APPLICATION ON SPOT WELDING TO DETERMINING PARAMETER SETTING BY TAGUCHI METHOD AT PT. ASTRA DAIHATSU MOTOR

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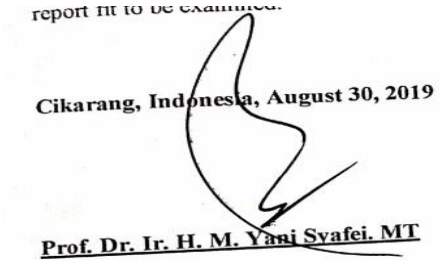
ACADEMIC ADVISOR RECOMMENDATION LETTER

This internship report is prepared and submitted by **Riana Eka Saputri** in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering has been reviewed and found to have satisfied the requirements for a report fit to be examined.

Cikarang, Indonesia, August 30, 2019



Prof. Dr. Ir. H. M. Yani Syafei. MT

COMPANY'S SUPERVISOR RECOMMENDATION LETTER

Riana Eka Saputri has performed and complete internship in PT. Astra Daihatsu Motor, in partial fulfillment of the requirements for the degree of Bachelor Degree in the Faculty of Engineering. I therefore recommend this report to be examined.

Cikarang, Indonesia, August 30, 2019

Ajat Suryanto, Amd.

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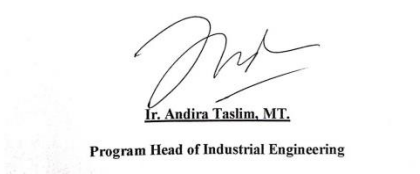

Ir. Andira Taslim, MT.

Program Head of Industrial Engineering

ABSTRACT

As a competitive company, PT. Astra Daihatsu Motor is automotive manufacturer, which converts raw material into goods that are ready for sale and use. Quality is one aspect that should be maintained to be able to survive in competitions of industries. PT. Astra Daihatsu Motor have a project to conduct optimization experiment using taguchi method with minitab and anova in order to increasing quality on welding machine through weld nugget diameter as well saving cost. Resistance spot welding is one of the process parts of manufacturing that is used to make products. Resistance spot welding (RSW) is one of the key metal joining techniques for high-volume production in the automotive, biomedical and electronics industries. Therefore, the need to do research to find the appropriate parameters so that the process runs according to what has been set. There are three parameter that used to this experiment which are current, time and pressure, as well, the three stages to doing analysis which are planning phase, implementation phase and analysis phase to get the great result that can be used as improvements. The result can show the significant parameter to implement on welding machine and the optimum value so that resistance spot welding produce high quality so that can be implemented in company. The objectives to this project are how to use Taguchi method to determine the optimum parameters in spot welding. The analysis of the proposed to overcome the problem.

***Keywords**: Optimization, Resistance Spot Welding, Taguchi Method, Minitab, Anova, Current, Time, Pressure, Planning phase, Implementation phase, Analysis phase.*

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LIST OF TERMINOLOGIES

Planning Phase	:	Serve the information needed to support the experiment which are the data collection and analysis to get the appropriate result
Implementation Phase	:	Input the information data into statistical method, to implement the value untill get the result to analysis
Analysis Phase	:	After the experiment produce the output and result will be out, there will be analysis to proof the result correctly. And there will be reconfirmation the result of the experiment .
Taguchi	:	Optimization method to improve the quality product or process which aims to reduce the cost. This mehtod use simple orthogonal array and simple process to evaluation so can less time to conducted the experiment
Welding Machine	:	Combining two or more metal with combination of current, time, pressure and held with electoda welding gun
Signal to Noise Ratio	:	Transformation value of multiple data repetition that represent the quality characteristic of experimetn
Weld Nugget Diameter	:	Made of welding machine, when the both of electroda work to weld the sheets

CHAPTER I

INTRODUCTION

1.1 Problem Background

In this era, many companies and manufacturer wants good quality with the lower cost and maximum time. To get the good quality, the company provide the quality division to take care of product and check each product that ready to be send to customer, and also each processing making a product.

In quality division, many main task or jobdesk that have to handle. Each process, each part, each colour, each complains from other division. One of the most important process in quality process is welding. Welding is a process that joining two to four sheets.

Resistance Spot Welding (RSW) is part of welding process in which contacting metal surface points are joined by the heat obtained from resistance to electric current. The quality came from the nugget size, heat affected zone and joint strength. From the **Table 1.1** it show that the process didn't established because not find yet the optimal appropriate to run on spot welding. Because many thickness part are same, so need to conduct the optimization in order to seeing wether small ampere can produce optimum nugget diameter, because, with the higher ampere it take higher cost and this process affect with the quality that produce. Therefore, it is important to conduct optimization to determining the optimal parameter . (Unal, 1991)

Table 1.1 The Data of Welding Process

No	Process	Gun	Thickness Part		Weld Time	Current
1	Process A	G	0.65	1.2	20	8.1
2	Process B	H	0.65	1.2	20	8.2
3	Process C	I	0.65	1.2	20	8.0
4	Process D	J	0.65	1.2	23	7.3
5	Process E	K	0.65	1.2	23	7.0
6	process F	L	0.65	1.2	22	7.1

PT. Astra Daihatsu Motor is manufacturing company in automotive industry which produces car and part that can joining in automotive. The daily activities in making a car for mass production requires high quality and standarization so that the cost that requires is higher and become the important thing to consider.

According to Hidayat (2016) One of the optimization methods is by using design of experiment (DOE) and the operating parameters were optimized using taguchi method. Taguchi method have proved to be succesful and always used for companies and manufacturer to help them controlling the quality and performance.

1.2 Problem Statement

The problem statement is how to determine parameter setting in spot welding in order to equalize quality by taguchi method?

1.3 Objectives

The main objectives is to determining suitable parameter regarding spot welding using taguchi method in PT. Astra Daihatsu Motor.

1.4 Scope

Due to limited time and resourches to conduct this research, there will be some scopes in observation:

1. This project conducted from May to Agust 2019
2. This report focus on taguchi method
3. The parameter only Current, Time and Pressure

1.5 Assumptions

There are some assumption to be needed to support this project, the assumption can be shows below:

1. The dataset has been aproved by company
2. The data processing using minitab 19
3. No machine breakdown

1.6 Research Outline

Chapter I Introduction

This chapter consist of problem background, problem statement, research objectives, scopes, assumptions and research outline.

Chapter II Literature Study

This chapter is theoritical background that support the reasrcher in conducting report and project.

Chapter III Research Methodology

This chapter is flow of this process and the explanation in which this research to conduct this project untill finished

Chapter IV Company Profile

This chapter explains the profile of the company and project conducted by the researcher.

Chapter V Data Collection and Analysis

This chapter is process analysis from the data that already gave dan data collection obtain from research. This result are level and parameter will be explained.

Chapter VI Conclusion and Recommendation

This chapter will be answered the problem statement, contains the outcome of this research and provides suggestion for future.

CHAPTER II

LITERATURE STUDY

This chapter explain about the theoritical that used to support this research. This theoritical will be explained robust design in taguchi method. And also this chapter will be explained about the sequence ways that used to conducted the experiment.

2.1 Resistance Spot Welding

According to Thakur (2014) Resistance Spot Welding to joined metal. Combining tow or more metal with combination of current, pressure and time also helped electroda welding gun. The sheet is pressed together locally which has a current applied to the electrode. It must be remembered that this initial load produces a high contact voltage between the electrode and the workpiece. The illustrate of spot welding are shown in **Figure 2.1**.

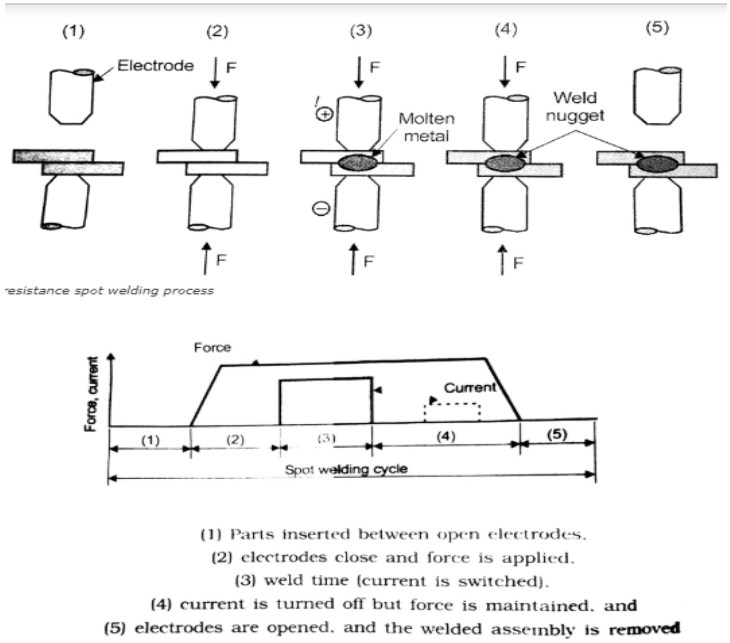

Figure 2.1 Part of Welding Process

Application of resistance spot welding:

a. It mostly used in automobile industry and to weld sheet metal for mostly.
b. In orthodontist`s clinic, small spot weld equipment used to resizing the metal “molar bands”.
c. The different metal and alloy steel, medium carbon and high carbon steels, low carbon steel can be welded

2.1.1 How Spot Welding Works

Spot welding is a method of welding two or more sheets of metal together using pressure and heat to the area to be welded. This process is used to combine sheet material and use electrodes to convey electric current through the workpiece (Thakur, 2014). sheets which are pressed together then melt, destroying the interface between the parts and the heated part can be in the form of "Nugget". Can be seen in **Figure 2.2**

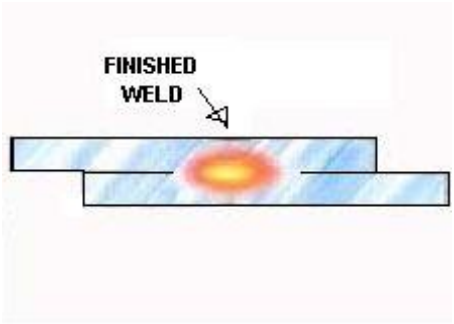

Figure 2.2 Weld Nugget of Spot Welding

Based on the table above to make the welding work copper electrodes pass an electric current through the workpiece. The heat generated depends on the electrical resistance and thermal conductivity of the metal, and the time when used. If everything matches the calculation, the goods produced will be of high qualityThe heat generated is expressed by the equation:

E=I2*R*t

where E is the heat energy,

I = the current,

R = the electrical resistance and

t = the time that the current is applied

2.2 Taguchi Method

According to Nalbant (2007) Taguchi method aims to improve the quality of products and processes. The method also aims to reduce costs and resources to a minimum. The Taguchi method uses a special matrix called the Orthogonanl Array (OA). This standard matrix is a step to determine the minimum number of experiments. The most important part of the Orthogonal Matrix lies in selecting the level combination of the input variables of each experiment.

The Taguchi method is off-line quality control which means preventive quality control, as a product or process design before arriving at production. Off-line quality control is carried out at the beginning of the life cycle product, namely repairs at the beginning to produce the product (to get right first time). Taguchi's contribution to quality is: (Genichi, 2013)

a. Loss Function: A. Loss Function: losses incurred by the public (producers and consumers) due to the quality produced.
b. Orthogonal Array: Orthogonal arrays are used to design efficient trials and are used to analyze experimental data. Orthogonal arrays are used to determine the number of minimal experiments that can provide as much information as possible of all the factors that affect the parameters.
c. Robustness: Minimizing system sensitivity to sources of variation

2.2.1 Signal to Noise Ratio

Signal to Noise Ratio used to determine in taguchi design to identify control factor that reduce variability in a process or product to minimize uncontrollable factors. because noise factors cannot be controlled during production or product use, but can be controlled during experimentation. Higher values of the signal to noise ratio (S/N) identify control factor settings that minimize the effects of the noise factors.

It is measures how the response varies relative to the nominal or target value under different noise conditions. Can choose from different signal-to-noise ratios,

depending on the goal of experiment. According to Taguchi, measurable quality characteristics can be divided into three categories: (Ghani, 1998)

2.2.1.1 The smaller-the-better

The smaller-the-better characteristic is one where the desired goal is to reduce the measured characteristic to zero. For example for porosity, vibration, car consumption, tool wear, surface roughness, response time to customer complaints.

2.2.1.2 The larger-the-better

The opposite of the lower-the-better is the greater-the-better characteristic. This is one where the ideal value is infinite. Applies to tensile strength, car mileage per gallon, engine efficiency, component life, corrosion resistance and others.

2.2.1.3 The nominal-the-better

Nominal-better-characteristics are the characteristics of the target value determined and the goal is minimal variability around the target. for example when measuring dimensions such as diameter, pan, thickness, width including pressure, area and etc.

2.2.2 Philosophy Taguchi Method

Taguchi philosophy Taguchi's quality philosophy can be summarized into seven principles as follows: (Nalbant, 2007)

a. Product loss causes people to think that the dimensions of product quality are important.
b. Continuous quality improvement and cost reduction are needed to maintain and improve competitiveness.
c. Quality improvement programs must be implemented to reduce various variations in product performance.
d. Customer losses are estimated to be proportional to the magnitude of the difference between actual performance and designed performance.

e. Quality and actual costs are determined by the amount of effort carried out in the engineering design and manufacturing process.
f. Performance variations can be reduced by using non-linear product impacts or performance process parameters.
g. Experiences can be used to identify the parameters of a product or process to enable the preparation of a statistical plan.

2.2.3 Strengths and Weaknesses of Taguchi Method

In every method for sure have strength and weaknesses to faced the problem. In the below shown strength and weaknesses of taguchi method. (Nalbant,2007)

2.2.3.1 Strengths of Taguchi Method

The strengths of taguchi method are :

1. Can reduce the number of trials carried out compared if using a full factorial trial, so it can save time and cost.
2. Can make observations of averages and variations in quality characteristics at once, so that the scope of problem solving is broader.
3. Can know the factors that influence the quality characteristics through the calculation of ANOVA and S / N ratio, so that these influential factors can be given special attention.

2.2.3.2 Weaknesses of Taguchi Method

From the use of the Taguchi method, if the experiment is carried out with many factors and interactions will intermingle some interactions by the main factors. As a result, the accuracy of the experimental results will be reduced, if the interaction is ignored indeed really influence the characteristics observed.

2.2.4 Taguchi Role for Manufacturing

Taguchi realized that the best opportunity was to design a product and its process itself. Consequently, a developed strategy for quality engineering that can be used in both contexts. The process has three stages: (Roy, 1990)

2.2.4.1 System Design

This stage is an effort where new concepts, ideas, methods and others are raised to bring up a product. This is the first stage in design and conceptual.

2.2.4.2 Design Parameters

This stage is a statistical experiment. The aim is to identify parameter settings that will provide an average performance on the target

2.2.4.3 Tolerance Design

Determination of tolerance of parameters related to losses to the community due to product deviation from the target. this stage tightens tolerance to parameters to reduce variability.

2.2.5 Procedure of Taguchi

This phase is divided into three phases which are finished discussing experimental. These three phases are the planning phase, the implementation phase, and the analysis phase. Planning phase is the phase to provide the expected information. The choice of factors and levels is chosen, and therefore is an important step in the experiment. The second phase is the implementation phase, a compilation of experimental results has been obtained. If done well, the analysis will be easier. Phase Analysis is positive or negative information related to the selected factors and levels generated based on the previous two phases. The main steps for completing an effective experimental design are as follows (Unal, 1991):

a. Problem formulation: Problem formulation must be specific and clearly defined.
b. The purpose of the experiment: The objective on which the experiment is based must be able to answer what has been agreed in the formulation problem
c. selecting quality characteristics: Non-independent variables are variables whose changes depend on other variables.
d. Selecting factors that affect quality characteristics: Independent variables (factors) are variables whose changes do not depend on other variables. Factors to be investigated will affect the dependent variable.

e. Identification of controlled and uncontrolled factors: In the Taguchi method, these factors need to be considered because there are differences between the two factors.
f. Level of determination of the level and value of the factor: Selection of the number of levels important for the accuracy of the results of the experiment and the cost of conducting the experiment.
g. Identification of interactions between Control Factors: Interactions that appear compilation of two or more factors that enhance joint evaluation will produce higher results on related characteristics.
h. Degrees of freedom (dof): Calculation of degrees of freedom is done to calculate the minimum number of experiments.
i. Select Orthogonal Array (OA): Consider the number of levels and factors.
j. Experiment Preparation and Implementation: Experiment preparation includes determining the amount of experimental replication and randomizing the experiment.
k. Number of Replication: Replication is a repeat of the same treatment in an experiment with the same conditions to get higher accuracy.

l. Data Analysis: In the analysis carried out data collection and data processing in order to produce an appropriate calculation.
m. Interpretation of Results: steps taken after the experiment and analysis are carried out. The interpretation made includes calculating the percentage of contributions.
n. Experiment Confirmation: Confirmation experiments are experiments conducted to check the conclusions obtained. The purpose of the confirmation trial is to verify the desired results.

2.3 Minitab

Minitab is one of the many statistical application programs used to simplify statistical data processing. Minitab has been recognized as a very strong statistical program with a high level of statistical assessment. Minitab has a programming language known as Minitab macros. In the discussion section the operator,

looping, control statement and data type are explained as a basis for advanced programming.

Minitab also provides some data processing for conducting regression analysis, making ANOVA, making statistical quality control tools, making experimental designs (factorial, response surface and taguchi) making forecasting with time series analysis, reliability analysis, and multi analysis (Abdul, 2011)

2.4 ANOVA

According Martin G (2008) Anova is a statistical analysis in a response variable between groups. The aim of Anova to test equality means by comparing variance among groups relative to wrandom groups. Anova was discovered and introduced by a statistician named Ronald Fisher.

Anova stands for Analysis of variance. Anova is also used as an analysis tool to test research hypotheses which assess whether there are average differences between groups.

2.4.1 ANOVA Interpretation

Anova is used to interpret data derived from regression and residual models. In simple terms, it can test the differences of more than two groups. The following is the output that will be released by ANOVA:

a. F-Value: Analysis is the value of the F test or F alpha. Value F Calculate this which will be compared with the values in table f. If the value of f alpha is more than f table, then it can be concluded that accepting H1 and rejecting H0
b. P-value: Show the value of probabilitas, how much value extrim that found. Based on the sampling distribution of F-values under the null hypothesis, P > 0.05 significat, Ho accepted.
c. MS (Mean of Square) is represent an estimate of population variance. It is calculated by dividing the corresponding sum of squares by the degrees of freedom.
d. The adjusted MS is calculated by dividing the number of squares adjusted for degrees of freedom.

e. SS (Number of Squares) is a measure of variation or deviation from the average. Calculation of total squares considers the sum of squares of factors and of randomness or error.
f. The adjusted SS does not depend on the order factors entered into the model.
g. Delta is the difference between the largest value to the smallest value.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research Flowchart

The following diagram illustrates the research methodology of this research are shown in **Figure 3.1.**

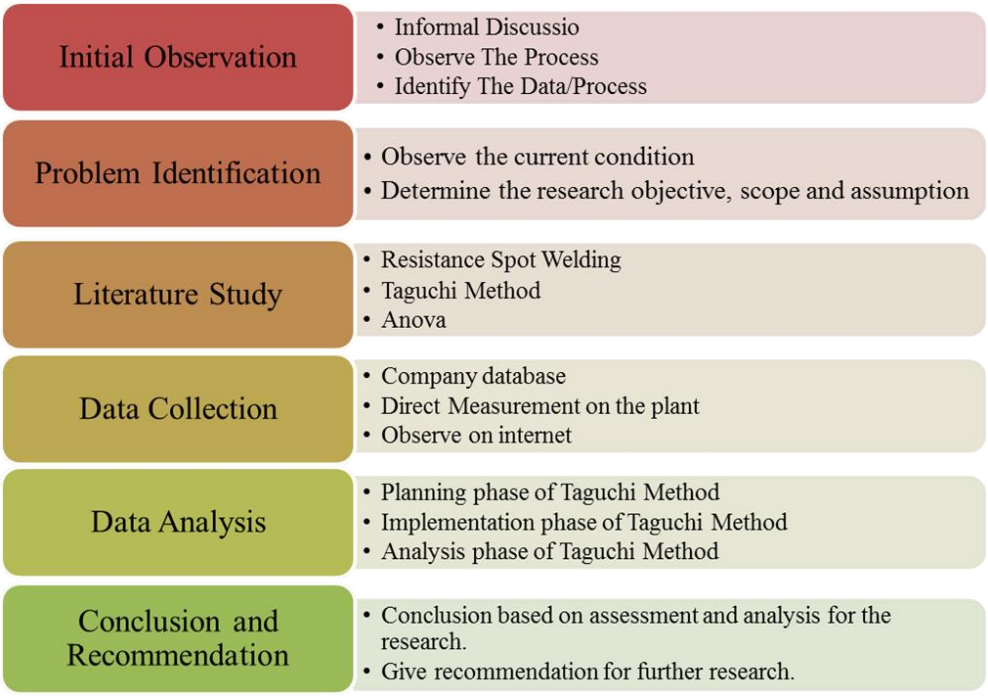

Figure 3.1 Research Flowchart

From figure above, it can be seen the first step is do the observation. In doing the observation, the researcher can know the first thing to do for the experiment. After that, identiying the problem, from that can found and identify the data for experiment. Next, find the literature as references. Then, the researcher will collect the necessary data. After that, analyze the problems as the indicator needed. The last step, the researcher give the conclusion based on analysis and give recomendation for further research.

3.1.1 Initial Observation

The observation is started from informal discussion to know the first process that have to do. After already know the procedure, so we do the observation to

know the process and taking data. Thus, the initial observation is conducted in order to get the data to determining level and parameter and analyst in minitab. There will be some another informal discussion with the Body Quality Control, Supervisor and Mentor to discuss about the data.

3.1.2 Problem Identified

The problem identified starts by seeing the datase is not arranged well. There are some inspection or issue about data processing so that the to determining the parameter and level to run order is postponed. Thus, this research will be conducted in order to finding the level and parameter to run order using taguchi method with suitable parameter.

3.1.3 Literature Study

In order to good arrange in data processing with good input and output also. This research supported by several information as a references. The literature study is from journal and e-book. The importance of study is also established to provide a strong basic for the research. The literature study is about:

1. Resistance Spot Welding
2. Taguchi Method
3. Minitab Software
4. ANOVA

3.1.4 Data Collection

There are several dataset to be collected to supported this experiment. The data would be collect through several activities and method, which are:

1. Data Base of Company. The data is needed in order to do the analysis. The data of process will be putted in the checksheet, will be taken from the company database.
2. Direct Measurement. There will be direct measurement on the plant, in order to take the detail and know the data processing. This data is very important to support the analysis of the research.

3. Survey on the Internet. There will be some survey on the internet, in order to know the what kind of data needed and the procedure to generate it.

3.1.5 Data Analysis

After the data is collected, there will be analysis that support the researcher to achive the objectives of research. The analysis can be seen as below:

1. Planning phase of taguchi method
2. Implementation phase of taguchi method
3. Analysis phase of taguchi method

3.1.6 Conclusion and Recommendation

The conclusion will be state based on the result form the analysis as the answer of the research objectives. And for recommendation as for future research.

3.2 Research Framework

This research framework is done by planning and studying the activities to conduct this research. Star from defining the objectives, identify the factors, determining level and parameter. After that the data has been collected, the data will be analyzed and data processing will be generated. If the data not correct, the data come back to fix start from collect the data, perhaps there will be wrong process or value, if correct, the data can be assesed and can make the conclusion and objective will be achieved.

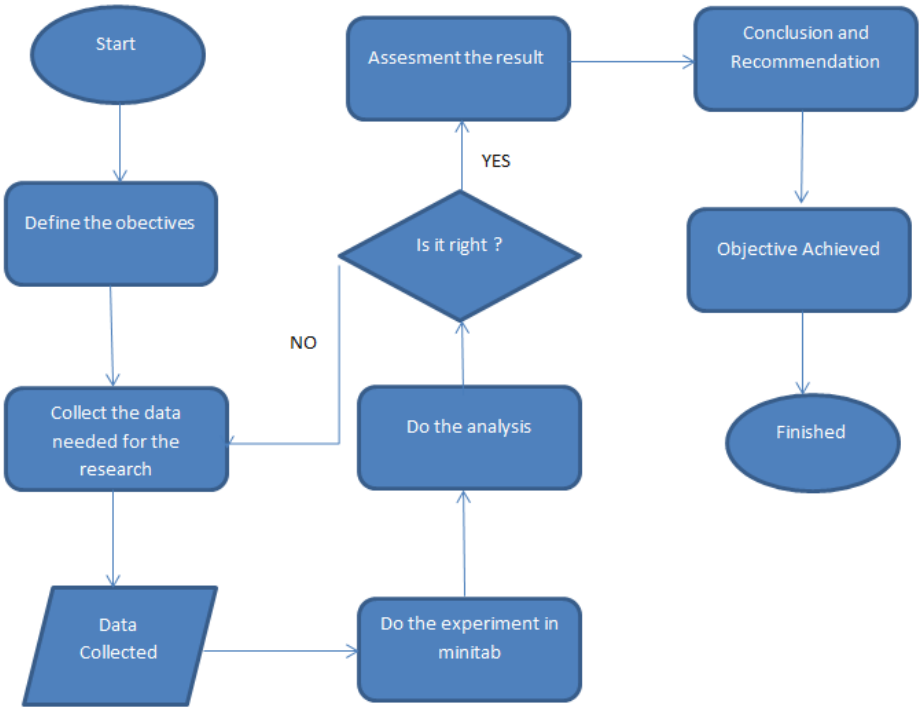

Figure 3.2 Flowchart of Data Processing

Based on figure above show how to run the experiment from taking data. On other hand, there will be differerent sequence but almost similar process. **Figure 3.3** explain the begin process from Body Quality Control Departement to conduct this experiment, to consider some things to be develop and run.

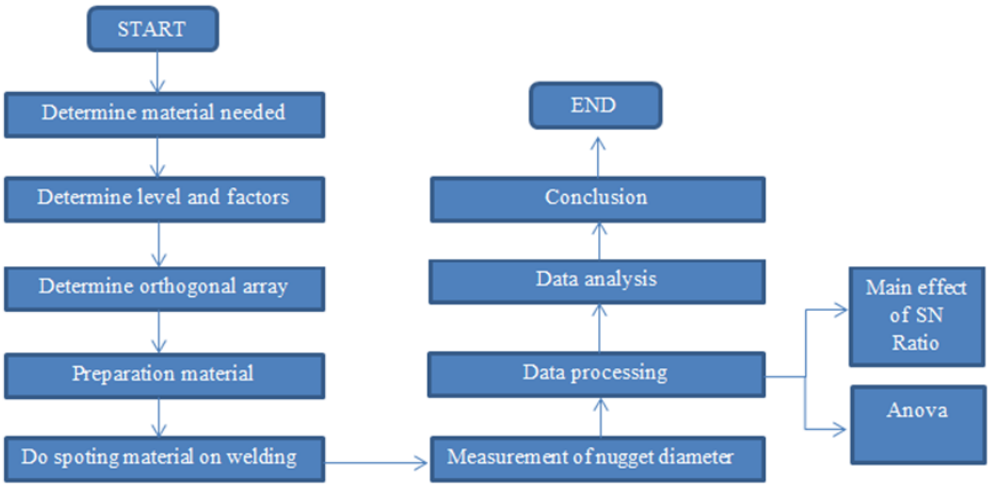

Figure 3.3 Flowchart of optimization

Based on figure above show the sequence of optimization start from determine the material needed, to know the standarization of material in order

to conduct the experiment, as well, to know the parameter that influence based on experiment. After that, can directly determine level and factors. Then input the level and factor into minitab or system, so that can know the orthogonal array or run order. If already know run order, can directly prepare the material needed, and next to spoting material on resistance spot welding. In to take sample part, better to take minimum five times in order to data accurately. After take the sample have to measuring the sample through calculate sn ratio. Then, if the value already got,next to data processing within minitab and divided into two categories data processing , such as, mean effect of sn ratio and analysis of variance to get the information needed. And directly to data analysis. After experiment is complete make conclusion and experiment is finish.

CHAPTER IV

COMPANY PROFILE

4.1 Company Profile

The historical and culture of company can explain in this chapter. Start from backgorund, the products, system that used, culture and organizational structure can explain in below.

4.1.1 History of the Company

PT. Astra Daihatsu Motor is a company engaged in the automotive field, which is manufacturing cars with the daihatsu brand. Establishment in Indonesia is inseparable from the role of Daihatsu Motor Center (DMC) Co., Ltd. which was established in Osaka, Japan in 1907. Until now the DMC is still the parent company and the largest shareholder of PT. Astra Daihatsu Motor.

In 1973, PT. Astra Daihatsu motor became the foundation of its establishment, the company obtained the authorization to import Daihatsu vehicles to Indonesia. Three years later, PT. Astra International was appointed as agent, importer and distributor of Daihatsu vehicles in Indonesia. Then in 1992, Astra Indonesia was established through the merger of 3 companies namely PT. Astra Daihatsu Motor, PT. Toyota Motor and PT. Astra International.

With its new slogan, "Innovation for Tommorow", PT. Astra Indonesia is committed to always realizing innovation by producing high-quality products that can benefit the wider community and be environmentally friendly. PT. Astra Indonesia has a vision of being No. 1 in the compact car market in Indonesia and as the main global production base for the Astra Daihatsu / Toyota Group which is the same as the Japanese factory quality standards that moved them to produce the best value compact cars and provide related services that are important for increasing stakeholder value and environmentally friendly and developing inspire their employees to achieve world-class performance.

4.1.2 Vision and Mission of the Company

Vision and mission can be stated below.

4.1.2.1 Vision

The vision is become No. 1 in the compact car market in Indonesia and as the main global production base for the Daihatsu / Toyota Group which is the same as the Japanese factory quality standards

4.1.2.2 Mission

There are two mission in PT. Astra Daihatsu Motor :

a. To produce the best value compact cars and provide related services that are important for increasing stakeholder value and being environmentally friendly
b. To develop and inspire employees to achieve world-class performance

4.1.3 Company Production Facility Layout

PT.XYZ has a head office and plant in order to support the company activities and built on the same location. On the plat divided into nine gate and production training center. The office and plant of the company can be seen in **Figure 4.1**.

Figure 4.1 Red Office and Head Office

Based on figure above shows the three office on the location which are head office located in Jl. Gaya Motor III No. 5 (Sunter), Jakarta Utara DKI Jakarta 14330 Indonesia, the training center in Jl. Gaya Motor Barat No.8, RW.4, RW.4, Sungai Bambu, Tj. Priok, Kota Jkt Utara, Daerah Khusus Ibukota Jakarta 14330, and assy plant in Jl. Gaya Motor Barat No.3, RT.6/RW.4, Sungai Bambu, Tj. Priok, Kota Jkt Utara, Daerah Khusus Ibukota Jakarta 14330.

4.1.4 Company Production System and Products

This stage show the system of company that do in dailty activity and products that produces.

4.1.4.1 Kaizen Concept

PT. Astra Daihatsu Motor use kaizen to increase productivitas. In japanese language, Kaizen means continuous improvement. That means the improvement concern with all staff, manager and employee and consist of cost in infinity amount. Kaizen consist of two world kanji such as (kai) means changing and (zen) means kindness. This concept below concern to get the better process, how the way to make something better than before.

a. Concept 3M (Muda, Mura dan Muri)

b. 5S (Seiri, Seiton, Seiso, Seiketsu dan Shitsuke)

c. Concept PDCA (Plan, Do, Check, Action)

d. Concept 5W1H

4.1.4.2 Morning Exercise

Clock begin at 7:15 a.m. but it is required for all employees to arrive at 07:05 because the morning exercise bell will ring. For the first, there will be an astra song and continued with morning exercise, until 7:15. If, there are those who are unable to take part in morning exercise, they are obliged to report to the supervisor who is authorized.

4.1.4.3 Briefing Every Morning

After Morning Exercise, continue with gathering together. Make a circle for one division. Opened with a moderator to pray together. Routine every day is done, then continue to discuss issues outside of work, then discuss the problem of work or just sharing information.

4.1.4.4 I-Care

After conducting the morning briefing, there will be where staff will take I-Care readings in sequence and provide examples. If when one staff member has read I-Care along with an example, other staff can provide an example for the concerned I-Care. The I-Care can be seen in **Figure 4.2.**

Figure 4.2 I-Care of Astra Daihatsu Motor

4.1.4.5 Products

There are several products that are produced by the company everyday, can be called as mass production. Every car can be shown on **Table 4.1**.

Table 4.1 List of Company Products

Product
Daihatsu Ayla
Daihatsu Grandmax PU
Daihatsu Terios
Daihatsu Xenia
Daihatsu Sigra
Daihatsu Grandmax MB
Daihatsu Taruna
Daihatsu Espass
Daihatsu Feroza
Daihatsu Luxio
Daihatsu Taft
Daihatsu Sirion
Daihatsu Charade
Daihatsu Zebra
Daihatsu Grandmax BV
Daihatsu Rocky

Daihatsu Hi-max
Daihatsu Copen
Daihatsu Hijet
Daihatsu Ceria

Figure 4.3 Example of Product Astra Daihatsu Motor

Based on figure above show some product that produce in PT. Astra Daihatsu Motor, the kind of famous car in daihatsu. Some product to be sent to overseas for sell it. The product make with consider about quality and safety.

4.2 Organizational Structure

The organizational structure located only at sunter assembly based on quality assurance division. The organizational shows structural that used for PT. Astra Daihatsu Motor to conducting the production and each task. The organizational structure can be seen in **Figure 4.4**

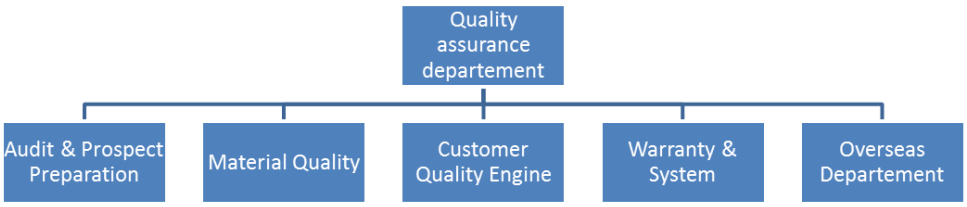

Figure 4.4 Quality Assurance Organizational Chart

PT. Astra Daihatsu Motor has several departement in quality division. Quality division divided into some departement such as Audit & Prospect Preparation, Material Engineering, Customer Quality Engine, Wuarranty & System and Overseas Departement. In this report focused on Quality Assurance Departement.

CHAPTER V

DATA COLLECTION AND ANALYSIS

5.1 Planning Phase of Taguchi Method

Planning phase is the first important phase from the experiment for serve the information needed. This phase is start from preparation untill the factor and level to be record. Therefore, this is the important thing in experiment.

5.1.1 Material

In this phase, material is needed to know about the standar that will be used in experiment and the object to determine the parameter and level. The process part process B with normal parameter are weld time is 20, current is 8.2 and pressure is 3800. Also for the size of electroda is 16ml with kind of GKDT (oval). In this experiment the sample part can be seen in **Figure 5.1**, the material that I used are:

1. SCGA (Steel Cold Galpanese Alloy) t: 1,2 mm
2. SPCC (Steel Plate Cold Coiled) t: 0,65 mm

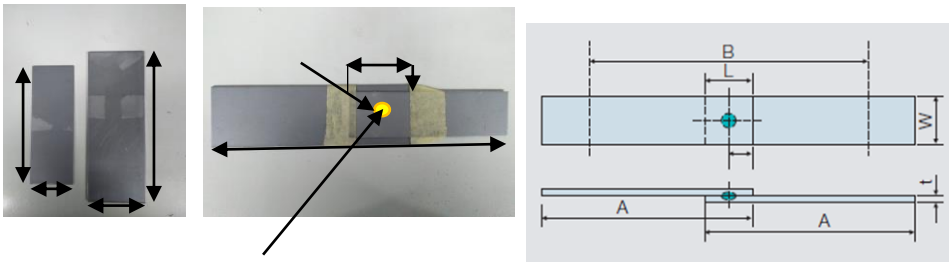

Figure 5.1 Actual Sample Material

And every material has standarization that refers to JIS(Jepang International Standard) G 3136, to know the standard efficient for each material. The standarization can be seen in **Table 5.1**

Table 5.1 Standard of material

Nominal thickness (t)	Width (W)	Lap allowance (L)	Test specimen length (A)	Distance between clamps (B)
0.3 ≤t<0.8	20	20	75	70
0.8≤t<1.3	30	30	100	90
1.3≤t<2.5	40	40	125	100
2.5≤t<5.0	50	50	150	110

Based on table above, it can be seen the standart material, this categorize tend to material that has the thickness and then have following the standar consist of Width, Lap Allowance, Test Specimen Lenght and Distance Between Length.

5.1.2 Determine Level and Parameter

In Taguchi Method, choose the Level is important to effeciency the experiment. More level to be found, the experimental results will be more accurate because more data will be obtained. To choosing the value start from seeing the low value from **Table 1.1** which below average to prove it is there possible to produce optimum number. And can next to find level and parameter in **Table 5.2** and **Table 5.3**

Table 5.2 Level and Parameter of Tensile Test

No	Parameter	Level		
		1	2	3
1	Current (kA)	7.0	7.1	7.2
2	Duration (cycle)	21	22	23
3	Pressure (kN)	3000	3300	3600

Table 5.3 Level and Parameter of Weld Nugget Diameter

No	Parameter	Level		
		1	2	3
1	Current (kA)	7.2	7.3	7.4
2	Duration (cycle)	21	22	23
3	Pressure (kN)	3500	3800	4100

Based on the **Table 5.2** and **Table 5.3**, resistance spot welding have three parameter when it working which are current, welding time and pressure. And also decided become 3 level for each parameter to using in experiment.

5.1.3 Determine Orthogonal Array

Orthogonal arrays are used to determine the number of minimal experiments that can provide as much information as possible of all the factors that affect the parameters. The most important part of orthogonal arrays lies in selecting the combination of levels from the input variables for each experiment. The orthogonal array are shown in **Table 5.4** and **Table 5.5**.

Table 5.4 Run Order of Tensile Test

Run Order	Current	Duration	Pressure
1	7.0	21	3000
2	7.0	22	3300
3	7.0	23	3600
4	7.1	21	3300
5	7.1	22	3600
6	7.1	23	3000
7	7.2	21	3600
8	7.2	22	3000
9	7.2	23	3300

Run Order	Current	Duration	Pressure
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 5.5 Run Order of Weld Nugget Diameter

Run Order	Current	Duration	Pressure
1	7.2	21	3500
2	7.2	22	3800
3	7.2	23	4100
4	7.3	21	3800
5	7.3	22	4100
6	7.3	23	3500
7	7.4	21	4100

Run Order	Current	Duration	Pressure
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3

8	7.4	22	3500	8	3	2	1
9	7.4	23	3800	9	3	3	2

From **Table 5.4** and **Table 5.5** above show the run order that already get in minitab, this run order use to take sample spot in welding process to the next processing. The sample that already got as sample to determine optimum value for tensile test and weld nugget diameter.

5.1.4 Calculating Material

For this experment, optimization conduct two experiment, first for tensile test and secon for weld nugget. The some information is the same and for the differences is how get the great value of test itself.

5.1.4.1 Calculation of Tensile Test

After the sample to be find, there will be measurement for Tensile test before calculate the weld nugget. The trial for tensile test doing three times so that the value that we get to be accurate. The sample can be show in **Figure 5.2**

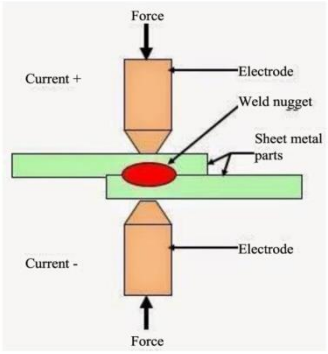

Figure 5.2 Resistance Spot Welding

Based on figure above, explain that the material is in the middle of the electrode for welding, the weld is in a round shape called a diameter nugget. Machine settings must be in accordance with the run order and the results that have been determined in order to produce goods that match the standardization. Flow and time are set with a Teaching Pendant and Regulator to determine the appropriate pressure.

Figure 5.3 Tensile Machine

It can be seen from figure above, the machine tensile has two mouth to clamp the material. Then if ready, the material will be operate in computer system and tensile machine will be move to pull over.

Table 5.6 Calculation Trial of Tensile Test

Run Order	Current	Time	Pressure	Trial-1	Trial-2	Trial-3
1	7	21	3000	2400	3200	4100
2	7	22	3300	3371	3455	3195
3	7	23	3600	3355	3446	3442
4	7.1	21	3300	3230	3231	3290
5	7.1	22	3600	3468	3471	3478
6	7.1	23	3000	3246	3151	4011
7	7.2	21	3600	3398	3293	3376
8	7.2	22	3000	3248	3173	3257
9	7.2	23	3300	3198	4230	3199

Based on the table above, it show the value from calculation of tensile test. There are three trial because the sample needed are three. This calculation take from the tensile machine and sofware system and when done the output value will out.

5.1.4.2 Calculation of Weld Nugget

To calculating weld nugget, need nine process to know the value and identify in digital microscope and the process have to right way to get the nugget diameter appear in the system. The process are:

a. Bandsaw

This step to cutting the sample part to be little part, and the part that to be cutted only part near diameter nugget.

b. Cutting Grinding

This process to splitting nugget diameter become two part with grinding. When machine work to cut, there is cool liquid to help the part not burning.

c. Mounting Press

The main idea for the mounting press is to unify small sample part for obtain flatness. This process help nugget diameter to be seen and also need

d. Grinding

This function is to subtilize sample part. The hardness is when the nugget diameter do not appear, the part must be continuesly smoothed but carefully, the part can be thin or empty so that when doing another process will be fail.

e. Sanding Speciment

This process to make part become smooth, there are three layer start from the roughest to the most smooth.

f. Polishing Machine

This objective to polishing the material with alumina liquid and wet sanding using water.

g. Drier

The function is to dry the part after doing wet process.

h. Etching

To desiccate sample part. Basically, this procces using slove , but slove broken since been a long time. The procces around one hour.

i. Digital Microscope

This objective to see the value of nugget diamater and penetran, also give the picture clearly regard diameter of weld nugget. From picture can see good or bad the

diameter, if there any broken surface can be analysis. After the last process already conducted, the number of trial will be out.

After that, if already following the existing way to determine nugget diameter, can directly to do the trial of nugget diamater. Can be show in **Table 5.7**

Table 5.7 Calculation Trial of Weld Nugget Diameter

Run Order	Current	Time	Pressure	Trial-1	Trial-2	Trial-3	Trial-4	Trial-5
1	7.2	21	3500	4.87	4.89	5.52	5.03	5.26
2	7.2	22	3800	3.87	3.62	5.15	5.06	4.85
3	7.2	23	4100	4.73	4.72	4.51	4.15	4.88
4	7.3	21	3800	4.11	5.06	4.94	4.63	5.17
5	7.3	22	4100	4.69	4.4	4.71	4.86	3.92
6	7.3	23	3500	4.35	5.25	5.25	4.99	4.82
7	7.4	21	4100	4.8	4.86	4.94	5.68	4.84
8	7.4	22	3500	3.81	4.45	3.95	4.27	3.77
9	7.4	23	3800	5.18	5.3	3.28	3.91	3.46

Based on table above, it can be seen from the microscope, the value will appear when process cutting check doing already. One pallet one diameter, and after that continue to the calculatinng SN Ratio and choose three number are similir or not much different.

5.1.5 Signal to Noise Ratio

Signal to noise ratio is used to eliminate factors whose interactions are not significant. And it is used to select the factors that have contributed to the reduction in the variance of a response. The signal to Noise Ratio use Larger the Better. In this section divided into 2 categories, first for tensile test and second for nugget diameter. Can be seen in **Table 5.8** and **Table 5.9**

Table 5.8 Calculation SN Ratio of Tensile Test

Experiment	**SNL= -10 log** $\left(\frac{1}{n}\sum_{i=1}^{n} 1/Y_i^2\right)$	**Result**
Ke-1	-10 log (1/2400² + 1/3300² + 1/4100²)	64.80
Ke-2	-10 log (1/3371² + 1/3455² + 1/3195²)	65.69

Ke-3	-10 log (1/3355² + 1/3446² + 1/3442²)	65.89
Ke-4	-10 log (1/3230² + 1/3231² + 1/3290²)	65.46
Ke-5	-10 log (1/3468² + 1/3471² + 1/3478²)	66.04
Ke-6	-10 log (1/3246² + 1/3151² + 1/4011²)	65.88
Ke-7	-10 log (1/3398² + 1/3293² + 1/3376²)	65.74
Ke-8	-10 log (1/3248² + 1/3173² + 1/3257²)	65.40
Ke-9	-10 log (1/3198² + 1/4230² + 1/3198²)	65.99

Based on table above, it shows how to calculate the experiment to know the value of signal to noise ratio for weld nugget. If there are three trial, then the calculation for Y (experiment data) will be additional from other untill the last trial.

Table 5.9 Signal to Noise Ratio of Weld Nugget Diameter

Experiment	**SNL= -10 log $\left(\frac{1}{n}\sum_{i=1}^{n} 1/Y_i^2\right)$**	**Result**
Ke-1	-10 log (1/4.87² + 1/4.89² + 1/5.03²)	9.083
Ke-2	-10 log (1/5.15² + 1/5.06² + 1/4.85²)	9.234
Ke-3	-10 log (1/4.73² + 1/4.72² + 1/4.88²)	8.802
Ke-4	-10 log (1/5.06² +1/4.94² + 1/5.17²)	9.301
Ke-5	-10 log (1/4.69² + 1/4.71² + 1/4.86²)	8.765
Ke-6	-10 log (1/5.25² + 1/5.25² + 1/4.99²)	9.47
Ke-7	-10 log (1/4.80² + 1/4.86² + 1/4.84²)	8.963
Ke-8	-10 log (1/3.81² + 1/3.95² + 1/3.77²)	6.917
Ke-9	-10 log (1/3.28² + 1/3.91² + 1/3.46²)	6.163

5.2 Implementation Phase of Taguchi Method

The second important phase is implementation phase, when already got the result of experiment. When the experiment to be success, the analysis will be easy and got the positive result about factor and level.

5.2.1 Minitab Software

Minitab is the tools tha designed to do statistical processing. Minitab combines the ease of use like Microsoft Excel with its ability to carry out complex statistical analyzes. Minitab in this experiment help to determine SN Ratios or Diagram Main Effect. SN Ratios is to show the quality of connectivitas. If the number higher is more better.

For this experiment, doing twice analysis with different proceess. First, for tensile test and second for the weld nugget diameter. Both of process doing saparated because different value but hopefully the same result.

5.2.1.1 Tensile Test

First process is tensile test. To doing analysis in minitab there will be sequence way that is open Mintab (already find OA) > Stat > DOE > Taguchi > Analysis Taguchi Design. After that put the S/N Ratios to the analysis and the output will be show the result in **Table 5.10**

Table 5.10 Response Table for Signal to Noise Ratios

Level	Current	Duration	Pressure
1	36.32	36.3	36.31
2	36.36	36.35	36.35
3	36.35	36.38	36.38
Delta	0.04	0.08	0.07
Rank	3	1	2

Based on figure above show the output from response for signal to noise ratio. It show that the first rank is time because delta is higher than other which is 0.08 , next the second rank is pressure delta is 0.07 and last Rank is current has value 0.04. and there is plot of main effect show in **Figure 5.4**

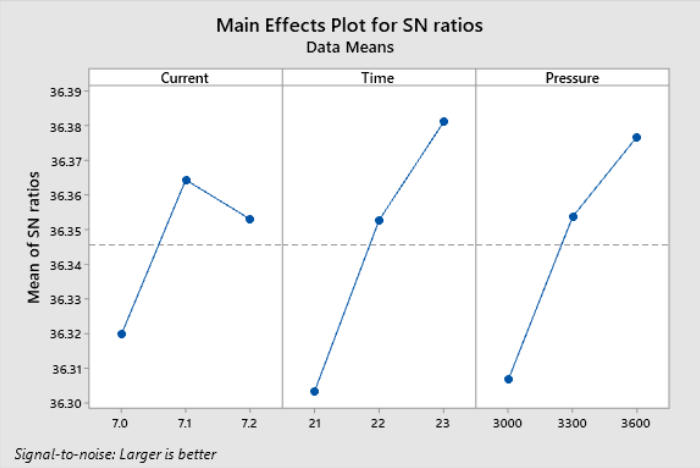

Figure 5.4 Main Effects Plot

Based on figure above, it show the best value for each parameter. For Current the value is 7.1 kiloAmpere, for second parameter is 23 cycle and last parameter is 3600 kiloNewton.

5.2.1.2 Weld Nugget Diameter

Second proceess is cutting check for nugget diameter. The process take a longer time because have to wait or retake the process if the nugget do not appear. And the sequence way is the same with tensile test. Open Mintab (already find OA) > Stat > DOE > Taguchi > Analysis Taguchi Design. After that put the S/N Ratios to the analysis and the output will be show the result, can be seen in **Table 5.11**

Table 5.11 Main Effect of SN Ratio Weld Nugget Diameter

Level	Current	Duration	Pressure
1	19.12	19.18	18.5
2	19.25	18.32	18.16
3	17.2	18.07	18.92
Delta	2.05	1.11	0.76
Rank	1	2	3

From **Table 5.11** can be seen, it shows the character of S/N Ratio used in this paper is the larger the better. Therefore, the greater the delta value of a parameter is the better. The optimum conditions on this approach obtained by sorting the delta in an order of significantly affecting the process. The higher the delta value

signifies the more effect its parameter contributes. And it can be concluded that the significant factors depend on analysis taguchi design according to S/N Ratio is Current with delta 2.05.

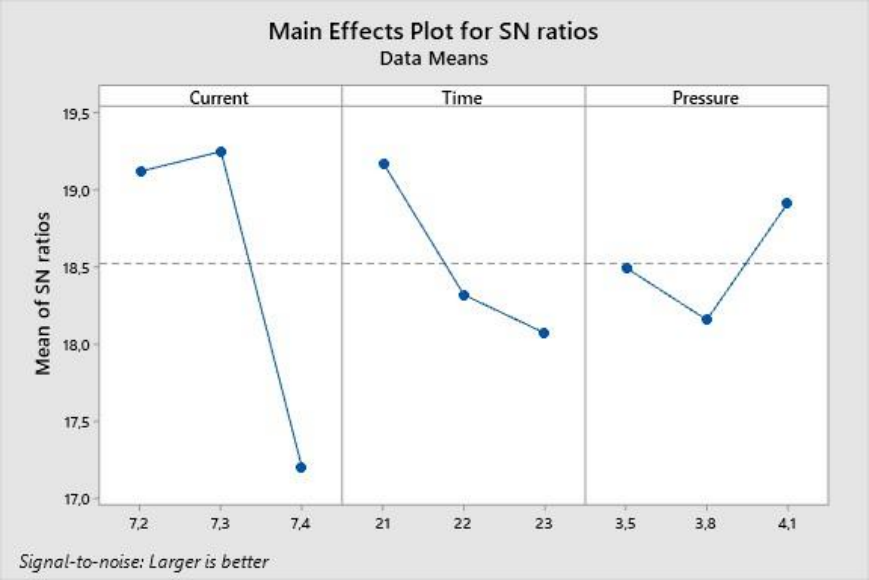

Figure 5.5 Main Effects Plot of Weld Nugget Diameter

The highest plots of each parameter were chosen as could be seen in **Figure 5.5**, with the reason that the ratio set was the larger the better. The same optimum conditions could be seen in **Table 5.11** by the delta values therefore, the optimum conditions obtained by this approach are as follows: Current, Duration and Pressure.

5.2.2 ANOVA

Anova is used as an analytical tool to test the research hypothesis which assesses whether there are average differences between groups. What will be sought in the ANOVA are as follows to determine sum of square, mean of square, f-value and p-value and can be show in **Table 5.12**

Based on **Table 5.12**, it show the value from Anova which is fit general linear model with the respon is SN Ratio and factors which are current, duration and pressure. If the data are complete, can directly calculate %Contribution can be seen in **Table 5.13** and **Table 5.15**. Then can determine the rank for know which parameter can much affect. And can be concluded that time is significant factor that much influence tensile test.

Table 5.12 Analysis Variance of Tensile

Source	DF	Adj SS	Adj MS	F-Value	P-Value	%C	Rank
Current	2	0.18056	0.09028	2.95	0.253	9.87%	3
Duration	2	0.53016	0.26508	8.67	0.103	38.79%	1
Pressure	2	0.43696	0.21848	7.14	0.123	31.08%	2
Error	2	0.06116	0.03058			20.26%	
Total	8	1.20882				100.00%	

For test the hypotheses of the signficance of main effect and interaction. Ho rejected states that there is no main effect or interaction and Ho accepted if there is main effect or interaction of the respond. If P-values more than ($\alpha = 0{,}05$) or Fvalue < Fα , so Ho accepted. Based on table above P-value is $0.252 > \alpha = 0{,}05$ or $2.95 < 19.00$, it means Ho is accepted because the main effect or interaction is affected, as well as on F-value, current is more significant because more than ($\alpha = 0{,}05$). So, depend on **Table 5.12** states that current, duration and pressure are affected to the respond.

Table 5.13 Calculation of %C

	Current	Duration	Pressure
SS'	0.1194	0.469	0.3758
%C	9.877401	38.79817	31.08817
Rank	3	1	2

Based on table above, it show that calculation of percent contribution which will determine which factors are most influential for each experiment. The biggest percent contribution will be the first choice. And the following percent will be next choice that will influence the factors. And the the second experiment, the reseult will be shown in **Table 5.14**.

Based on table below, it show the value from Anova which is fit general linear model with the respon is SN Ratio and factors which are current, duration and pressure. If the data are complete, can directly calculate %Contribution and

then can determine the rank for know which parameter can much affect. And can be concluded that based on the percent contribution,current is significant factor that much influence in weld nugget diameter.

Table 5.14 Analysis Variance of weld nugget

Source	DF	Adj SS	Adj MS	F-Value	P-Value	%C	Rank
Current	2	6.3647	3.1823	2.74	0.267	68.971%	1
Duration	2	1.5591	0.7795	0.67	0.598	12.039%	2
Pressure	2	0.5319	0.266	0.23	0.813	9.104%	3
Error	2	2.3197	1.160			8.28%	
Total	8	10.7754				100%	

And based on test the hypotheses of the signficance of main effect and interaction. Ho rejected states that there is no main effect or interaction and Ho accepted if there is main effect or interaction of the respond. If P-values more than ($\alpha = 0,05$) or Fvalue < Fα , so Ho accepted. Then based on table above that P-value is $0.267 > \alpha = 0,05$ or $2.74 < 19.00$, it means Ho is accepted because the main effect or interaction is affected and depend on **Table 5.14** states that current, duration and pressure are affected to the respond, as well as on F-value, current is more significant because more than ($\alpha = 0,05$).

Table 5.15 Calculation %Contribution of Weld Nugget

	Current	Duration	Pressure
SS'	5.8341921	1.01841	7.70165E-07
P	68.971861	12.0396	9.10489E-06

From the table above are shown percent contribution for each factors. The biggest percent contribution will be the first choice. And the following percent will be next choice that will influence the factors.

5.3 Analysis Phase of Taguchi Method

This analysis phase is when the positive and negative information related factor and level that have been choose based on two phase before. This analysis is the last important thing which the reseacher will be get the positive result.

5.3.1 Confirmation

In this stage, to make the recapitulation of result. The recapitulation are shown below.This result show the the value that already found which show the significant value are mantioned.

Table 5.16 The Result of Taguchi Method

	No	Parameter	SN Ratio	ANOVA SNR	Parameter Value
Tensile Test	1	Current	3	3	7.1
	2	Duration	1	1	23
	3	Pressure	2	2	3.6
	No	Parameter	SN Ratio	ANOVA SNR	Parameter Value
Weld Nugget	1	Current	1	1	7.3
	2	Duration	2	2	21
	3	Pressure	3	3	4.1

Based on table above, it show the significant faktor for each experiment from SN Ratio mean effect and anova that calculate persen contribution. For the tensile experiment it can be concluded that the significant factor is duration, and, for the weld nugget is current. The optimum value of each test depend on parameter setting.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From the analysis of tensile test that has been done using taguchi method, here are some conclusion which are:

a. Based on tensile test parameter that more affect on spot welding is duration for first rank with value 7.1 A, then pressure the second rank with value 21 Cycles and last is Current with value 3600 kN
b. Based on cutting check parameter that more affect on spot welding is current for first rank with value 7.3 A, then duration the second rank with value 21 Cycles and last is pressure with 4.100 kN.
c. Based on the output, small parameter can produce nugget diameter that are not much difference than first condition and can be called good quality. So that higher parameter can be replaced with low parameter and can produce cost reduction

6.2 Recommendation

There are several recommendation for further research, such as:

a. For further improvement need to more consider, in order to improve the quality of nugget diameter. The pallet should be take minimum five times to get more accurate data about the result.
b. To produce good quality, it requires commitment from all parties to learn parameter settings. It will become a culture within the company and provide satisfaction for all stakeholders.

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APPENDIX I

Result of Oprimization compare with current condition

S.W No	Plate Thickness (mm)			e Of Measur	Nugget Diameter (mm)							Penetration							Final	Remar
	(mm)	Plate 2 (mm)	Plate 3 (mm)		Std (mm)		1 (mm)	2 (mm)	Class STD Min	Class ACT	Judge	Std (mm)		1 (mm)	2 (mm)	Std (%)		1 (%)	2 (%)	Judge	Judge	
Welding Condition Aktual Produksi																						
1.1	0.65	1.20			≧	3.22	4.66		B	A	O	≧	0	0.31		≧	20	48		O	OK	
1.2	0.65	1.20			≧	3.22	4.49		B	A	O	≧	0	0.32		≧	20	49		O	OK	
Welding Condition Optimasi																						
2.1	0.65	1.20			≧	3.22	4.33		B	A	O	≧	0	0.20		≧	20	31		O	OK	
2.2	0.65	1.20			≧	3.22	4.03		B	A	O	≧	0	0.36		≧	20	55		O	OK	

Figure 1. Comparison Optimization and Current Condition

APPENDIX II

Documentation during process cutting check nugget diameter. Sequence way start from beginning untill finish to get the value of diameter nugget

1 

2. 

Figure 1. Bandsaw(1) and Example of Bandsaw Part(2)

1. 
2. 

Figure 2. Cutting Grinding(1) and Example of Cutting(2)

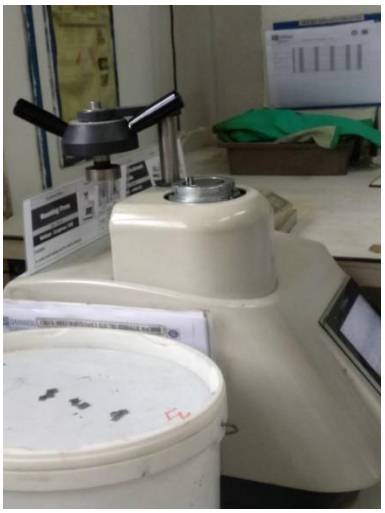
1.  2. 

Figure 3. Mounting Machine(1) and Result(2)

Figure 4. Grinding machine

Figure 5. Sanding machine

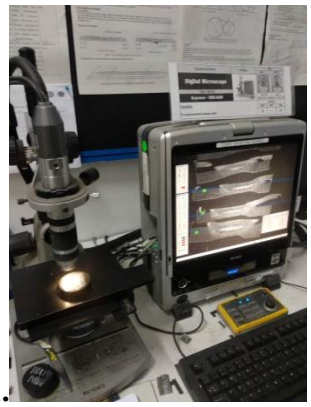
Figure 6. Wet sanding, Polishing and Alumina liquid

Figure 7. Drier Machine

1. 

2. 

Figure 8. Ethcing Machine(1) and Plate of Nugget(2)

1. 
2. 

Picture 9. Digital Microscope(1) and Nugget Diameter(2)