DESIGN AND MAINTENANCE OF MANTLE CRUSHER

MUHAMMAD ZUL IQBAL BIN CHE ISMAIL

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Signature : .....
Supervisor : SITI NORBAYA SAHADAN
Date : .....

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MUHAMMAD ZUL IQBAL BIN CHE ISMAIL

This report submitted in partial fulfillment of the requirements for the award Bachelor's Degree in Mechanical Engineering (Plant & Maintenance) with honours

Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature : .....
Author : MUHAMMAD ZUL IQBAL BIN CHE ISMAIL
Date : .....

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Final year project is an integral for any degree program and for that purpose I had completed my final year project which Design and Maintenance of Mantle Crusher.

From this final year project I would like to express my gratitude to all of them who in some or other way helped me to accomplish this challenging project. No amount of written expression is sufficient to show my deepest sense of respect and gratitude to them

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ABSTRAK

Penghancur kon digunakan dengan kerap di dalam industri perlombongan. Mesin penghancur ini digunakan untuk mengecilkan saiz partikel batu kepada saiz yang lebih kecil yang dipanggil aggregate. Dengan teknik penghancuran mampat, teknik ini terbukti dapat menghancurkan batu yang besar kepada kecil dengan lebih effisien. Walaupun begitu, dengan teknik penghancuran mampat ini kepada batu yang dihancurkan mempengaruhi mantel penghancur. Di dalam laporan ini akan membincangkan tentang meningkatkan kebolehpercayaan mantel penghancur dengan mengkaji bahan yang terbaik yang digunakan untuk mesin penghancur. Bahan yang digunakan untuk mesin penghancur kon lebih kurang sama tetapi komposisi bahannya adalah berbeza. Setiap syarikat mempunyai ciri-ciri yang mereka kehendaki yang mana mereka perlu untuk menekankan dalam tujuan pemasaran. Oleh itu, dalam laporan ini akan menunjukkan bagaimana salutan pada mantel penghancur boleh memanjangkan hayat mesin tersebut. Selain dari itu, punca kegagalan yang juga membawa masalah kepada penghancur mantel juga akan dibentangkan di dalam laporan ini. Kegagalan mesin penghancur juga mempengaruhi ke atas produktiviti industri itu sendiri. Oleh yang demikian, salutan permata telah digunakan untuk meningkatkan jangka hayat bahan mantel penghancur. Untuk menyiasat kadar haus dan kekuatan bahan mantel penghancur, mesin pin disk dan mesin kekerasan telah digunakan. Spesimen yang telah disalut menunjukkan perningkatan terhadap kadar haus dan kekerasan berbeza dengan spesimen yang tidak disalut. Ini menunjukkan peningkatan yang memuaskan untuk bahan tersebut dan seterusnya menolong dalam meningkatkan jangka hayat mantel penghancur.

ABSTRACT

Cone crusher are used extensively on mining industry. This crusher are used for breaking rock particles into small fragment called aggregates. By the compressive crushing, it is been proven that it is the most efficient way of reducing size of rock particles. Nevertheless, from the usage of compressive force towards the material being crushed, it also affect the mantle crusher which is the component for the crusher itself. In this report, it will be discussing on the improvement of the mantle crusher reliability by determining on the best material used for the crusher itself. The material used in the cone crusher is nearly the same, but the composition of the material is difference. Each company has their own desired properties that they need to emphasize in marketing purposes. Therefore, in this report it will also shows that how the coating on the mantle crusher itself can prolong it service. Apart from that, the root cause of failure which also leads the mantle crusher problem also will be presented in this report. The failure of the crusher have influence on the productivity of the industry itself. In order to improve its reliability, the critical root cause of failure is needed to be identified so that the replacement can be made on time. The goal on this report to carry out experiment on how the strength of the mantle can be increased as well as its wearing time during operation. This is in order to prevent from increasing downtime error in the industry. Therefore, a coating which is Diamond like Carbon has been use to improve its wear life on the mantle crusher material. In order to investigate the wear rate and improvement in the wear life of mantle crusher, pin on disc and hardness tester experiment has been conducted. For the coated specimen, the result shows increasing in the wear resistance of the material and its hardness compare to the uncoated specimen. This shows a great improvement on the material thus, helping in prolong the service of the mantle crusher.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Quarry industry is a big profitable business to start with. The return of investment and higher profit gaining sure make the industrial leaders to awake at night. Investor depends on how the industry respond to the commodity prices and the challenge before they start gaining their confidence to invest in this type of industry. In Sweden during 2010 approximately 8.8 million tons of industrial mineral and 61.5 million tons of ore were mined. In comparison to 2009, the global production of ore increase to 1.8 billion tons in 2010 which correspond to the growth of 15.4 %.(Bergverksstatistik 2010)

Mining and quarrying in Malaysia has been classified as one of the major economic sector. This involving in high processing of mineral from the surface and the underground. In 2012, the performance for mining and quarrying in Malaysia revive into positive growth territory. This sector is expect to be increasing year by year in Malaysia. The highest total output of non-metallic mineral is being monopolize by the aggregate production (SCH Group Berhad, 2014). In order to promote growth for the quarrying industry in Malaysia, researchers has studying on how to increase the production capacity in the quarry.

One of the main solution is by optimizing the equipment used in the industry itself. For an aggregate production, one of the main concern in producing output is by the crusher. The crusher is used for breaking rock material which is big into small fragment. This small fragment is used for many type of categories such as construction of building, and roadways (Marshak, 2005)

Nowadays, there are many type of crusher has been invented and sold in the market such as jaw crusher, cone crusher, impact crusher, and gyratory cone crusher. Each type of crusher has their own characteristic on crushing the aggregates. In the mining industry, after the blasting process on the quarry, the product that being blast will be transferred to the crusher. The size and condition of the aggregate after being blasted is big and hard. Therefore, in order to crush this type of aggregate, the usage of jaw crusher would be the suitable one. This is because jaw crusher used impact force on the aggregate instead of using compressive force just like cone crusher. This is the reason for the jaw crusher to be installed as the primary crusher as the plate can last longer than cone crusher. Although the plate for jaw crusher can last longer, it cannot crushed the aggregate into fine material, and that's where the cone crusher become handy.

The cone crusher is suitable in crushing the aggregate which is soft to medium hardness only. It is to prevent from the mantle of the crusher became wear easily. Normally for the mantle of cone crusher, its wear life is around 100 hours of operation or 2 to 3 weeks of 8 hours operation per day. The wear on this cone crusher was being thoroughly research by (Lindqvist, 2005). The biggest problem of the mining industry problem is the downtime error. This sort of downtime error usually cause by bearing problem, misalignment in eccentric shaft, leaking of lubrication oil and wearing of the mantle. By changing the mantle itself, it took about a day before it can start operate normally again. From this corrective maintenance, the operation cost will be increase and the production process will be on hold.

Therefore in order to reduce the operation cost, one of the main solution is prolong the service of the mantle by using better material or technique. Apart from that, the minor failure on the crusher need to be minimize so that less cost will be used for the maintenance purposes. In order to recover its performance and operational reliability, its critical components are to be identified first to ensure that replacement make in time. (Sinha et. al, 2013)

1.2 PROBLEM STATEMENT

Mantle crusher lifetime is between 100 to 1000 hours of operation based on type of material it is crushed. In JKR Kuari, the lifetime of the mantle crusher is about two weeks of 7 hours per day operation or 84 hours operation which is less than expected life. The engineer in charge has given me a task to solve the downtime during the replacement of the mantle crusher which had cause the cost of operation increase and as well as stop the whole production in the quarry. In this study I would propose to put coating into the mantle crusher to prolong its wear life and as well as prolong its service. In this quarry, apart from the corrective maintenance on the mantle crusher, other problem such as bearing wear also become a problem which can affect other parts on the crusher. Because insufficient skilled worker in this quarry, a simple problem on the crusher could lead to total failure.

1.3 OBJECTIVES

1. To investigate the root cause of failure on the crusher
2. To improve the mantle crusher which can prolong its service during operation
3. To investigate the effect of Diamond like Carbon Coating to the mantle crusher

1.4 SCOPE OF PROJECT

1. Detect the root cause of crusher failure which could affect production
2. Experiment to compare the wear life of mantle crusher
3. Apply the coating to the mantle crusher to improve its material structure.

CHAPTER 2

LITERATURE REVIEW

2.1 CRUSHER PROBLEM

There are many kind of problem can happen to a crusher during the production process. From a minor problem until bigger problem which could lead to catastrophic failure. According to Sinha et. al, 2013 the random component failures of the crusher have considerable influence on productivity of the plant. Usually a component that affect the productivity of the plant is the mantle crusher itself. The wear life of the mantle crusher is usually range between 100 to 1000 hours of operation (Lindqvist, 2005).

When the materials get into the crushing chamber, the material will keep falling until they meet the mantle. Then the materials are pushed against the concave surface by the mantle until the material get squeeze into the right size. This process will cause the wearing in the mantle crusher when operated in a long period of time. This is a common reason for the plant shutdown when there is a need on maintaining of wearing mantle crusher. This maintenance is crucial because the mantle are designed to withstand high load and high vibration of the input aggregate.

Therefore, the wearing of the mantle could lead to lower quality of product or worse could damage the spindle of the crusher. Regular maintenance for this component is necessary, but if the maintenance also been done although there are no problem to the crusher it is not advantageous either, since the cost of new component and downtime is needed to be less than the potential gain in production profit (Hulthén, 2010). The maintenance of the mantle crusher is shown in the Figure 2.1 and Figure 2.2 below.

Figure 2.1 : Wearing of mantle crusher in JKR Kuari

Figure 2.2 : Changing of new mantle crusher

Apart from that, there are several other problem that needed to be maintain such as the crusher motor, lubrication oil pipe, bearing of the motor, eccentric shaft and the conveyor. This type of maintenance is needed to make sure the crusher is efficiently doing its job perfectly. The type of maintenance that is suitable for this

type of component is condition based monitoring. From this type of maintenance, the industry can minimize the cost use for the maintenance purposes instead of frequently maintenance or schedule maintenance. Apart from that, by monitoring the component in the crusher, we can identify and detect any sort of problem before it become worse. For the bearing and shaft we can use vibration analysis to detect problem and for oil lubrication pipe we can use oil analysis to test the lubrication oil whether it is contaminated or not.

2.2 OPTIMIZATION OF CONE CRUSHER

Achieving a perfectly crusher is a researchers dream. Nowadays, the crusher sold in the market has begun competing with others to produce a reliability and long lasting crusher. Each company have their own specialty in designing the crusher, based on their research and development team, they have produce a design of crusher but with the same function. The differentiation between this companies is their optimization of the crusher itself.

For an example, the Sandvik company produce a computerize crusher which has the Automatic Setting Regulation System (ASRi). This type of system not only optimizing the production but also keep track of liner wear in the crusher (Sandvik Mining and Construction, 2012). Whereas for the Terex Company, they produce a balance design which reducing the vibration of the crusher and design the crusher for fast changeover. This type of design can reduce downtime to the minimum when replacing the wear parts and no need to remove the cone head. (Terex Mineral Processing System, 2011). Therefore, In order to successfully and prepare to face the challenges ahead, efforts must be focused towards improving the performance and efficiency of existing crushers and crushing processes *(*Evertsson*,* 2000)

There are many type of development that can be thoroughly research in producing high efficiency of crusher. According to (Lindstedt et. al, 2006) the changes for value development and incremental improvement have since then been made to the machines alongside their development over time.

Therefore, In order for the cone crusher to improve in crushing the particle efficiently, the parameter that need to be considered are eccentric speed, the Closed Side Setting (CSS) and the stroke which is also known as eccentric throw. The optimal compressive crushing differs depending on the application and optimization objective (Marshak, 2005).

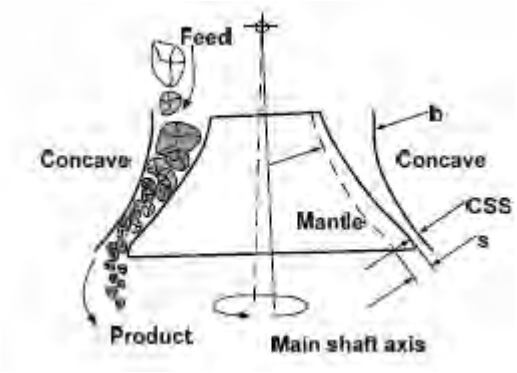

Figure 2.3: Schematic illustration of cone crusher
Source: (Evertson, 2000)

As shown in Figure 2.3, the CSS is defined as the smallest distance between the mantle and the concave during crusher operation. During the process of the crushing, the kinetic energy applied to the particles are needed to be considered. This is because the higher the kinetic energy applied to the particles, the harder the particles are thrown against a mantle or a bed of particles which subsequently determines the amount of breakage of the particles. (Wills, 2006). Assuming that, most of the minerals and rock materials are brittle, the transformation of potential energy to the elastic energy will create a critical level of stress. A crack will then start propagates, and a new surface will transformed from the elastically stored energy (Wills et. al, 2005).

For the eccentric speed of the operating crusher, the increasing of eccentric speed in the cone crusher correspond to the increasing of size reduction and the number of crushing zones in the cone crusher. The results indicate that the number of crushing zones in a cone crusher increases with the eccentric speed (Evertsson, 2000).

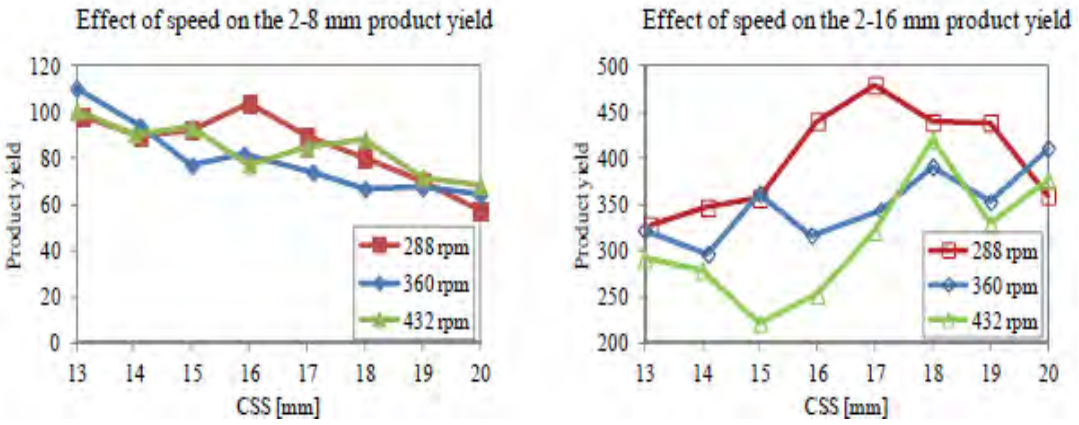

Figure 2.4 : Effects of eccentric speed on the product at 36mm stroke
(Source: Evertsson, 2000)

According to Atta et. al, 2013 the ability of on-line optimization of cone crusher which is specifically maximization of the total throughput of the crusher by changing the eccentric speed is advantageous with unknown time varying characteristics. From the previous technology, the speed of the crusher is usually fixed since speed change by changing pulleys is a labour intensive activity. The effect of the dynamic speed and the change of close side setting to the product yield is shown in the Figure 2.4 above.

Nowadays, the new technology from Sandvik mining and construction, 2012 the speed of the crusher can be regulated by the system. According to Hulthén, 2010 the crushing stage where the speed were tested the performance of the crusher is from 4.2% to 6.9% compared to a good fixed speed. In real life however, the performance was increased by almost 20% since an appropriate speed was selected during installation. As a bonus, one of the test plants for the dynamic speed, the lifetime of the mantle wear parts increased 27% on the evaluated crusher, as a consequence of change crusher dynamic.

2.3 COATING OF THE MATERIAL

Studies on the wear of a material is a reoccurring subject because due to the fact that it affects the production capacity because of the environmental effect (Andersen, 1990). According to Bhushan (2002) wear occurs when a hard rough surface slides over another surface. According to American Society for Testing and Materials (ASTM) International, wear is define as loss of material due to hard particles that are forced against and move along a solid surface. The wear in a cone crusher specially is typically categorized as only abrasive, this cause changes in the liner profiles and in turn affects the crusher's performance. The amount of wear in cone crusher depends on several factors such as moisture, particle size distribution and material properties. (Lindqvist, et. al, 2006)

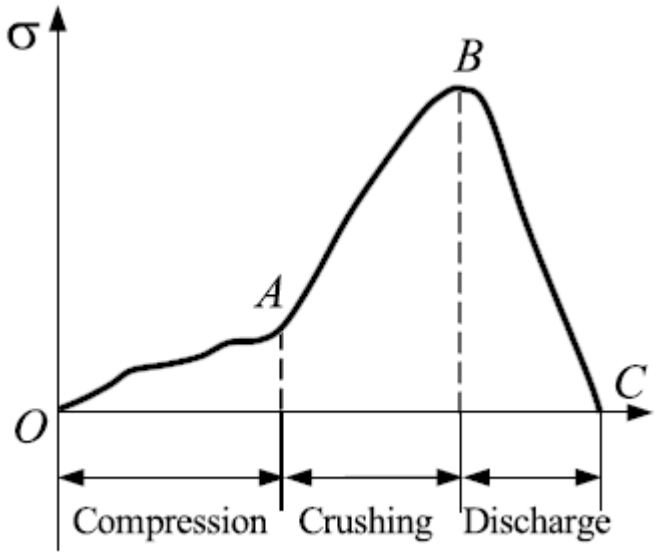

Figure 2.5 : Whole process of dynamic crushing on material
(Source: Lindqvist et.al, 2006)

For the material properties, we can see that on this Figure 2.5, the stress is higher in the transition between crushing and discharge phase. This dynamic σ vs ε curve enters the discharge phase after the peak. This material layer store a large number of energy in the compression and crushing phase and then release energy during the process of discharge for fragmentation of particles and the development of crackle (Evertsson, 1998).

Therefore, in order to increase the material mechanical properties, many researcher has design treatment system on producing the high end material which is hard enough to sustain the impact. One of the treatment is by coating the material with a chemical so that the strength or other mechanical properties can be improved. A Thin coatings on the material is important in order to give them the hardness, wear resistance, chemical inertness, and electrical characteristics needed in a desired application (Ladwig et. al, 2009).

Nowadays, there are a great demand for thin functional coating in the industry. This is include semiconductors, medical devices, automotive and aerospace technology (Ferrari, 2004). In Malaysia, there is a great demand on coating on the DLC or known as Diamond like Carbon Coating. In Malaysia, there are industry who give service to people and to the manufacturer. This including the coating of watch, gear and bearing (Nocon Technolgy Sdn, Bhd, 2013). The Diamond-like carbon (DLC) possesses an array of valuable properties: outstanding abrasion and wear resistance; chemical inertness; exceptional hardness; low coefficient of friction; and high dielectric strength. (Robertson, 2002). From this valuable properties, it can increase the wear life of certain product, and give it less in friction resistance. The widest use of diamond like carbon films is mainly of the hydrogenated DLC in applications exploiting the low friction coefficients and high wear resistance of material. (Grill, 1999). According to the McHargue et. al,1998 the usage of diamond like carbon coating on the stainless steel and titanium alloys used for components of artificial heart valve, has been found to satisfy both mechanical and biological requirements and be capable of improving the performance of these components. Therefore for the cone crusher, the material for the mantle will be coated to see whether it is efficiently improved or not during operation.

CHAPTER 3

METHODOLOGY

3.1 PROCESS FLOW CHART

In this chapter is the discussion about the PSM project flow and the methodology required to achieve the objectives of this study. This chapter explain on the project flow chart, the experiment conduct and how to obtain the data from the experiment.

The overall flow process of the whole project are explain in the Figure 3.1. Figure 3.1 show the flow for both *Projek Sarjana Muda 1* and *Projek Sarjana Muda 2*. The project phase starts from the beginning and end with the submission of the report.

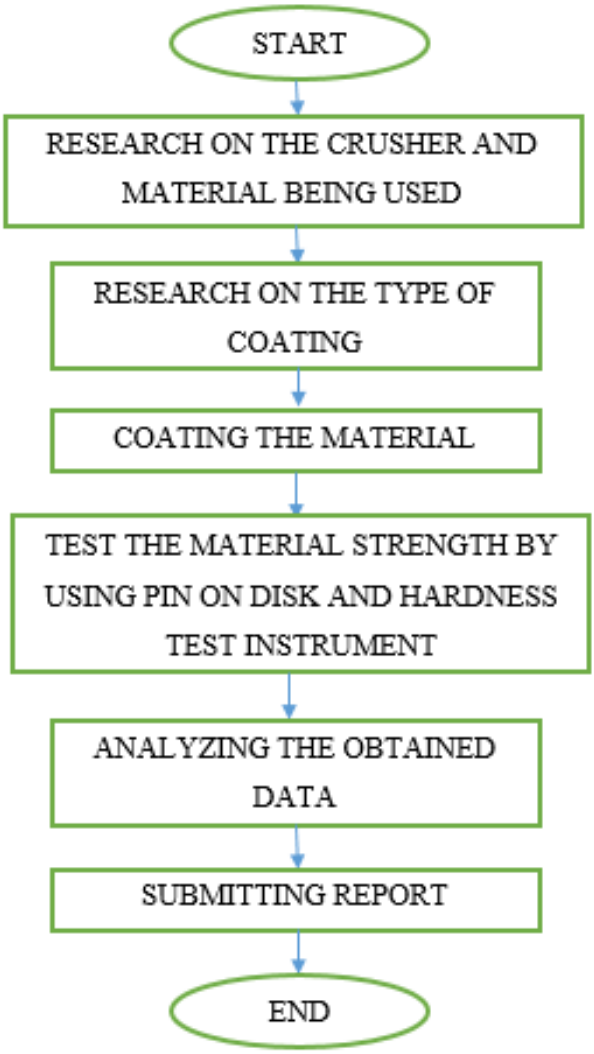

Figure 3.1: Flow Chart of Final Year Project

3.2 INTRODUCTION ON EXPERIMENT

For the experiment throughout this report, the experiment manipulated variable are the present of coating on the material. For the responded variable in the pin on disk instrument is the wearing on the material whereas for the hardness test equipment is the hardness of the material. On the pin on disk experiment, the constant variable is the rpm of the disk rotate which is 1000 rpm whereas for the hardness test the constant variable is the force acting on the specimen.