# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Quality Improvement using Factorial Design: A Case Study in Manufacturing Company**

SESI PENGAJIAN: **2014/15 Semester 2**

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# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Management) (Hons.). The member of the supervisory is as follow:

……

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# ABSTRAK

Pembelajaran ini bertujuan untuk melakukan penambahbaikan kualiti gula di Kilang Gula Felda Perlis Sdn. Bhd. dengan memaksimumkan hasil gula mengikut saiz yang ditetapkan. Proses pendidihan merupakan salah satu proses yang terlibat dalam penghasilan gula. Proses pendidihan di pilih setelah selesai melakukan pemerhatian dan perbincangan dengan pekerja yang berpengalaman dalam mengendalikan proses tersebut. Tambahan lagi, proses pendidihan adalah salah satu proses yang menyumbang kepada masalah kualiti. Di dalam projek ini, terdapat tiga objektif yang perlu dicapai. Pertama, beberapa parameter atau faktor dikenalpasti dan dikaji dalam proses pendidihan yang memberi kesan kepada hasil gula. Projek ini bertujuan mempelajari dan memahami proses pendidihan untuk kemudahan mengenalpasti faktor atau parameter yang terlibat mempengaruhi hasil daripada proses tersebut. Kedua, untuk menjalankan eksperimen berdasarkan rekabentuk factorial. Kaedah ini bertujuan untuk menghasilkan rekabentuk eksperimen dan mengetahui semua interaksi antara faktor yang terlibat. Seterusnya, keputusan eksperimen di analisis dengan menggunakan perisian kepakaran rekabentuk untuk mengetahui keputusan ANOVA, model regresi, dan graf grafik. Penggunaan perisian ini memberikan kelebihan kepada pengguna, Ini kerana ia berkemampuan untuk menganalisis keputusan dengan pantas. Selain itu, dengan menggunakan perisian ini nilai ketetapan optimum pada mesin dapat diketahui. Objektif yang ketiga, untuk mencadangkan nilai ketetapan yang terbaik pada mesin pendidihan berdasarkan daripada keputusan yang diperoleh daripada perisian tersebut. Keputusan tersebut akan dianalisis dan digunakan oleh kilang tujuan penambahbaikan kualiti gula.

# ABSTRACT

The purpose of this study is to improve the quality of sugar in Gula Felda Perlis Factory Sdn. Bhd. by maximizing the yield of sugar in standard size. Boiling process is one of the process involve in sugar producing. Boiling has been selected after done with observation and discussion with person that have experience in the boiling process. In addition, process boiling is one of the process that contribute to the quality problem. There are three objectives of this project. First, to identify and analyze a list of input variables or parameter in boiling process which suppose to have an effect to the maximum yield of sugar. The purpose of this project is to study the flow process of boiling and identify the factor or parameter that influence the output of the process. Secondly, to conduct experiments using factorial design. The purpose is to build the design of experiment and know all the interaction of of each factor. Then, the result of experiment is analyzed by using the design expert to know the result of ANOVA, regression model and graphical result. This software gives more advantage to the user because it can work with the fast result from the analysis. By using this software, the optimal setting value of boiling process can be determined. Third, to suggest better quality improvement for the boiling process operation based on the result of the experiment. Result from the experiment will be analyzed and use for improvement to the company to maximize the sugar yield.

# DEDICATION

To my beloved family, lecturers, and friends whose have guided and inspired me to complete this project successfully.

# ACKNOWLEDGEMENT

In completing this project, I have contact with many people in different level and background have shared their knowledge and opinion that contributed towards my understanding and thoughts. First of all, I wish to express my sincere appreciation to my core supervisor, Prof Madya Dr Lukman Sukarma who give this project to me and also guidance, encouragement, and criticism how to get a better result while conducting this project. My sincere also extends to Kilang Gula Felda Perlis Sdn. Bhd because give the permission and opportunity to do my project at their company, especially En Hadzmerul Hadzree B. Hassan who helps a lot. Unfortunately, it is possible to list all of them in this limited space of this report. Also a big thanks to my colleagues who have involved in completing this project. Lastly, great thanks are due to my beloved parents and sibling for their support, encouragement and sacrifice.

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ANOVA | - | Analysis of Variance |
| CV | - | Coefficient of Variation |
| DOE | - | Design of Experiment |
| DM | - | Data Mining |
| FYP | - | Final Year Project |
| MA | - | Mean Aperture |
| PDSA | - | Plan, Do, Study, Act |
| SO2 | - | Sulfur Dioxide Gas |

# CHAPTER 1
# INTRODUCTION

This chapter gives a general review about the project entitled "Quality Improvement using Factorial Design". Background study, problem statement, objectives, and scopes are also discussed in the following sections.

## 1.1 Background of Project

This project is done to propose quality improvement toward the white refined sugar product using a factorial design focus on boiling process. Factorial design is probably the one of suitable statistical technique for research into the manufacturing process for the purpose of quality improvement. Quality of product is rapidly becoming an important role in any organization. The best quality of product will lead to gain profit and automatically will increase the customer satisfactions. To obtain a good quality of products, there are several factors need to examine and control in the manufacturing process that influence the quality of the finished products.

Kilang Gula Felda Perlis is suitable place need to be applying this method of the factorial design due to the problem happen with quality of sugar. This company produces sugar through the sugar refining process from raw material until to refined sugar, which is supplying a good quality product. Raw materials are imported from various companies such as Australia, Thailand, Brazil, etc. From overall process, one process has been selected, which is boiling process that involve in a crystallization stage of sugar.

Then, one or several response variables are known as output that require to be improved. In case for this project only has one of response variable which is sugar yield with regular size. In the boiling process, the optimum setting of those input variables needs is identified and the settings may result in significant improvements in response variables. This in turn may lead to significant quality improvement. The further action is carried out experiment using factorial design with the current setting. Lastly, the results of the experiment will be analyzed using Design Expert software to come up with a list of significant factors that have an effect on the response variables.

## 1.2 Problem Statement

The low quality of the product is part of the quality issues concern in the Kilang Gula Felda Perlis in which the unwanted irregular size of fine sugar is produced. The impact of this problem lead to increasing the percentage of rejecting rate and exceeding the key performance indicator of the company. The key performance indicator has been set by the management after benchmarking with the percentage reject rate value with another factory and agree to accept the value is under 0.4%. So, the company need find the solution to solve this problem and make sure the key performance indicator of their company is achieved. It will be an advantage if the company can achieve with the zero reject of sugar. The standard size of fine sugar is determined by mean aperture (MA) of the mean/average between 0.9 and 1.2 and coefficient of variation (CV) of the measure of the regularity of the crystal size less than 40. The higher the Coefficient Value the more irregular the crystals are. Refer the Figure 1.1 for percentage reject rate of sugar.

After having a discussion with the expert in the production of sugar, boiling process is one of the existing process that contribute to quality problem on sugar where the process is depended on the vacuum pan conditions before boiling process begin. This will lead to the producing of sugar in irregular size if boiling process operation did not fulfill the condition of vacuum pan in prior.

Poor quality of products becomes waste to the company because if the products are out of the specification, it can be reprocessed. However, loss in terms of cost and materials

was happened during reprocessing. If the problem cannot be solved immediately, it can become worse and the waste will increase from time to time. So, the method of the Factorial Design will be used to solve this problem and produce better quality of products.

The unwanted irregular size of fine sugar needs to decrease to make sure the sugar yield increase by using factorial design experiment. Before introducing and applying this method, the company have done the several efforts to overcome this problem; training the operator, upgrading the vacuum pan machine and much more. Figure 1.2 is the example for irregular of sugar.

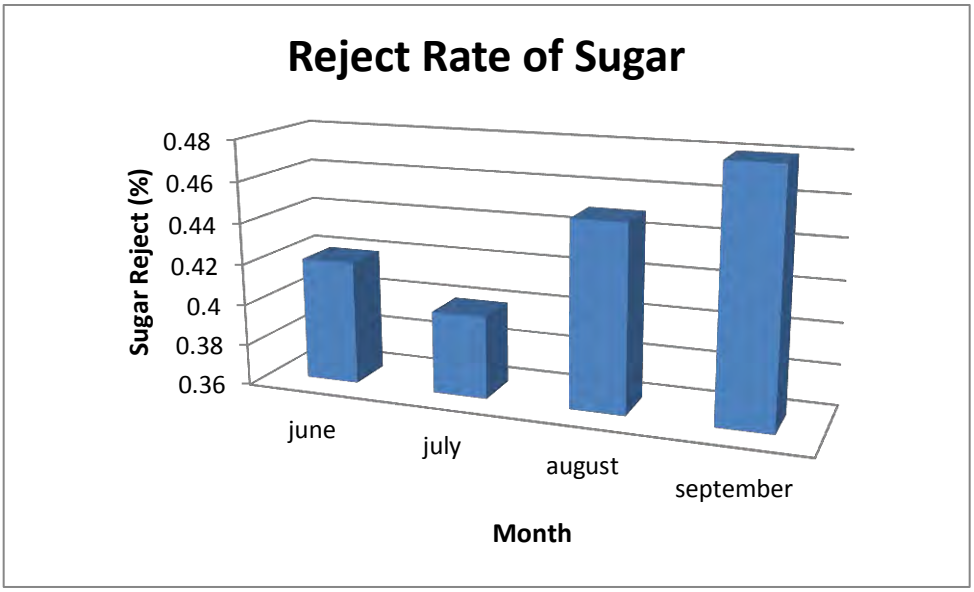


**Figure 1.1:** Reject Rate of Sugar (Sources from Company)

**Figure 1.2**: Poor quality of sugar

## 1.3 Objectives

i. To identify and input variables /factors in boiling process which suppose to have an effect to the maximum yield of sugar.

ii. To conduct experiments based on Factorial Design and analyze the result by using the Design Expert Software.

iii. To suggest the optimal setting based on the result from the experiment for better quality improvement.

## 1.4 Scopes

i. To review the maximum yield of sugar with the combination setting of the boiler in the vacuum pan.

ii. To apply factorial design method in data analysis to capture the optimal proportion of quality product.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Quality Improvement

Global competitive pressure is inflicting organizations to search out ways that to higher meet the wants of their customers, scale back prices, and increase quality and productivity. Continuous improvement of merchandise and services has become a necessary issue of an organization‟s business strategy. Since improvement is expected on transformation, creating effective changes to manner business are run has become a matter of survival. The speed and extend of improvement to merchandise, processes, and system is directly associated with nature of changes that are developed and enforced. There is a way to develop a transformation is to look at this system for defects and opportunities for improvement. According to Moen et al., (2012) stated that although improvement requires change, not all the improvements need a change. How to know the change is an improvement and what the best change that is required? The answer is to ensure that changes are beneficial require learning, and learning must involve testing or experimentation.

Data mining (DM) has spread been applied for quality improvement in producing as a group systems and analysis tools. Many input and output variables don't seem to be straightforward to optimize which will involve in quality issues. According to Koksal et al., (2011) unraveling quality improvement and management downside with success using data processing are terribly helpful that involve multiple variables knowledge during a kind of product/process life cycles. Mining functions are classified as

knowledge summarizations, classification, prediction, clump and so on. The kind of information is very important to those categories which will be discovered in databases (Choudhary et al., 2008; Wei et al., 2003). The different software is used for numerous aim mining in quality data which are spreadsheets, databases, statistical software, data mining software, special purpose software, and high-level languages. Comparison between data mining and traditional statistical method, the traditional statistical method still give valuable information with a relatively small number of records and variables. As a conclusion, the knowledge that earned by data mining application must be hard to explain and use. However, it's not given the problem, because the applied studies mostly perform by academic experts.

## 2.2 Principles for Design and Analysis of Planned Experiments

The method of planned experimentation is designed to give understanding about how the various causes and conditions of variation in a process or a system could affect the outcomes of the of the process. The effect of the changes on the outcomes can be studied after the causal variable is changed. Selecting the variables to change need to be done haphazardly or by convenience, but minimal learning would take place. The plan experimentation gives strategy to optimize the learning from PDSA (plan, do, study, act) tests of change. Planned experiment makes an effort to focus for all the components and measures of a process, product, or system (Moen et al., 1999). These variables will be classified as one of the four types in an experiment:

**Table 2.1:** Types of variables and justification. (Moen et al., 1999).

| Type of variability | Justification |
|---|---|
| Response variable | • A variable that called as the dependent variable.<br>• The results of the experiment and are usually the quality characteristic of a product, process or system.<br>• An experiment will have one or more response variable. |
| Factor | • It's called as an independent variable or causal variable.<br>• Variables that are changed in a controlled way in an experiment to see the effect on the response variables. |
| Level | • The specific setting of a quantitative factor.<br>• The level of factor selected may be fixed at certain values of interest.<br>• A particular combination of a factor and levels is called a " treatment " in describing the experiments |
| Experimental Unit | • The smallest division of units such that any two units may receive different combinations of factors and levels.<br>• Deciding which combination of factors and levels will be assigned to each experimental unit.<br>• The selection of experimental units will determine the appropriate unit of analysis when analyzing the data. |

## 2.3 Application of Experimental Design

The experimental design plays a role in the initial stage of the development cycle, in which the new product are designed, make the improvement to the existing product designs and optimize the manufacturing process, will lead to product success. The effective use statistical tools of Design of experiments (DOE) can lead to products that have high reliability and easy to manufacture, enhance field performance as well as troubleshooting activities. DOE was established in many industries such as electronic semiconductors, automotive, medical device, food and etc. According to Montgomery (2008a) stated that in engineering and science world, the experimental design is an important tool for improving the product realization process. Applying this experimental design technique at the initial stage in process development can:

i. Improve process outcomes
ii. Decrease the variability and nearer correspondence to nominal or target demand
iii. Decrease the development time
iv. Decrease the overall cost

In engineering design activities, the experimental design method is important fundamental, where developing new products and improving the existing ones. According to Montgomery (2008b) there are some application of this method in engineering design involves:

i. Assessment and comparison of basic design configurations.
ii. Assesment of material alternatives or other possibility.
iii. Select the design parameters, then the product will work well under a wide variety of field conditions and become robust.
iv. Identify the key product design parameters that affect product performance.
v. Formulation of latest products.

By using experimental design in product realization, the products are easy to manufacture and also improved field performance and reliability, lower product cost, and shorter product design and development time.

## 2.4 Types Design of Experiment

The technique of determine and researching all probably conditions in an experiment involving the multiple factors identify as the Design of Experiments. The types of Design of Experiments which are Factorial Design and Taguchi Method are spread used. According to Minitab Design of Experiment, the Factorial Design known as a type of designed that enables for simultaneous study of the effects that certain factors or parameter toward the response or output. While conducting the experiment, differing the levels of all factors at the same time, instead of one at a time enable for the study of interactions among the parameters or factors. Then, in full factorial design, the outputs are measured at all combinations of the experimental factor levels. In order to minimize the time and cost it is probably to keep out several factors level combinations. The factorial design that one or more level combination keeps out, are known as fractional factorial design. (Packianather et al., 2013)

## 2.5 Factorial Design

Factorial design was developed by R. A. Fisher in the 1920 where the purpose is to identify optimum processing variables affecting most manufacturing processes. This method is presently used by manufacturers as part of their associate endless effort to produce defect free components, whereas work thought of an experimental approach to agricultural analysis in European countries. An experiment must be so carefully planned, because the small effects due to intentional changes in materials and methods can be result in the existence of major and environment changes cannot be controlled. Factorial design is the most powerful method into any manufacturing process between the various experimental design techniques. The primary reason why experimental design is

recommended to be used for investigating industrial problems because it create clear results at lower cost and in the short period of time. Another reason is the conventional experiments cannot give learning about interactions among variables and the inclination to estimate experimental error quantitatively. To start the research, planning, the randomize blocks, Latin squares, factorial experiments and fractional factorial experiment known as a standard plan that need to be correct chosen by the researchers. The success of the research depends on how the researcher adapts the standard plan that suitable with their problem. Most researchers are preferred to the factorial experiment as a standard plan that will be used to solve their problem (Lim, 2005).

### 2.5.1 Advantage of Factorial Design

According to Loh et al., (1989) stated, using factorial design while conducting of experiments gives a lot of benefits. This method more efficiently used than conventional experiments of one factor at a time that usually used by researchers. Besides, the factorial design also allows the study of both the main effect and interaction effects between factors. Furthermore, whether the parameter to be minimized with respect to a combination of factors or not, by using the factorial design it will give the combination near to the minimum (or maximum). This result cannot be achieved if using the conventional experiments. The experimental data were computed and carried out by using Yate‟s algorithm. The analysis of variance (ANOVA) and F test can be used to determine the effect of each factor and interaction between factors. By using the analysis of variance (ANOVA) and F test, the main effect of each factor and the effect of interaction between factors were determined. The physically impossible for the third and higher order interaction. This could be used as an estimate of experimental error.