited spaces for two peoples to perform the job. The micro grinding process with the description of the practice is stated below.

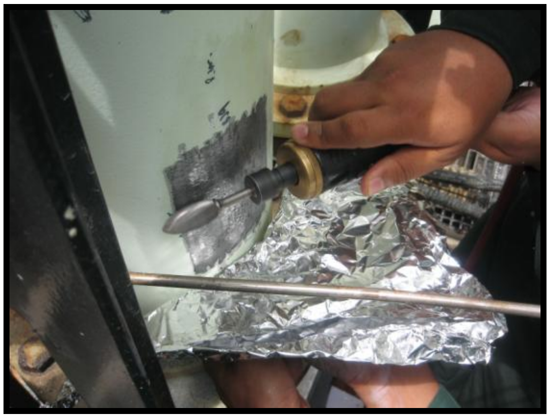


Figure 1.0: Micro grinding process on static vessel where pineapple bit rotates clockwise and a personnel who is manually holding the rounded magnet to seize the material dust and another personnel who is performing the grinding process; allowing

the amount of air pressure to rotate the pineapple bit. Material dust or debris then are collapsed and seized by the rounded magnet.

Figure 1.1: Micro grinder machine with pineapple bit

In the other hand, the properties of material of pressure vessel must be found out roughly, mostly type of carbon steel which it can accommodate the grinding process. The most probable element of material in carbon steel should be lead by Ferrite (Fe), then carbon (C), manganese (Mn) and then followed by other small quantity element. Besides, by replacement of ferrite by NdFeB materials for permanent rare earth magnet in magnetic steel attachment, actually it has their both advantages and disadvantages. The application to use the NdFeB rather than Fe is to perform an alternative permanent rare earth magnet based on its price, magnetic, chemical, corrosion, mechanical and magnetization properties.

1.2 Problem Statement

The enhancement of micro grinding process in material verification project shall be made to increase the performance of microscoop sampling process. The main problems are stated on the next two paragraphs.

The material dust of grinding process could be spread out to the work environment during performing this process. This bad behavior could lead to the hazardous of debris going into microscooper's noses who performing this job. The material dust might be wasted to the work environment. Meanwhile the work area could be untidy during performing this job. The design of new magnetic steel attachment should be made to replace the existing two (2) rounded magnets.

The process of micro grinding process would take about 20 minutes to collect 20 gram of material debris for each vessel. By replacing 2 bonded ferrite magnet with steel attachment and NdFeB magnet would be appropriate to reduce the time constraint and to enhance the safety measurement on that work.

1.3 Significance of Study

The significance of study is to develop the manner of production and skill of manufacturing of micro grinding process. Furthermore, Oil and Gas Management (M) Sdn Bhd. (OGM) may acquire the credibility on dealing with the tools and equipment at offshore where professional methodology is being used throughout with safety requirements are placed at higher priorities.

If this final year project is successfully done, it would be the best contribution to OGM Sdn. Bhd. who had given advises and experiences to author during author’s internship training in semester July2007.

1.3 Objective

The objectives to be accomplished by the end of this project are; to design and develop the magnetic-steel attachment that can be adhered to the static vessel during performing grinder process at the platform. This process involve important data such as accumulated time to perform micro grinding process by using magnetic steel attachment with variation of bonded NdFeB formation applied on the steel attachment.

1.4 Scope of Study

Author has to find appropriate literature survey regarding the properties of Neodymium-Iron-Boron. The survey would be best to deal with the experts that relate to this project. Seminars has been conducted in the phase of progress week with the expert and supervisor to seek out any possible data and requirement to understand and to identify the scope of study before going into implementation and manufacturing new magnetic steel attachment. The use of AutoCAD software is vital in designing the drawing of magnetic steel attachment. The study on properties of pressure vessel is to get to know generally about the chemical composition and mechanical properties of the vessel before starting to grind the surface of the equipment. The SEM and X-RD analysis is applied to analyze NdFeB bonded magnet

Figure 1.2: Horizontal Separator. Type of vessel that can be grinded.

CHAPTER 2

LITERATURE REVIEW

2.1 PRESSURE VESSEL

2.1.1 Properties of Pressure Vessel

A material property of most pressure vessels that may undergo this grinding process is basically a carbon steel type. The database which author has referred to is based on appendices, recorded from metal database dated 16th September 2000. The actual identification for this pressure vessel and its location of upstream platform is confidential to be revealed. From the data shown by referring to A516-Grade55 data at appendices part, the material of carbon manganese steel is in plate form which specified in ASTM A 516 description. The chemical composition of this pressure vessel comprises of 0.18 percent of Carbon material followed by Manganese 0.90 percent, Phosphorous 0.035 percent, Sulfur 0.035 percent and Silicon 0.40 percent. The remainder would be definitely ferrous material which is the main part of carbon manganese steel. [1]

2.2 PRINCIPLES OF MAGNETISM

Magnetism can produce a force between magnetic materials depending on their magnetic fields. Magnetic fields can be formed by moving charged particles in electromagnets or in permanent magnets. The magnetic field is much powerful at the poles than anywhere of magnetic area. The direction of the field lines is from the North Pole to the South Pole, and the external magnetic field lines never cross. When they line up in a row, they combine to increase the magnetic field strength. By placing a magnet beneath a piece of paper and placing iron dust on top of the piece of paper, the iron filings will place themselves to perform the formation of magnetic field lines. This invisible magnetic force, which exists in the air or space around the magnet, is known as a magnetic field and the lines are called magnetic lines of force.

Ferromagnetic materials for example iron and cobalt are those materials which is capable of aligning to create a magnetic field. Because of this ability, they provide a simple path for external magnetic field lines. Magnetic materials lose their magnetism if heated to or above the expected temperature. Diamagnetic materials are the opposite of ferromagnetic materials; they are weakly repelled by a magnet since electrons within their atoms act as electromagnets and oppose the applied magnetic force.

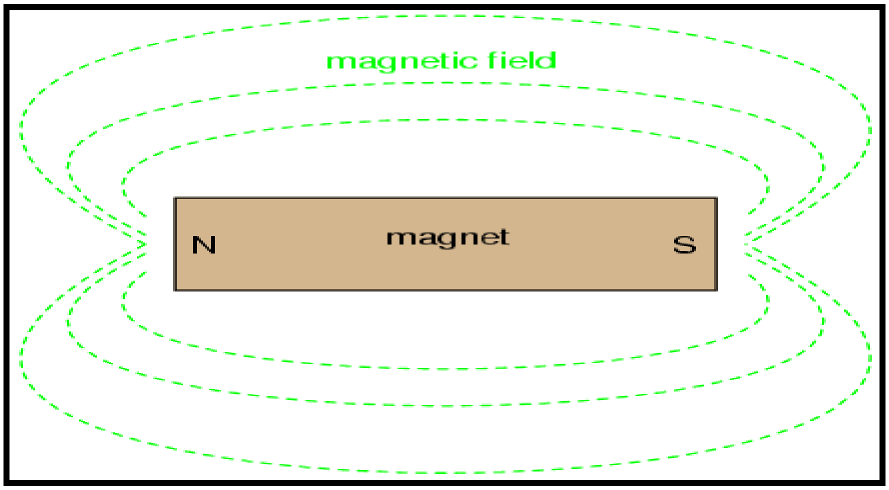


Figure 2.1: Magnetic field of single bar magnet (green line).

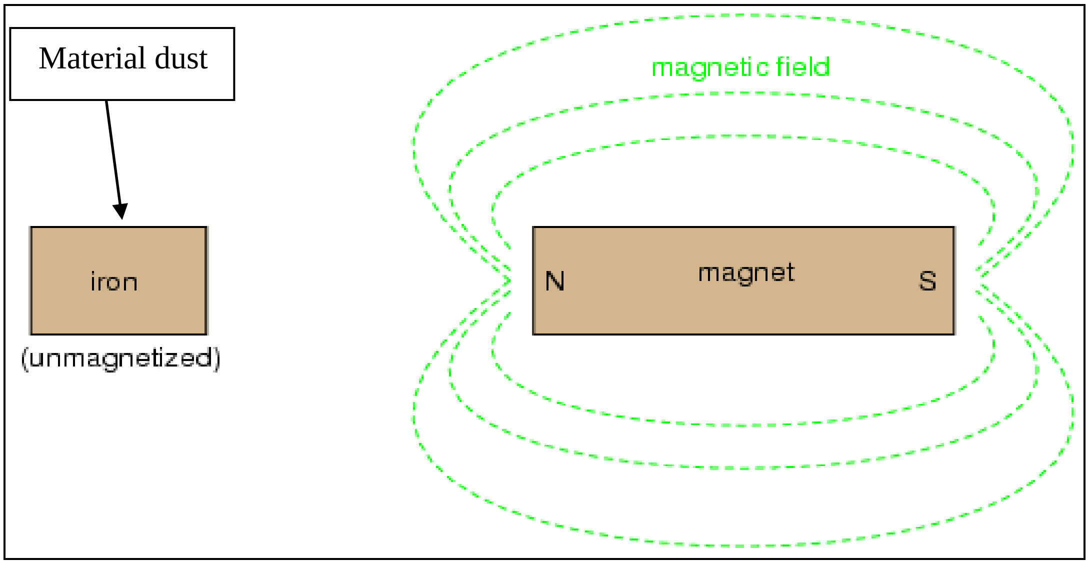


Figure 2.2: The unmangnetized iron; which considerably stated as material dust will obtain the North and South Pole as it places nearest to the permanent magnet. The green line indicates as magnetic field.

The previously unmagnetized iron becomes magnetized as it is brought closer to the permanent magnet. No matter what pole of the permanent magnet is extended toward the iron, the iron will magnetize in such a way as to be attracted toward the magnet:

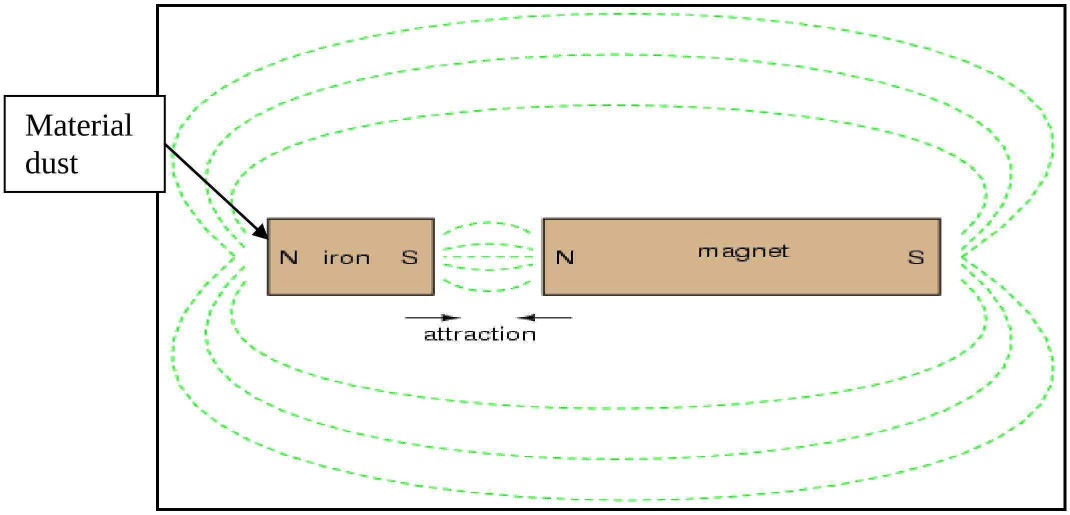


Figure 2.3: The behaviour of magnetic field (green line) when material dust obtain its North and South Pole.

This behavior is the background of how the material dust obtained from the microscoop process can be attracted to the permanent earth magnet. Of the two diagrams, diamagnetic materials are the strongest. In the presence of an external magnetic field; they actually become slightly magnetized in the opposite direction, so as to repel the external field. [7]

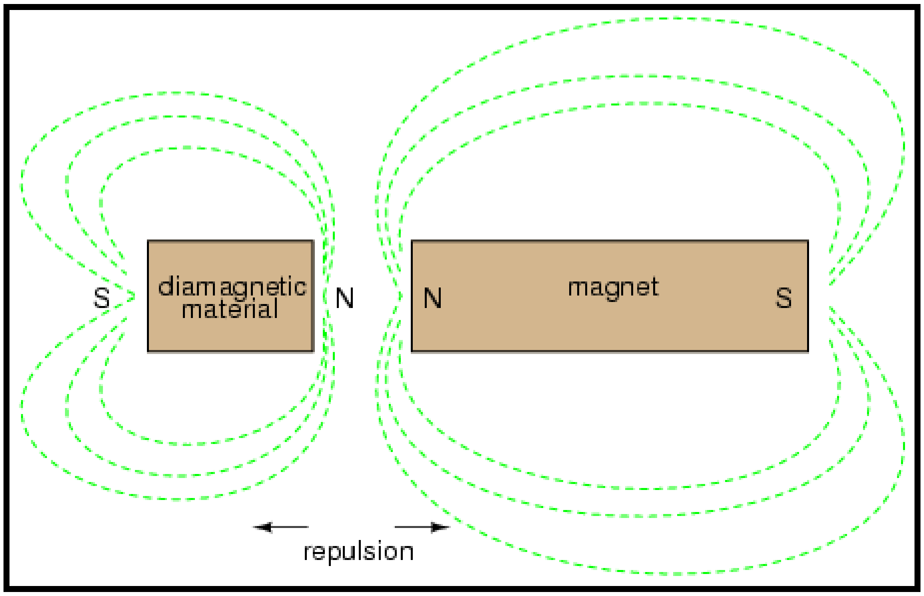


Figure 2.4: The behaviour of diamagnetic material and permanent magnet when

2.3 NdFeB, Permanent magnet

The main product of permanent magnet for this project is bonded NdFeB which is about 3 MGOe. NdFeB are used widely as the total global output showed 72 tons in 1985, it became 8000 tons in 1997. The use of NdFeB magnet is rising both in developed and developing countries such as Japan, USA, China, East Europe and Southeast Asia. The computer, communication and informative industries are the major users of NdFeB magnets. The probable (BH) max, MGOe for these application industries usually ranges between 25 – 50 MGOe. [2] From the previous internship conducted by author, Ferrite magnet of 1.2 MGOe was used to collect the steel powder. Therefore NdFeB with the BH_{max} of 3-10 MGOe is higher field than the ferrite to collect the powder of the steel. The use of 3 MGOe for this FYP is basically sufficient to attract the material dust or debris in a small fragment of quantities 20grams for each vessel and the main body of product permanent magnet are produced by applying powder metallurgical or “sintering” technique on NdFeB.[3]

2.3.2 Properties of NdFeB and Pressure Vessel

The main part of this literature review is to describe the main properties of NdFeB as a main product of magnetic steel attachment. The main properties would be chemical, corrosion and magnetization behaviour. The surface of the pressure vessel need to be analyzed as it must meet the requirement needed before going for metal grinding process.

2.3.2 Chemical Properties of NdFeB

According to B. Grieb, NdFeB magnets are considered to be metallic materials and exhibit their general characteristics. Whereas they are largely resistant to alkali media, they dissolve in acids, and oxidation rates in a wet atmosphere varying according to material composition. The sensitivity of conventional NdFeB to oxidation is caused in the microstructure formed by magnetic grains of $Nd_2Fe_{14}B$ and a surrounding grain boundary phase of free Neodymium. This almost elementary Neodymium is very reactive. Even simple condensation and oxygen attack leads to the formation of oxides and hydroxides, resulting in dissolution of the grain boundary phase completely. Because of processing limitations it is not possible to eliminate this grain boundary phase completely. [4] From the explanation of Grieb, NdFeB are resistant to alkali media means it oppose to or no effect to alkali media, dissolve in acid and undergoing process of oxidation in a wet atmosphere with in variation of material composition. Most of oxidation process occurs is caused by magnetic grains that create the arrangement of microstructure. NdFeB materials are much more ductile, making handling safer rather than other permanent rare earth magnet. The amount of damaged magnets using processing is reduced which is important for saving costs.

2.3.3 Corrosion Properties of NdFeB

The investigation has been made by B.Grieb [4] of different material in an atmosphere which is generated in an autoclave of 130^{o}C, 3 bars and saturated vapour condition. The test is operated by Grieb to get an immediate view of the corrosion resistance against oxidizing temperatures. From the test conducted, the decrease of weight remaining during the first day is very small and then followed by next days, the corrosion attacks becomes very strong. The magnets are weighed before and after the experiment undergone. Based on the graph of Figure 2.5, the magnet seemed to have failed because of the magnets were dissolved in ten days.

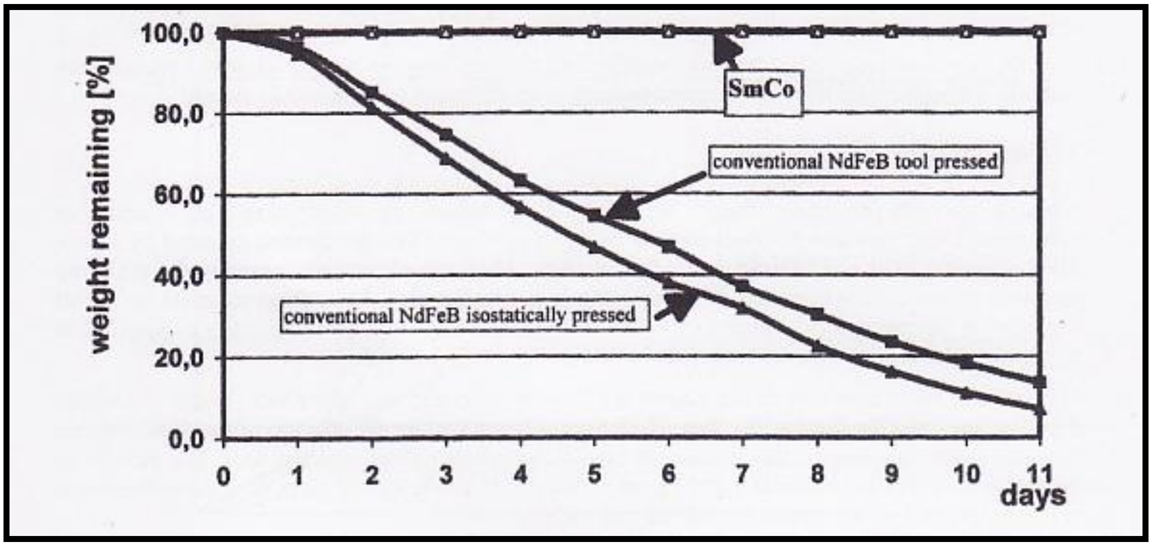


Figure 2.5: Corrosional stability of conventional NdFeB in an autoclave at 130^{o} and 3 bar under saturated water vapour. The scale extends from 0-100%.

According to B. Grieb, due to the intermetallic grain boundary phase formed during heat treatment from the basic element and additives the new NdFeB materials show a stable microstructure in total. The course of the dissolution curve Figure 2.6 is stable after a small, minimal surface corrosion reaction. The material has a passivating character and offers long term resistance similar to that Sm_2Co_{17} which is well known corrosion resistant material. The additives which give the new material its corrosion stability are also responsible for the excellent temperature stability. [4]

Based on Figure 2.6, the NdFeB magnet is showing stable microstructure in total after new additives have been mixed with the conventional NdFeB.

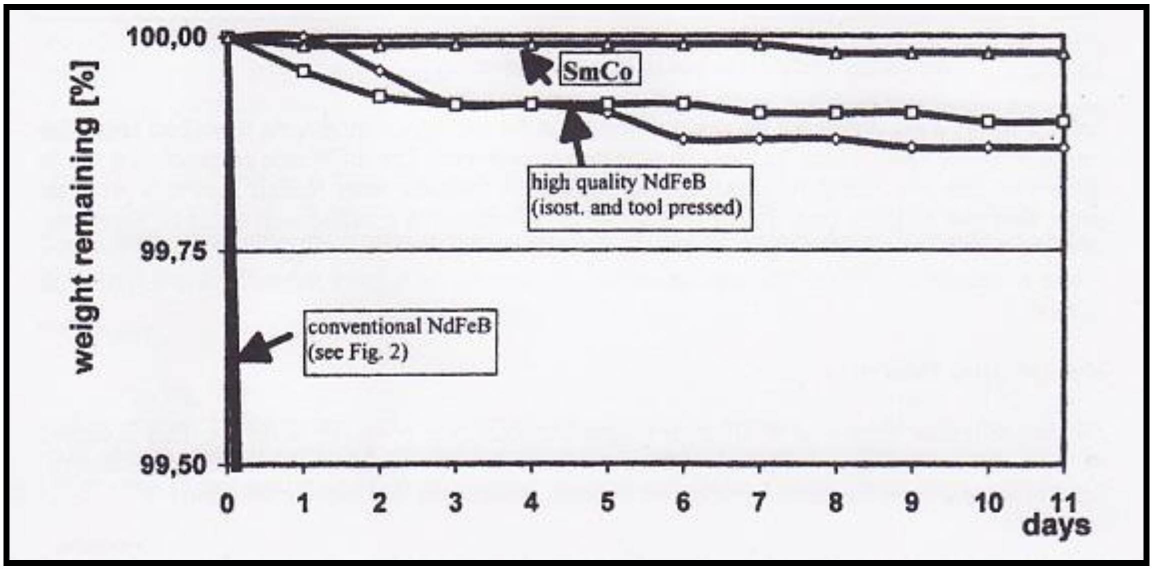


Figure 2.6: Corrosional stability of conventional and of stable NdFeB in an autoclave at 130^{o} and 3 bar under saturated water vapour. SmCo is used as material comparison. The scale extends from 0-100%.

2.3.4 Magnetization Behaviour of NdFeB

Magnetization is caused by different hardening mechanisms which originate in the microstructures of the materials. Sm2Co17 magnets are hardened by pinning process whilst NdFeB and SmCo5 by nucleation.

According to B. Grieb, pinning magnets are hard to magnetize and to demagnetize. The degree of saturation is approximately linear to the strength of the magnetizing field. To saturate NdFeB magnets a considerably lower magnetic field is necessary, the magnetization behavior has an S- shape depending on the generated field. Saturation is fully reached at about 2500 kA/m or 3 Tesla, to achieve the internal magnetization field the given external field must be increased by the value of the demagnetization. NdFeB 180/250w show excellent behaviour. Despite their high resistance to demagnetization by high coercivities, these materials can be saturated comparatively easy. The values are less than 2000 kA/m and therefore below the fields necessary for known NdFeB materials. [1]

From this literature review, NdFeB is suitable to be applied on magnetic steel attachment as it produces low magnetization behaviour which is below 2500 kA/m or 3 Tesla.

2.3.4 Manufacturing of NdFeB

From author's research, there are several methods in manufacturing NdFeB magnet. Several research relates to this matter are as below.

According to David Brown Bao-Min Ma and Zhongmin Chen, The composition, microstructure and processing of NdFeB-type permanent magnets are all critical factors for the successful production of high performance magnet components. Three common fabrication routes can be used to categorize these NdFeB-based bulk magnets: sintering, polymer bonding and hot deformation. Generally, the former type of magnet has a high-energy product (30–50 MGOe), full density and a relatively simple shape. Bonded magnets have intermediate energy products (10–18 MGOe), lower density and can be formed into intricate net-shapes. Hot deformed magnets possess full density, intermediate to high-energy products (15–46 MGOe), isotropic or anisotropic properties and have the potential to be formed into net shapes. This article discusses the critical issues of improved magnetic performance, environmental stability, net-shape formability and magnetization behavior for the main categories of NdFeB magnets. [5]

2.4 Scanning Electron Microscope (SEM)

Scanning electron microscopy is used for inspecting topographies of specimens at very high magnifications using a piece of equipment called the scanning electron microscope. SEM magnifications can go to more than 300,000 X but most semiconductor manufacturing applications require magnifications of less than 3,000 X only. SEM inspection is often used in the analysis of die/package cracks and fracture surfaces, bond failures, and physical defects on the die or package surface.

A SEM may be equipped with an EDX analysis system to enable it to perform compositional analysis on specimens. EDX analysis is useful in identifying materials and contaminants, as well as estimating their relative concentrations on the surface of the specimen. During SEM inspection, a beam of electrons is focused on a spot volume of the specimen, resulting in the transfer of energy to the spot. These bombarding electrons, also referred to as primary electrons, dislodge electrons from the specimen itself. The dislodged electrons, also known as secondary electrons, are attracted and collected by a positively biased grid or detector, and then translated into a signal. (6)

EDX Analysis stands for Energy Dispersive X-ray analysis. It is sometimes referred to also as EDS or EDAX analysis. It is a technique used for identifying the elemental composition of the specimen, or an area of interest thereof. The EDX analysis system works as an integrated feature of a scanning electron microscope (SEM), and can not operate on its own without the latter.

During EDX Analysis, the specimen of NdFeB is bombarded with an electron beam inside the scanning electron microscope. The bombarding electrons collide with the specimen atoms' own electrons, knocking some of them off in the process. A position vacated by an ejected inner shell electron is eventually occupied by a higher-energy electron from an outer shell. To be able to do so, however, the transferring outer electron must give up some of its energy by emitting an X-ray. (6)

2.4.1 The Scanning Electron Microscope and Optical micrograph analysis of bonded NdFeB magnet

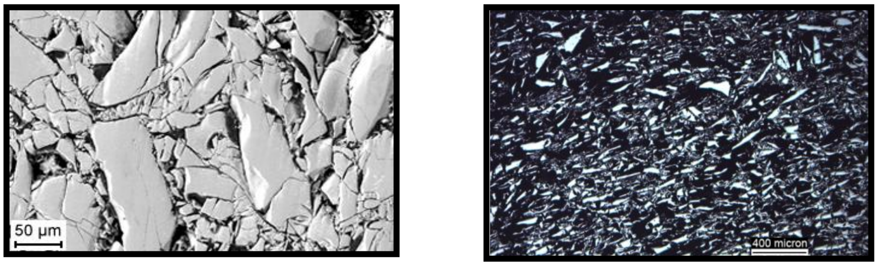


Figure 2.7 and 2.8: SEM and Optical micrograph of compacted bonded NdFeB Magnet with a mixture ratio 5:95 of epoxy to NdFeB powder.[8]

From the SEM and optical microscope images, some pores are found in the bonded magnets. This can be the result of debonding occurring between the epoxy and NdFeB powder, as the powder is not wet well enough to be firmly bonded with the epoxy and LNR matrix. The average thickness of the melt spun powders of the pressureless bonded NdFeB magnet is 30µm. The texture of the powder particles are seen to be flaky. Meanwhile for the compacted bonded NdFeB magnet, the average thickness is also 30µm and the powder particles are found to be in very small fragments, presumably crushed during the compaction consolidation process. [8]

CHAPTER 3

METHODOLOGY

3.1 Research Methodology and Project Activities

Research methodology for this project is basically depends on appropriate literature review and paperwork that obtained from reliable sources. Author has to find the behaviour, characteristics and manufacturing method of NdFeB magnet. Rough analysis also has been described in the result and discussion session for an initial research before full analysis could be made for further progress part.

Project activities for the phase of the interim part includes the understanding the literature review's research work, searching appropriate material for steel attachment and processes involved, rough design analysis. While the progress that has been made for the next part would be Scanning Electron Microscope, X-RD and the experiment conducted on the magnetic steel attachment.

3.2 Method of manufacturing NdFeB and SEM analysis

The procedure of manufacturing NdFeB samples are stated below:

1. NdFeB material dusts are going to be undergoing the powder metallurgy process. NdFeB material dust was weighed for 100 gram
2. Epoxy and hardener were mixed to a binder with composition of 5%. Asetone was stirred a little bit as a stirrer agent to mix the NdFeB material dust with binder.[11]
3. Both binders and NdFeB material dust were mixed together by using stirrer machine for about 15 minutes.

4. The mixture was weighed 3 gram.
5. The sample of 3gram mixture then was transferred to mold and pressed by using Auto Press machine. The pressure of compaction is 5 ton. The decomposition process would take about 3 minutes time with constant, 3 ton of weight.
6. All samples were cured in oven at 60^{o}c for 4 hours.
7. Steps 1 to 5 were repeated until 10 samples were pressed.
8. The samples were analyzed by using Scanning Electron Microscope (SEM), X-Ray Diffractometer with the purpose of analyzing the material's composition, microstructure, crack compactions and magnetic properties. [3]

Figure 3.1: Process flow of manufacture bonded NdFeB starting with stirrer (picture 1), Auto Pallet Machine (picture 2) and oven (picture 3)

3.3 Method of Manufacturing Steel Attachment (Cage)

1. The carbon steel was measured in millimeters.
2. It is then ticked with marker on which part of the steel is going to be cut.
3. The carbon steels were cut into several parts according to its measurement.
4. All parts were connected by both bolts and nuts.
5. The placement of NdFeB is located at the base of the steel attachment.

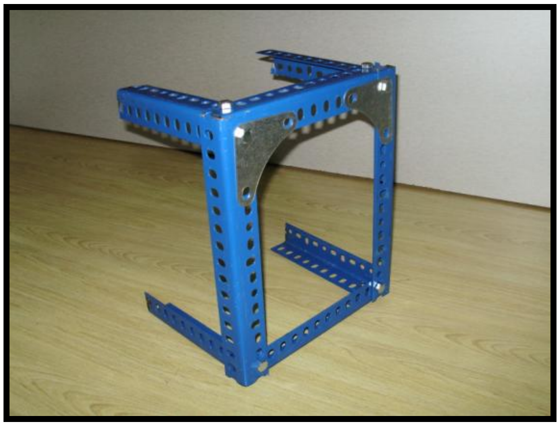
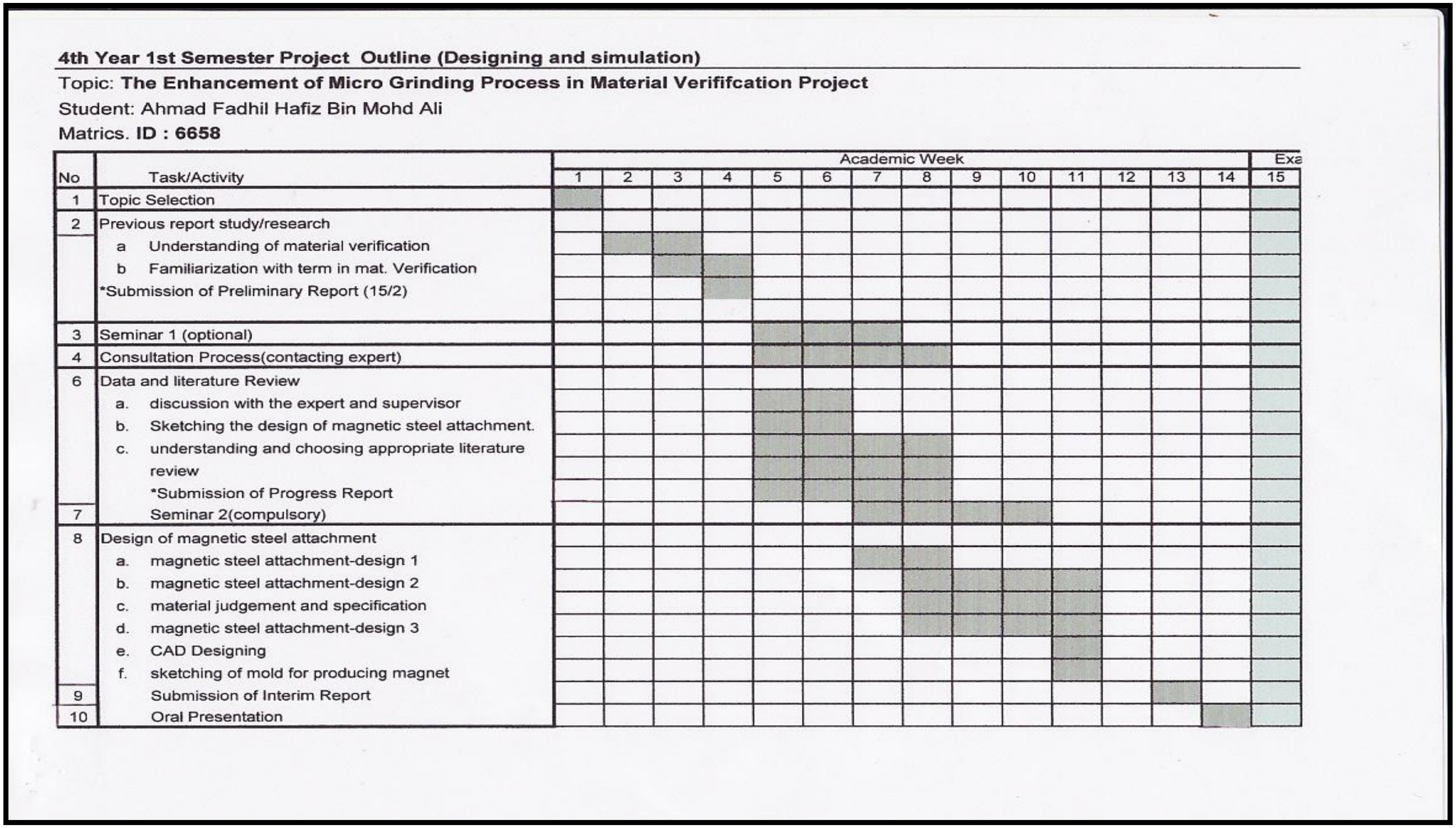


Figure 3.2: Steel Attachment

3.4 Gantt Chart for FYP I and FYP II



4th Year 1st Semester Project Outline (Designing and simulation)

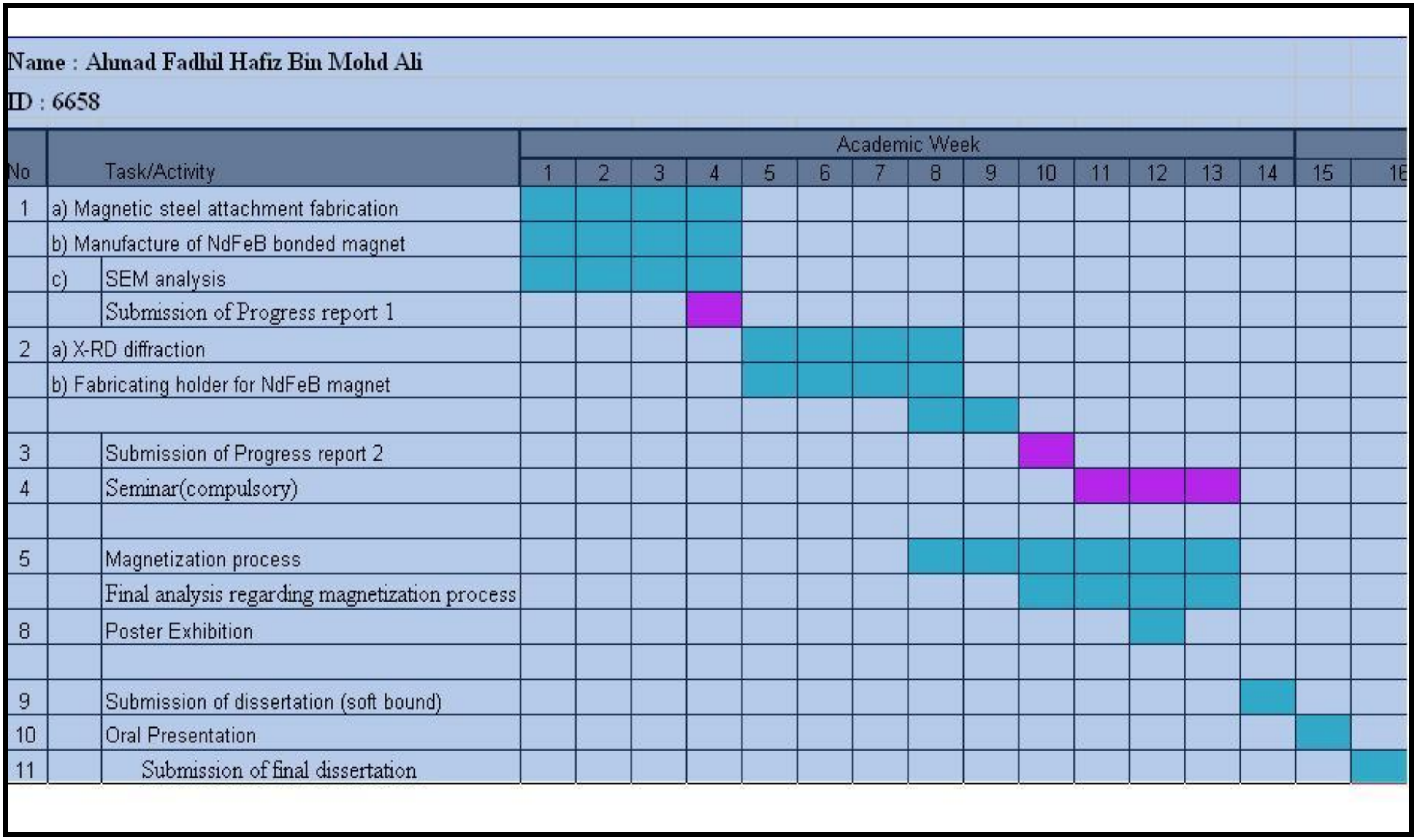
Topic: **The Enhancement of Micro Grinding Process in Material Verififcation Project**

Student: Ahmad Fadhil Hafiz Bin Mohd Ali

Matrics. **ID : 6658**

		Academic Week														Exa
No	Task/Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Topic Selection	■														■
2	Previous report study/research															■
	a Understanding of material verification		■	■												■
	b Familiarization with term in mat. Verification			■	■											■
	*Submission of Preliminary Report (15/2)				■											■
																■
3	Seminar 1 (optional)					■	■	■								■
4	Consultation Process(contacting expert)					■	■	■	■							■
6	Data and literature Review															■
	a. discussion with the expert and supervisor					■	■									■
	b. Sketching the design of magnetic steel attachment.					■	■									■
	c. understanding and choosing appropriate literature					■	■	■	■							■
	review					■	■	■	■							■
	*Submission of Progress Report					■	■	■	■							■
7	Seminar 2(compulsory)							■	■	■	■					■
8	Design of magnetic steel attachment															■
	a. magnetic steel attachment-design 1							■	■							■
	b. magnetic steel attachment-design 2								■	■	■	■				■
	c. material judgement and specification								■	■	■	■				■
	d. magnetic steel attachment-design 3								■	■	■	■				■
	e. CAD Designing											■				■
	f. sketching of mold for producing magnet											■				■
9	Submission of Interim Report													■		■
10	Oral Presentation														■	■

Figure 3.3: Gantt Chart for FYP I



Name : Ahmad Fadhil Hafiz Bin Mohd Ali

ID : 6658

No	Task/Activity	Academic Week															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	a) Magnetic steel attachment fabrication	🟦	🟦	🟦	🟦												
	b) Manufacture of NdFeB bonded magnet	🟦	🟦	🟦	🟦												
	c) SEM analysis	🟦	🟦	🟦	🟦												
	Submission of Progress report 1				🟪												
2	a) X-RD diffraction					🟦	🟦	🟦	🟦								
	b) Fabricating holder for NdFeB magnet					🟦	🟦	🟦	🟦								
									🟦	🟦							
3	Submission of Progress report 2										🟪						
4	Seminar(compulsory)											🟪	🟪	🟪			
5	Magnetization process								🟦	🟦	🟦	🟦	🟦	🟦			
	Final analysis regarding magnetization process										🟦	🟦	🟦	🟦			
8	Poster Exhibition												🟦				
9	Submission of dissertation (soft bound)														🟦		
10	Oral Presentation															🟦	
11	Submission of final dissertation																🟦

Figure 3.4: Gantt chart For FYP II

CHAPTER 4

RESULTS AND DISCUSSIONS

4.0 MAGNETIC STEEL ATTACHMENT

4.1 The Idea of Magnetic Steel Attachment

The design of magnetic steel attachment has been made to give some rough idea of several views of design regarding to this project. The main idea of designing magnetic steel attachment is to replace the old manner of grabbing the material dust material sampling process.

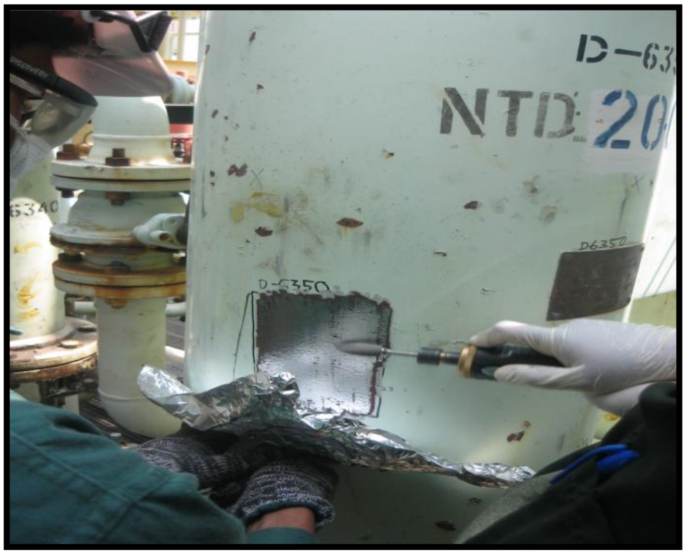


Figure 4.1: A conventional manner of grinding process. This process needs 2 people to perform the micro grinding process. One person hold 2 rounded magnet below the aluminium foil whilst other person operates the grinder machine.

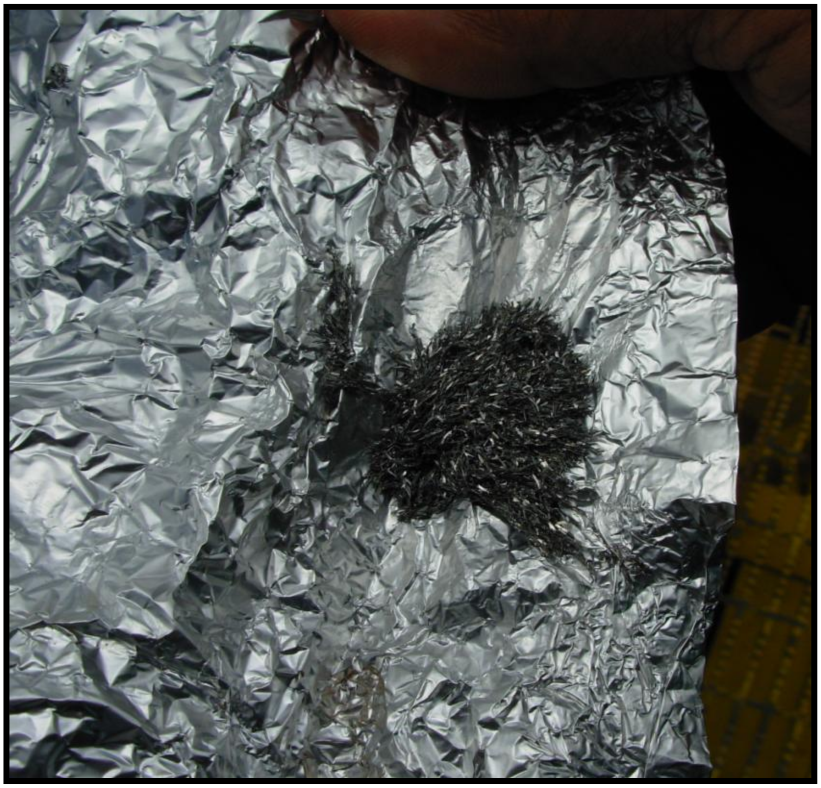


Figure 4.2: Material dusts which are weighed 20g, ready to be sampled.

In this project, team project need about 20g material dust to be sampled out in the plastic. But in this case, author feel it is the best way to cut down the time to collect the material dust as the design of magnetic steel attachment will help to outcome of the problem whilst safety measurement maintained in the first priority.

4.2 Magnetic Steel Attachment

The new design specification is advantageous because it needs just one person to operate the micro grinding process. Author has designed a type of magnetic steel attachment to be considered in his discussion part. The measurement of the design is 0.15 x 0.25 x 0.30 m3 which is in the figure shown, there are 4 straight steel fixed at the middle of the steel attachment. The permanent rare earth magnet, rounded NdFeB will be placed at the base of the steel attachment. The inner part of the magnetic steel attachment will be wrapped up by aluminium foil or viable plastic to avoid the magnet seizes the debris directly.

4.5.3 The Design of Magnetic Steel Attachment

The design basically was drew after author had decided to buy the steel attachment from the hardware shop. Author had bought the steel as it features many holes along its crossbar surface of the steel. The purpose of the holes is to make a joint between the steel bars. The thickness of steel bar is 1 mm. the measurement of this design 250 x 200 x 300 mm^3. The location of each magnet that needs to be placed at the steel attachment is to be considered at the base of the steel attachment for in manufacturing part of NdFeB magnet. Therefore, there are several rounded NdFeB will be placed at the top base of the magnetic steel attachment.

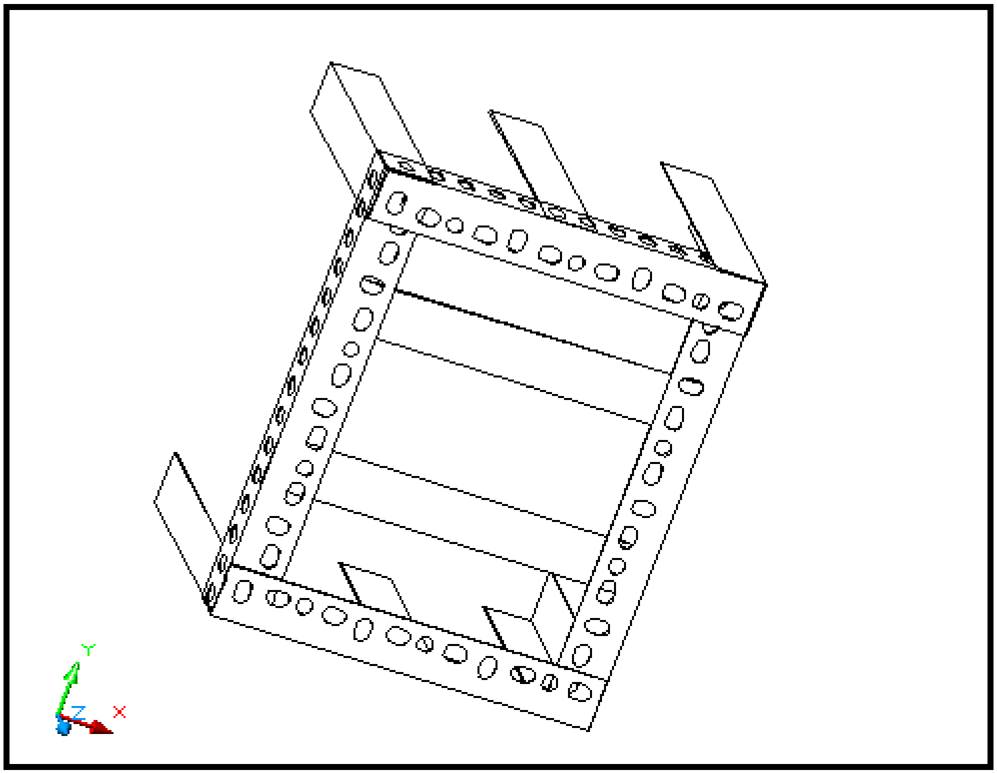


Figure 4.3: The Third Design of Magnetic Steel Attachment (3-D view)

4.6 Scanning Electron Microscope Analysis

In this experiment, author chose one sample of unmagnetized bonded NdFeB to undergo Scanning Electron Microscope. Based on the overview, author can detect the microstructure of the sample such as crack compaction, the composition of each material at certain portion of the sample.

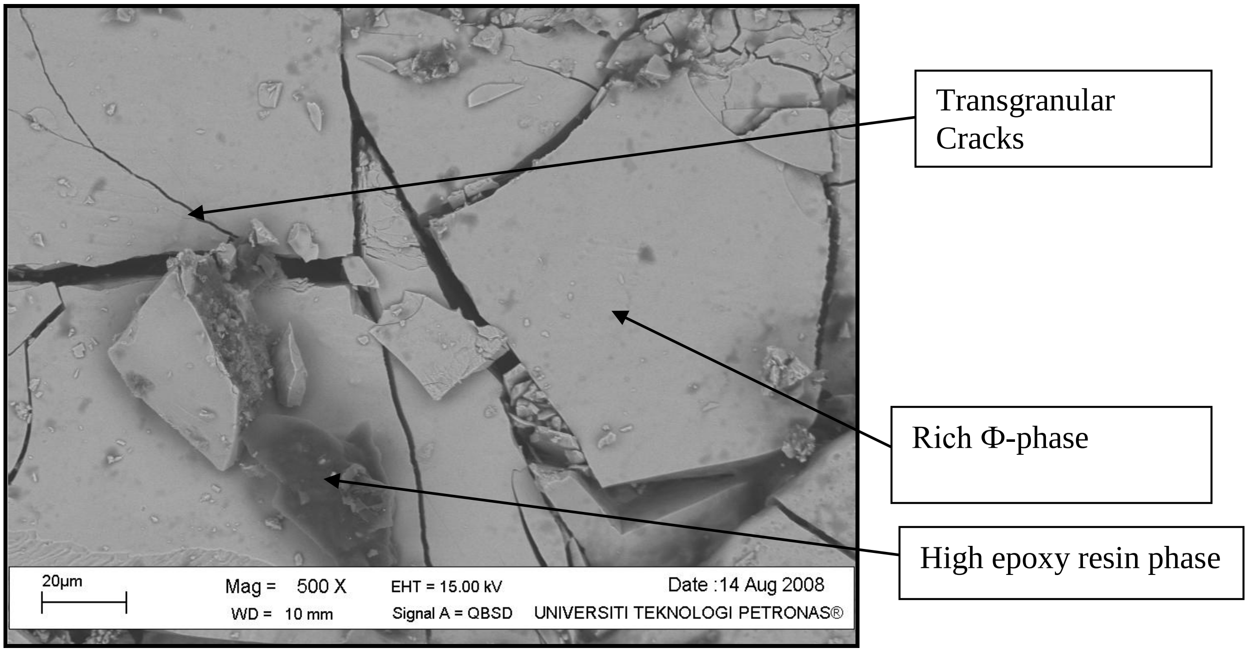


Figure 4.4: Image of SEM at the centre of the samples. The pores and crack is less formed at the center of the sample bonded NdFeB magnet.

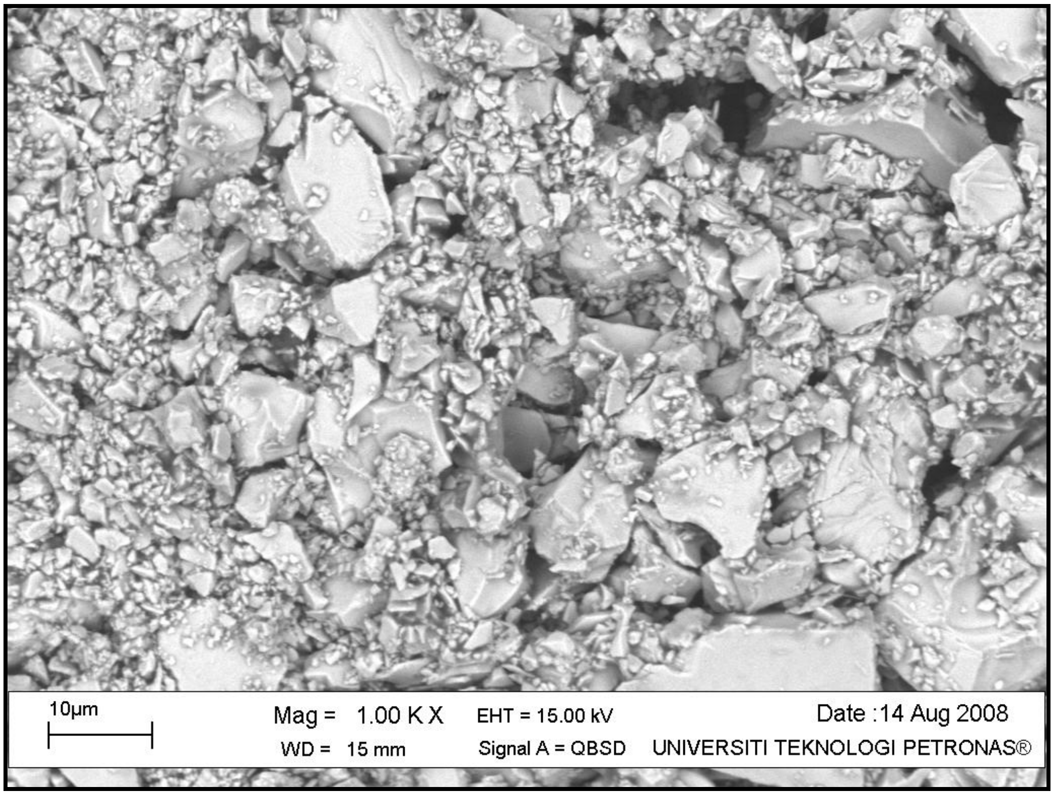


Figure 4.5: Image of SEM of NdFeB at the edge of the sample. The pores and crack formation is highly formed at the edge of the sample.

The electron micrograph of figure 4.4 image shows the crack formed at the centre of the samples. The bright part shows NdFeB and the dark part represents the epoxy of resin and hardener. The magnifying power of this Scanning Electron Microscoop is 500X. In addition, the image shows the samples which lays between 10µm to 20µm. The pores were not much observed at the centre compared to the edge of the sample. The morphologies for this bonded magnet are portrayed in figure 4.4 and figure 4.5.

Author implies that some of epoxy was flowing out during the compaction process, and as a result, the act of 5 ton pressure was not uniformly compressed the sample. From the figure above, it shows that the center of the bonded NdFeB magnet has a good compaction rather than at the edge of sample.

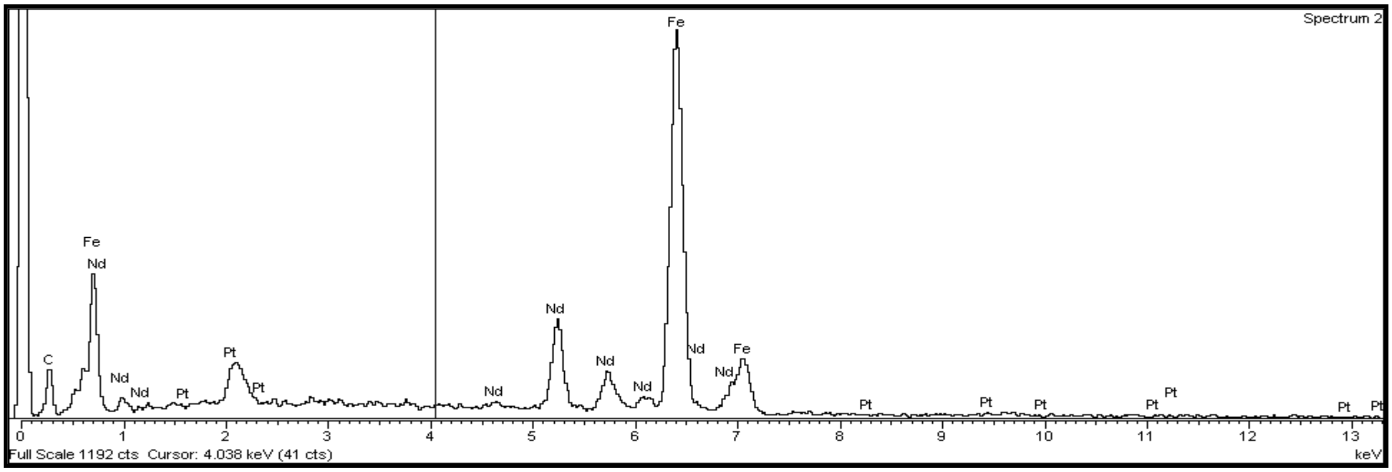


Figure 4.6: The composition of Neodymium (Nd), Iron (Fe), and Carbon (C) at the center of the sample.

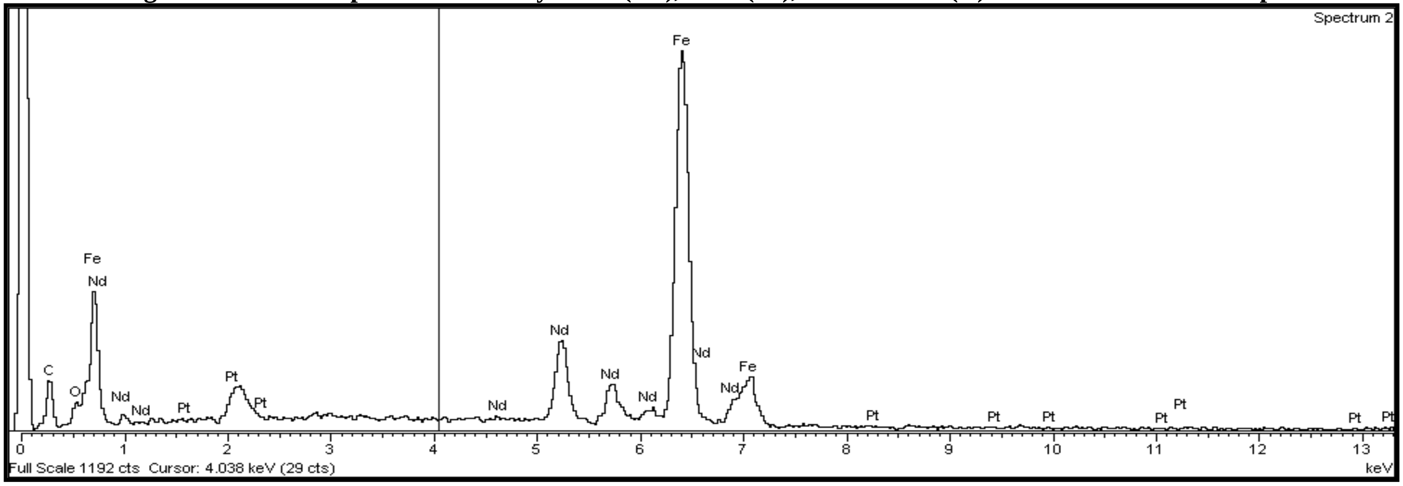


Figure 4.7: The composition of Neodymium (Nd), Iron (Fe), and Carbon (C) at the edge of the sample.

Figure 4.6 and 4.7 shows the existences of elements in the magnet were revealed by using SEM with EDAX. EDAX analysis shows that the presence of Neodymium (Nd) and Ferrite (Fe) in high quantity compared to carbon (C) while Boron cannot be detected as it is hard to expose their presence by using EDAX. Other elements also appeared in the material which is Plutonium (Pt) and oxygen (O).

Figure 4.8: The EDAX mapping of Neodymium (Nd), Iron (Fe), and Carbon (C) represent the dotted green, red and blue respectively at the centre of the sample.

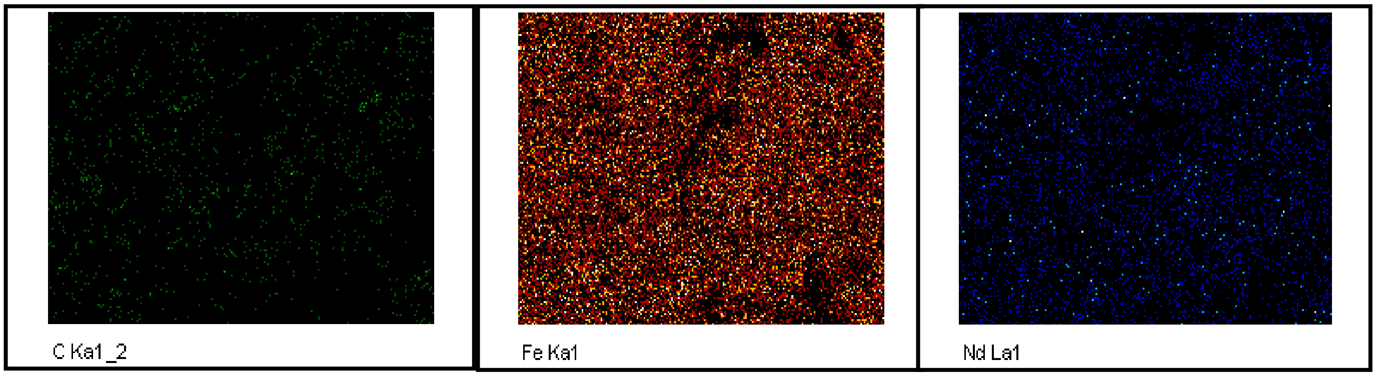


Figure 4.9: The EDX mapping of Neodymium (Nd), Iron (Fe), and Carbon (C) represent the spotted green, red and blue respectively at the centre of the sample.

Element	Weight%	Atomic%
C K	15.74	51.83
Fe K	58.61	41.52
Nd L	20.39	5.59
Pt M	5.27	1.07
Totals	100	100

Table 1: the element composition of NdFeB

Figure 4.7 and 4.8 demonstrates the EDAX mapping of each part of both center and edge of the sample. The dark fraction is described as pores and crack compaction that exist on the image while the dotted colours means that the presence of materials of carbon, iron and Neodymium.

4.7 X-ray Diffraction

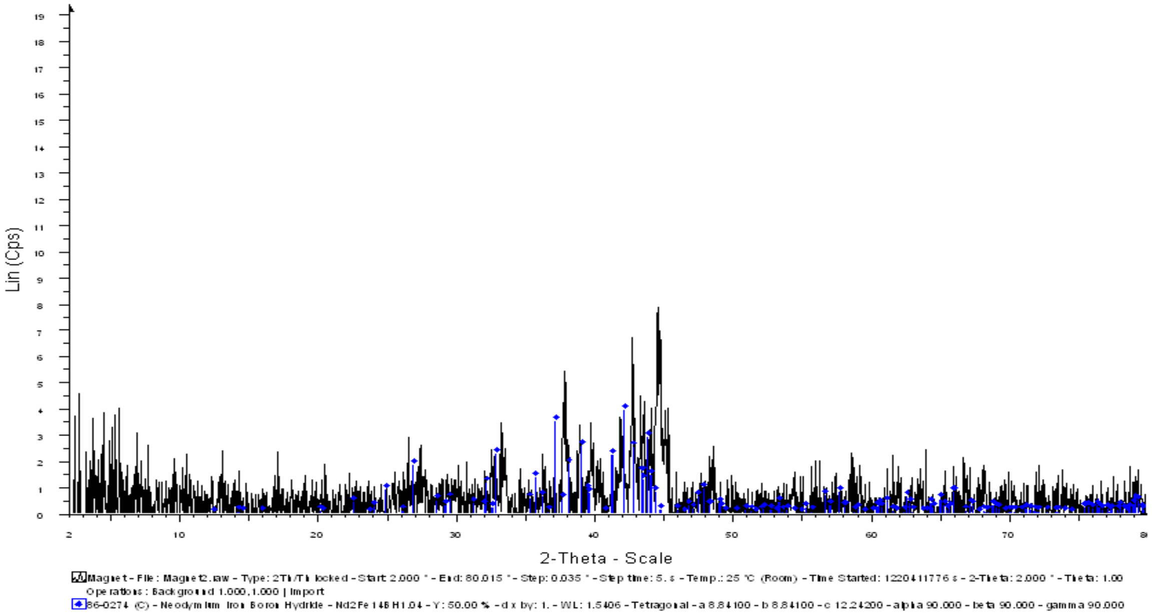


Figure 4.10: the result of the X-ray Diffraction for thickness of 45μm of NdFeB

There are two phases monitored in figure 4.10, which is α-Fe phase and Φ-phase (NdFeB phase). From figure 4.10, Φ-phase could be detected due to high content of Neodymium and Ferrite in the sample which contributes 20.39 and 58.61 weight percent. (Refer table 1). Therefore, the high Ferrite composition would eventually promote the formation of NdFeB phase. The result had shown those XRD analyses on 45μm of NdFeB. It proves that the majority of the phase is crystalline NdFeB and this is shown in Figure 4.10. No significant of amorphous phase detected in any size of fraction of the power studied, although the smaller particles exhibited peak broadening. It was predictable that very fine particles are at least partially amorphous, but they could not be easily separated for measurement. [9, 10].

4.8 Mounting of NdFeB on the Steel Attachment

The placement of magnet at the base of steel attachment is to maximize the percentage of material dust plunge into the magnet surroundings. In addition the factor of gravity attraction is considered, as a result of not placing the magnet against the grinding surface. The formation of NdFeb on the steel attachment is placed as portrayed in the figure below:

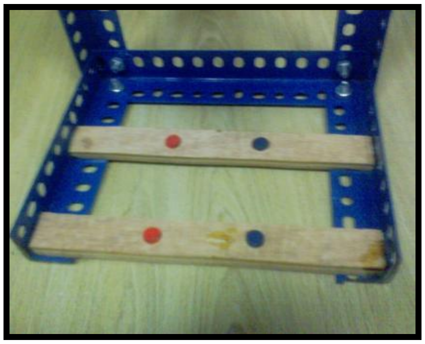


Figure 4.11: The location of 4 bonded NdFeB magnets on steel attachment

The result for the best formation (4 bonded NdFeB magnet placed) are as follows:

Table 2: Minutes of grinding process and Material Dust Seized by NdFeB in grams

Time (minutes)	Material Dust Seized by NdfeB (gram)
1	2.5
2	5
3	7.9
4	12.1
5	14.4
6	17.9
7	20.6
8	24.4
9	26.7
10	29.9

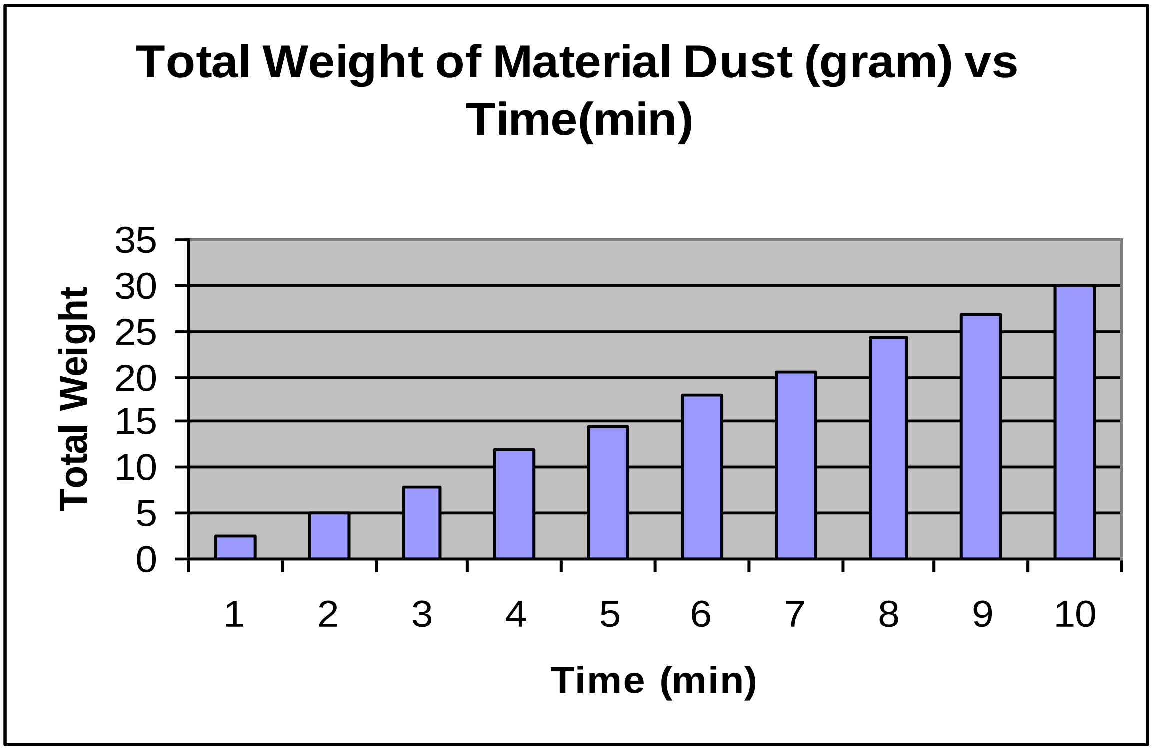


Figure 4.12: The accumulated weight of carbon steel dust seized by four NdFeB magnets in 10 minutes

From the graph shown, a total of 20gram material dust can be seized on the 7th minute of process compared to conventional one which stretches until 20 minutes for each grinding. Somehow the rate of collecting dust is not maintained for each minute probably because of manual-force grinding process acted on the grinding surface. This shows that the use of NdFeB in collecting material dust is more reliable rather than ferrite magnet.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

By replacing Ferrite magnet with NdFeB, it is proven that it can seize more material dust within expected time. The precise time for collecting accumulated 20 gram of carbon steel dust is 7 minutes compared to the conventional method, 20 minutes. Thus the objective of this project is achieved.

It proves that the majority of the phase is crystalline NdFeB in the X-RD analysis whilst EDAX analysis shows that the presence of Neodymium (Nd) and Ferrite (Fe) in high quantity compared to carbon (C) while Boron cannot be detected as it is hard to expose their presence by using EDAX

5.2 Recommendation of the Project

Even there are little bit problems that author has faced throughout this progress part, the project is still relevant. As for future project work, it is greatly suggested to use vacuum machine to avoid bubble inside the sample. All the equipment must be collaborated before using the machine for experiment. Author also found that the plunger is too tight to be pulled out during the process of manufacturing the magnet.

It is recommended that all the samples are going to be examined under this analysis. Since there were time constraints in this project, author noticed that this project must be proceeding to the next phases which are magnetization process. Besides, further analysis is recommended to be done on the samples including the hardness test and corrosion test to investigate the mechanical properties of the magnet. Other than that, magnet coating can be applied to reduce and eliminate the oxidation process or rust. NdFeB magnets are susceptible to oxidation compare to other magnet materials [6]. Effective coating materials are applied such as nickel plating, zinc plating and organic coating. [7]

The process of micro grinding process should be done safer. These are the requirement before performing any job that needs the person to imply the safety analysis such as Job Hazard Analysis (JHA) and Permit To Work (PTW) as shown in the appendix. Actually, this document is mandatory to be fulfilled before commencing the work process at the platform. Otherwise the job cannot be done and need to be analyzed again. Author suggests that this requirement must be passed at all critical work places so that there are no constraint and problem in the future. For future project work, it is recommended that the use of NdFeB can be broadened to the other application. The fabrication and the power magnetization of NdFeB should make some interest in exposing this magnet to the community.

CHAPTER 6

REFERENCES

[1] OGM database, material verification data of pressure vessel, upstream platform, March 11 2008

[2] Mr. Eric Ang , Technical Manager of OGM Sdn. Bhd. Personal Interview. Feb. 14 2008

[4] L. Schultz, K.-H.Muller. Rare Earth Magnets and their Applications Volume 1, Journal on Replacement of Samarium-Cobalt by Neodymium-Iron_Boron Magnets- Technical instruction Production and Raw Materials, Beijing, April, 1998, p. 15-30

[5] David Brown, Bao-Min Ma and Zhongmin Chen, journal on Developments in the processing and properties of NdFeb-type permanent magnets, http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6TJJ-461XM2B2&_user=10&_coverDate=08%2F31%2F2002&_rdoc=1&_fmt=high&_orig=browse&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=4cd314cc3d7d2907750ac9c21ff6f0e2 visited on 20th April 2008.

[6]Website sciencedirect visited on 14th July 2008, <http://www.siliconfareast.com/SEMTEM.htm

[7] Kuphaldth , journal on permanent magnet, visited on 24th March 2008
http://www.rareearth.org/permanent_magnets.htm

[8] Siti Aisyah Patthi[1], P. Hussain[2], M. H. Salleh[2], I. Zainol[2], M. Mohammad[2], S. Omar, A.Shaaban and I. Ahmad
FURTHER WORK ON FABRICATION OF PRESSURELESS MADE POLYMER BONDED NdFeB MAGNET USING EPOXY RESIN TOUGHENED WITH REACTIVE LIQUID NATURAL RUBBER AS THE BINDING MATERIAL.

[9] P. Hussain, Y. Y. Wai , M. Saleh and M. Mohammad, A. Shaban and I. P. Almanar
Phases and Magnetic Properties of Nd-Fe-B Melt-Spun Ribbon (NQP-C) in the Fabrication of Permanent Magnet

[10] Mohmad Soib bin Selamat and Patthi Hussain
NdFeB permanent rare earth magnet and its potential in device application

[11] Journal refers to Muhamad Zaki Bin Baharuddin
The Influence of Particle Sizes on the Magnetic Performance of Bonded NdFeB Magnet.

APPENDICES

Appendix A Carbon Manganese Steel ASTM A516 Gr55

Record Listing from Metals Infobase 16 - September 2000 15:14 Wed Feb 28 2001

:d

Designation Grade 55, Grade 380, UNS K01800

Description Carbon Manganese Steel
Carbon Steel

Form Plate

Specified in ASTM A 516/A516M-

Equiv. Stds None Advised

Country (Matl) United States (US)

Chemical Comp.

Elements	Min %	Max %
C		0.18
Mn	0.60	0.90
P		0.035
S		0.035
Si	0.15	0.40
Fe	Remainder	

Mechanical Prop.

Property/Unit	Condition	Temp	Size	Min	Max
Elongation in 200mm %	AR or N	RT		23	
Elongation in 2inch %	AR or N	RT		27	
Elongation in 50mm %	AR or N	RT		27	
Elongation in 8inch %	AR or N	RT		23	
Tensile Strength ksi	AR or N	RT		55	75
Tensile Strength N/mm²	AR or N	RT		380	515
Yield Stress ksi	AR or N	RT		30	
Yield Stress N/mm²	AR or N	RT		205	

Heat Treatment Plates 1.50 inch (40 mm) and under in thickness are normally supplied in the as-rolled condition (AR). The plates may be ordered normalized, stress relieved, or both.
Plates over 1.50 inch (40 mm) in thickness shall be normalized (N).
When notch-toughness tests are required on plates 1½ inch (40 mm) and under in thickness, the plates shall be normalized unless otherwise specified by the purchaser.
If approved by the purchaser, cooling rates faster than those obtained by cooling in air are allowed for improvement of the toughness, provided the plates are subsequently tempered in the temperature range 1100 to 1300°F (595 to 705°C).

Notes This specification covers carbon steel plates intended primarily for service in welded pressure vessels where improved notch toughness is important.
The maximum thickness of plates is limited only by the capacity of the composition to meet the specified mechanical property requirements; however, current practice normally limits the maximum thickness of plates supplied to this grade to 12 inch (305 mm).
The steel shall be killed and made to the fine austenitic grain size requirement of Specification A 20/A 20M.
In the chemical composition table, the carbon and manganese contents apply to a plate thickness of ½ inch (12.5 mm) and under. Thicker plate shall have carbon and manganese contents as follows:

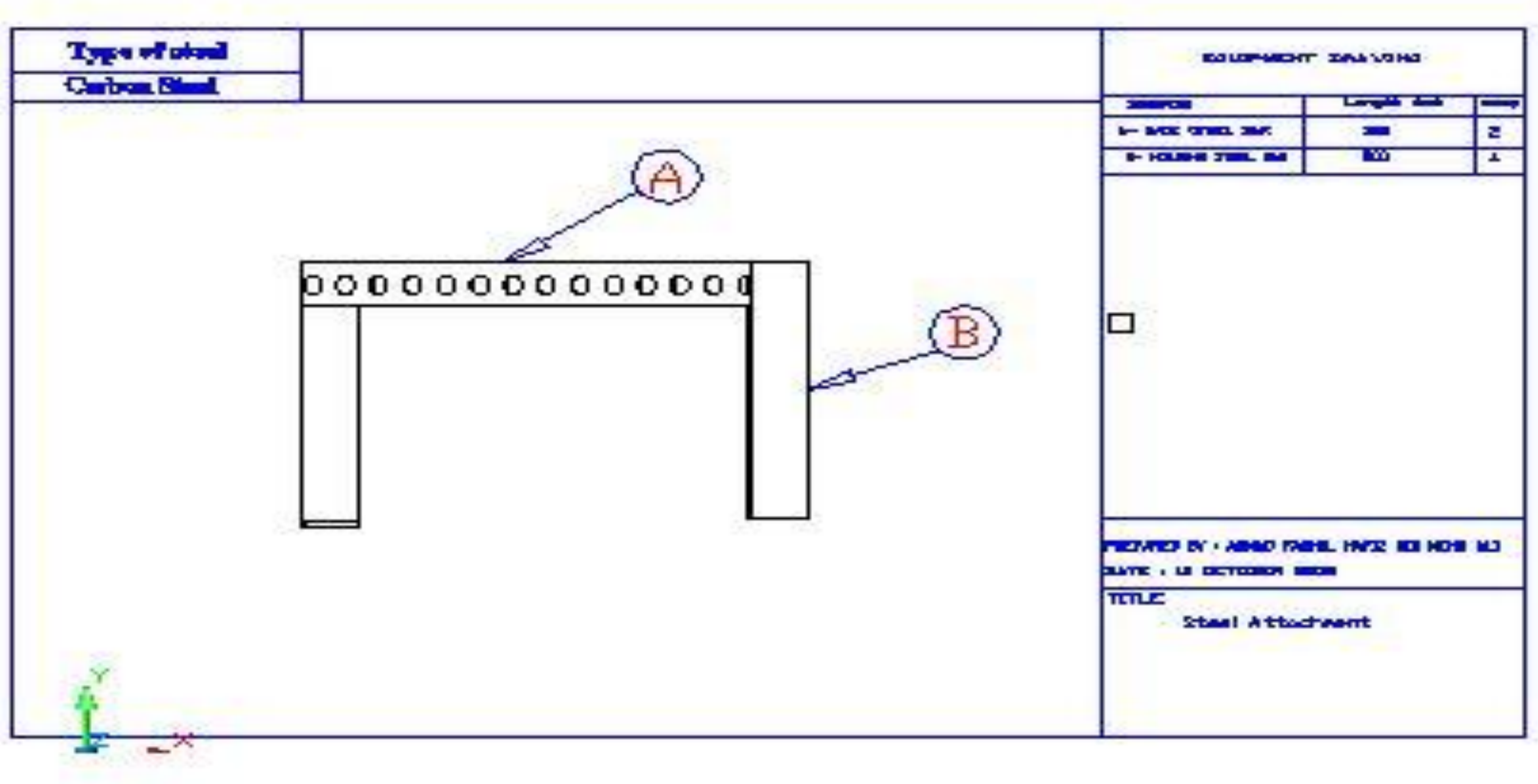
Plate Thickness Inch	mm	Carbon content % maximum	Manganese content % range
> ½ <= 2	> 12.5 <= 50	0.20	0.60-1.20
> 2 <= 4	> 50 <= 100	0.22	0.60-1.20
> 4 <= 8	> 100 <= 200	0.24	0.60-1.20
> 8	> 200	0.26	0.60-1.20

In the Temperature column of the mechanical properties table, RT = Room Temperature.
The yield strength shall be determined by either the 0.2% offset method or the 0.5% extension under load method.
The metric grade is designated 380.
It is imperative that you should check the original specification.

Update ? (Matl) No

IMPORTANT NOTICE! This information is not a substitute for the source document to which you must refer.

Appendix B – AutoCAD Drawing of Steel Attachment



Appendix C – Job Hazard Analysis

JHA NUMBER	**TASK SAFETY MANAGEMENT OUTLINE**	**Date This JHA Created :**	Nov 2007
		Date JHA Last Revised :	

WORK ACTIVITY EQUIPMENT			
Type of Equipment	**Manufacturer**	**Tag No**	**Precise Work Site**
37DL Plus (Panametrics)	Olympus – Panametrics, USA	061437912	Selected Equipment
Hardness Test	Time, China		Selected Equipment

WORK ACTIVITY PARTICIPANTS				**THIS JHA CREATED BY**		
Name	**Discipline**	**Position**	**Performed Job Before?**	**Name**	**Discipline**	**Position**
Maadi Bin Mohamad	Mechanical	Technician	Yes	Maadi Bin Mohamad	Mechanical	Technician
Mohd Kamal Aizat Bin Ahmad	Mechanical	Technician	Yes			
Mohd Naquib B Mohd Faizal Din Chan	Mechanical	Technician	Yes			
Mohd Syahmi B Ramli	Mechanical	Technician	Yes			
Ahmad Fadhil Hafiz B Mohd Ali	Mechanical	Technician	Yes			

WORK ACTIVITY RESPONSIBLE				**JHA SUBMITTED BY**		**JHA REVIEW BY**	
WORK LEADER		RECEIVING AUTHORITY		APPROVING AUTHORITY		AREA AUTHORITY	
Name :	Maadi Bin Mohamad	Name :	Mohd Syahmi B Ramli	Name :		Name :	
Signature		Signature		Signature		Signature	
Date :	Nov 2007	Date :	Nov 2007	Date :		Date :	

Time :		Time :		Time :		Time :	

HOW TO USE THIS FORM:	**Installation Facility**	PLATFORM
1) Crew performing task reviews ALL generic JHA considerations.	**Location**	
2) Review previous JHA update (s) for useful information which will help this task.	**Associated Work Permit Type**	HWP
3) Create new JHA update with generic form and ALL considerations for this task.	**Associated Work Permit Number**	
4) Carry out task per plan. If any conditions change **– STOP & RE-ASSESS.**	**Lifting Certificate Number**	
5) File JHA update for future reference.	**Physical Isolation Certificate Number**	
WORK ACTIVITY Scoop Sampling activities at selected vessels(refer to PTW for specific)	**JHA Cross-Reference Number**	

Job Step	**Description of Job Step**	**Potential Hazard/s**	**L**	**S**	**R**	**Control / Recovery Measures**	**L**	**S**	**R**	**Result**
1.	Prepare all equipments and tools for the activity.	Wrong tools and equipments.	2	2	4	Double-check with tools/equipments list before perform the activity.	1	1	1	1
2.	Confirm the thickness at the vessel using the UT measurement set.	Hydrocarbon and equipment error.	2	2	4	Wear full PPE and make sure the equipment is being calibrated before perform jobs.	1	1	1	1
3	Confirm the hardness at the vessel using the HT measurement set.	Hydrocarbon and equipment error.	2	2	4	Wear full PPE and make sure the equipment is being calibrated before perform jobs.	1	1	1	1
4	Scoop the surface of the selected vessels using the scoop machine	Hydrocarbon and equipment error.	2	2	4	Wear full PPE and make sure the equipment is being calibrated before perform jobs.	1	1	1	1
5	Taking picture of selected vessel and nozzles	Flash of digital camera may cause spark	2	2	4	Switch off the flash	1	1	1	1
6	Housekeeping the place.	Expose with hydrocarbon	2	2	4	Use and wear full PPE.	1	1	1	1

L - LIKEHOOD		
CATEGORY		DEFINITION
LOW	1	Remote
MEDIUM	2	Possible
HIGH	3	Probable

S - SEVERITY				
CATEGORY		DEFINITIONS		
LOW	1	No Injury	No Damage	No Pollution
MEDIUM	2	Non LTI	Minor Damage	Minor Pollution
HIGH	3	Lost Time Injury	Major Damage	Major Pollution

IS THERE A SAFER WAY TO COMPLETE THE JOB? ARE THERE ALTERNATIVES WITH LESS RISK?

S

R - RATING			
H	3	6	9
M	2	4	6
L	1	2	3
	L	M	H
LIKEHOOD			

RESULT	
6 – 9	UNACCEPTABLE
3 – 4	TOLERABLE
1 – 2	ACCEPTABLE

Appendix D – Project Flow Chart