DETERMINING THE NUMBER OF EMPLOYEE REQUIREMENT USING WORKLOAD CONTROL TO REDUCE THE LABOR COST

THESIS

Submitted to International Program
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THESIS APPROVAL OF SUPERVISOR

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THIS THESIS IS DEDICATED TO:

Mama, Siti Khusnul Khotimah

Bapak, Timbul Nurhidayat

Pak Dhe, Suparman

Mbak Tri Anna Purnamasari

Mbak Amalia Cahya Ratnasari

MOTTO

"What I do is what you just can't do"

"Be Excellent, and success will chased you"

PREFACE

Assalamualikum Wr.Wb.

Alhamdulillahi robbil a'lamin. First of all, I would like to say thanks to Allah SWT that always give us bless and mercy for all mankind who had faith and worship to God. Because of His bless and mercy, I can finish my thesis with Title **DETERMINING THE NUMBER OF EMPLOYEE REQUIREMENT NUMBER USING WORKLOAD CONTROL TO REDUCE THE LABOR COST.** This Thesis is part of requirement to get bachelor's degree of Industrial Engineering Department at University Islam Indonesia.

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Yogyakarta, May 27,2011

Ibnu Sandy Ardiansyah

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ABSTRACT

The workload control concept is known to robust shop floor control concept. It is especially suited for the dynamic environment of small and medium enterprises (SMEs) within the make to order sector. Currently there are so many small and medium enterprises (SMEs) because in past several years economic global experiences obstacles. In order to gain more profits the SMEs have to efficient and have to reduce unnecessary feedback from the production floor .The objectives of this research reducing number of employee requirement to reduce the labor cost using workload control method by grouping the workstation based on the operation chart (OPC). To make sure the concept is applicable in the SMEs, simulation can be conducted.

Keywords: SMEs, Workload control, costs, labor, OPC, simulation.

CHAPTER I

INTRODUCTION

1.1 Background

Small and Medium Enterprises (SMEs) have the potential to develop the Indonesian economy. This was proven with the durability of SMEs in the global crisis that occurred some time ago. SMEs is a term that refers to a type of small business that has a net worth of Rp 200.000.000,00 excluding land and building and a stand-alone business. According to Presidential Decree no. 99 of 1998 Small Business sense is: Economic activity of the people that small-scale businesses that are majority are small businesses and need to be protected to prevent unhealthy competition. One of the potential profitable of SMEs industry is Bamboo Craft. The potential of this craft has reached the export markets like Japan, America, and Germany.

One of the obstacles to SMEs development is in terms of availability of information. So far the feedback information on the SMEs were still very poor, such as, timeliness, accuracy and completeness of information production is still very important. For orders release mechanism functions so far there is no better solution from a variety of literature in overcoming the situation of lack of accurate feedback information. Some opinions stated that with the improvement of information technology to overcome these problems (timeliness, accuracy and completeness of information) but the use of information technology is still experiencing barriers to their implementation in SMEs.

Problems of information above can be solved by the concept of WLC (work load control). WLC is one of the concepts applied to the appropriate type of SMEs make to order in the regulation of the production floor. Use WLC believed to provide the right solution to overcome the problem of workload at the time of the production process to reduce errors in the feedback information for timeliness, accuracy and completeness of the information can be overcome. WLC Thus information problem can be resolve using WLC (*work load control*).

Several studies of workload include: Determination of Total Labor Workload Analysis Method Based On CV KG Plated Jogjakarta (Rahmawati, 2005), the study only workloads are calculated. Determination of the Optimal Number of Worker Who Work Load Analysis Method Based on Hybrid Simulation (Nurzaman, 2009). Then the results of his research is the number of workers just need to move a worker at another workstation that does not make firing or recruitment. Minimizing the Workload in Manufacturing System using WLC Method by grouping the Machine Capacity conducted by Kurniawan (2010). This research only focused on how to minimizing the workload, not focused the cost that affected after using WLC method.

From the literature review that has been done, it still exist some shortcomings, then it is necessary to develop advanced research. In the development of this research will control the workload to reduce errors in the feedback information for timeliness, accuracy and completeness of the information can be overcome.

In accordance with the research background in the preparation of this proposal hence writer take title: *Determining The Number of Employee Requirement Using Workload Control to Reduce the Labor Cost*.

1.2 Problem Formulation

How to determine the employee requirement number to reduce the labor cost using Workload Control method?

1.3 Problem Boundaries

From the background above, this study has limitations in the following issue:

1. The study was conducted in the Muda Kreatif bamboo furniture business.
2. The cost efficiency focus on the labor cost.
3. In the simulation and calculation, some processes are ignored, such as drainage of the bamboos, idle time, and the materials cost.

1.4 Research Objectives

The objectives of this research are:

To determine number of employee using Workload Control to decrease labor cost.

1.5 Research Benefits

This research is expected to provide benefits:

1. Adding a repertoire of knowledge, especially resource planning in production systems.
2. Knowing the work load with WLC method.
3. Optimizing the production by minimizing the workload.

1.6 Thesis Structure

In order to get a well-structured thesis report, hence this thesis will be continued by containing:

CHAPTER II LITERATURE REVIEW

This chapter is the backbone to determine the current study from the previous related ones. It contains information about the result of related previous studies and supporting literatures underlying the research.

CHAPTER III RESEARCH METHODOLOGY

This chapter describes a detailed series of research object, model development, model analysis, system developed, research design, research procedure, and data collecting, processing and analyzing method.

CHAPTER IV DATA COLLECTING AND PROCESSING

It explains the data collecting and processing to the final answer, as well its result and analysis, including the supporting figures, tables, and graphics.

CHAPTER V DISCUSSION

This chapter consists of the data processed result analysis or research result discussion, in conformity with the background to the study described in previous chapter, problem formulation, objectives, and hypotheses (if any) which pointed to the conclusion of research result.

CHAPTER VI CONCLUSION AND RECOMMENDATION

Conclusion gives short and precise statements described from the research result and discussion. Recommendations related to the current study in purpose of the advancement in future study are given with suggestions based on the limitations of the current one. Some suggested improvements for the company might be given also in this chapter.

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LITERATURE REVIEW

2.1 Small and Medium Enterprises

Small and medium enterprises (SMEs) are now developing rapidly, one of the roles of SMEs is to create the job vacancies and producing output. On 2001 based on BPS data, the percentage of SMEs compare to total of enterprises in Indonesia is 99,9%, and in the same year SMEs require 99,4% of total employees. Small and medium enterprise itself has different definition and standard in some country. In Indonesia, some of government institution has the definition of small and medium enterprise. In UU No. 9/1995, an enterprise categorized as SMEs or UKM if only has asset less than IDR 200 million, exclude land and the building. Therefore in small and medium enterprises, the information traffic is not as good as the big company, the information system is very simple because SMEs has low budget for the information traffic.

2.2 Workload Control

Workload is one of the problems which may affect the performance of the company in manufacturing products or services. To maximize the production, we must control the workload for the entire production unit, include machines and the workers. Workload Control is a concept that especially suited to small and medium enterprises, where it is elaboration between shop floor control (SFC) and make to order (MTO) environment (Hendry and Kingsman 1989). Workload Control (WLC) is based on principals of input/output control as defined by Plissl and Wight (1973), and heavily depends on the use of 'order review and release' techniques as defined by

Bergamaschi *et al* (1997). Workload Control will control the input and output of the production process because WLC will provide us the result how to reduce the lead time of the release order. Along WLC can provide us to reduce the lead time of the release order, therefore the inventory time of the materials will reduce. Indirectly, the WLC will reduce the inventory cost and setup cost, so we can maximize the profit. To determine the lead time, the planner requires information from the production units, in order to determine the production units has a lot of work in process or not. If the planner doesn’t know the production unit is busy, and the planner release the order, it will give more workload for the production units. From the information before, this technique require a lot of feedback.

The WLC concept is based on the principles of input/output control as defined by Plossl and Wight (1973). The concept heavily depends on the use of ‘order review and release’ techniques as defined by Bergamaschi *et al*. (1997), where the arrival of an order does not necessarily involve the release to the shop. Before orders enter the shop floor, they are collected in a so-called ‘order pool’. A central planner releases these orders periodically to the shop floor in such a way that the workload in front of the capacity groups on the floor will be balanced. Balancing and restricting the load on the floor leads to a transparent shop floor with predictable throughput times. For a description of the characteristic elements of WLC and their application in SMEs, see Henrich *et al*. (2004).

The central planner needs various types of information for the order release decision. This information comes from the customer (e.g. due date) or can be derived from the incoming order itself (e.g. process plan). For controlling and balancing the workload on the shop, information on the current shop status (i.e. the actual distribution of the workload – measured in operation processing time – across the individual capacity groups) is also necessary (Bergamaschi *et al*. 1997). More precisely, the central planner needs feedback from the shop floor, indicating the detailed status and position of each order.

During the last two decades, much research has been done on the WLC concept. In the early 1980s, simultaneously different WLC approaches were developed. These concepts (Bertrand and Wortmann 1981, Tatsiopoulos 1983, Bechte 1984, Wiendahl 1995) have been extensively discussed (Bechte 1994, Cigolini *et al*. 1998, Perona and Portioli 1998, Kingsman 2000) and compared (Land and Gaalman 1996, 1998, Oosterman *et al*. 2000). For a recent overview of research on this topic, see Gaalman and Perona (2002). Perona and Miragliotta (2000) conclude that most of the research on WLC focuses on theory building and not on the practical aspects of the different WLC approaches. In addition, Breithaupt *et al*. (2002) indicate a lack of WLC implementations in practice. Up to now, little is known about the implementation of WLC thesis approaches and its actual functioning in SMEs. Due to special needs of SMEs, structural adaptations of the WLC concept that could lead to an improvement for the practical relevance of the WLC approach are scarce.

One of the first implementations of WLC in a small company was described by Tatsiopoulos (1983). While implementing his WLC approach, he struggled with the lack of sufficient feedback information from the shop floor necessary for order release. As a rigorous solution, he proposed an adapted approach limiting the need for feedback information to the registration of job completion. Unfortunately, this solution may lead to an unacceptable performance loss (Oosterman *et al*. 2000). In addition, Melnyk and Ragatz (1989) describe that the timeliness and accuracy/completeness of shop floor information is crucial for the functioning of the order release mechanism. But after 1983, no better solutions have been proposed in the literature for situations lacking accurate feedback. One might expect that the enormous improvements of information technology (IT) in the last decade would have erased this problem. Nevertheless, many obstacles still exist around the introduction and use of IT, especially within the environment of SMEs. While introducing WLC, we especially experienced that the requirements of the WLC concept regarding feedback information might still hinder its functioning in many SMEs. We observed several shortcomings in the supply of feedback information in practice. The available feedback information is often inaccurate (delayed, incorrect, incomplete) or insufficiently detailed.

Two alternative approaches can be used to solve the above mismatch: either the information feedback can be improved or the WLC concept can be adapted according to a more realistic information feedback within SMEs. In this thesis, the latter approach is followed in line with Melnyk and Carter (1987), who confirmed the need for designing the supply of feedback information appropriately. Thus, the objective of the present paper is to enable the WLC concept to deal with the limited feedback information available in SMEs. A redesign of WLC release methods is presented that can handle limited feedback information. It is tested in a simulation study to quantify its impact on the shop floor performance.

2.3 Information feedback in SMEs

For order release, it is important that the central planner knows what order is queuing (or being processed) at what capacity groups. The planner needs a detailed overview of the shop floor status. For detailed information feedback within the WLC concept, any status change on the shop floor has to be registered and transmitted to the central planner so that he/she can get the actual status overview of the shop floor. The process of information feedback thus includes the registration of status changes, the transmission of these data and its interpretation by the central planner.

In practice, it can be observed that particularly within 'smaller' SMEs, it is the central planner who performs this process of information feedback. Another group of SMEs has grown from a 'smaller' shop floor. An expanding shop floor generally leads to an increase in machines, operators, the numbers of orders being simultaneously on the floor, etc., and cannot be monitored completely by the planner anymore. It asks for a more formalized approach to handle the increased complexity. To reduce this complexity, the floor often is subdivided into some production units (PUs), monitored by unit leaders or foremen. In these situations, a commonly observed structure for the generation of feedback information is that of regular meetings between foremen and planner, with the foremen reporting the progress of jobs. The status change registration and transmission part of information feedback are moved away from the planner to the foremen.

The exact knowledge of status changes in these more mature shop floor structures is distributed across the functions and the related tasks on the floor (table 1). For instance, the main task of the foremen is to control the material flow within the PUs, therefore they can register any order entering or leaving 'their' department. Only the operators exactly know which individual job is actually queuing or being processed at their machines.

Within the informal planning concepts of many SMEs, it is sufficient that only the foremen have an exact knowledge of which jobs are being processed in their unit, combined with a rough notice of the internal PU job progress. But the introduction of a formalized WLC concept requires the feedback of detailed information on

Function	Order release/ order completion	Start/completion in PU	Start/completion in the shop
Planner	X		
Foremen		X	
Operators			X

Figure 2.1. Status change knowledge related to function

completed operations to the planner. This generally leads to the involvement of the operators in the feedback process. Either manual (e.g. notes on the routing sheet) or automated (scanning) solutions are introduced to transmit the information to the planner. Typically, this feedback appears to be an important obstacle in the introduction of the WLC concept.

Several reasons can be distinguished for the disfunction of feedback systems involving all operators. On the one hand, complex motivational problems and reservations against organizational (and/or technological) changes may occur. As the status change registration is not the core task of the production-focused operators or as, for example, operators may feel being ‘watched’ regarding their productivity, it can become difficult to motivate all the operators to give accurate (reliable, correct, on time) feedback of any performed operation all the time. On the other hand, a couple of practical problems arise with the registration and transmission of the relevant data. Manual data registration and transmission leads to an exhaustive data set that cannot be interpreted entirely by the planner on time. Though IT is state of the art and broadly available, different obstacles exist around its introduction and use in SMEs (Henrich 2000). Often the specific knowledge and know how on IT is not present within SMEs. In addition, different computer systems and data formats may not be integrated, which makes data exchange difficult. In addition, very practical problems such as how to scan an operation processed in parallel by two operators occur. However, putting effort in the instruction and monitoring of operators can solve nearly all problems. But with a substantial number of operators, it raises the question whether the information need of the concept is worth these efforts.

Within informal planning systems the intermediate role of foremen in providing feedback has been proven successful. The foremen generally feel more involved in job progress issues and at least the number of foremen to keep involved is relatively small. However, involvement of foremen will be best facilitated when only the shipments between the PUs have to be registered. Though the foremen will also have an indication of the detailed progress of jobs within their PU, formal registration may require much more effort.

We assume that the organizational division of the shop floor helps in structuring feedback on PU level. This information is not as detailed as feedback information on performed operations (given by the operators). However, it might be much more accurate (reliable, complete, on time) and easier to collect. The arising conflict between this way of information feedback and the need for status information by WLC is discussed in more detail below.

2.3.1 Redesign of the feedback information need in WLC

This section first analyses the WLC concept. Here it focuses on the elements that depend on feedback information. A deeper understanding of these elements enables one to restructure the concept according to the more realistic information supply. This redesign is described and motivated in the second part of this section.

2.3.2 Use of feedback information in WLC

Order release is the most central control element within the WLC concept. To understand the use of feedback information, it is necessary to focus on this control element.

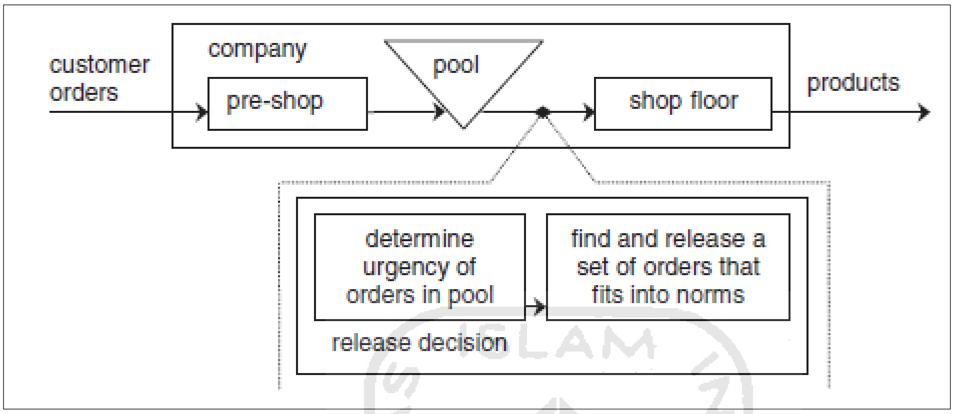

Figure 2.1 Central Order Release

As depicted in figure 1, after the acceptance of an order, some pre-shop operations (engineering/process planning) may be necessary before the order is ready for release to the shop floor. The order will generally have to wait before it is selected for release. Waiting before release takes place in a so-called order pool. The decision to release an order is based on two aspects: the urgency of the order itself and its influence on the momentary shop floor situation. The latter is determined by comparing the workloads with norms. The norms can be defined for each capacity group and are usually expressed in time units. They should guarantee a small but stable buffer of work in front of the resources within the capacity groups.

A stable buffer in front of a capacity group allows for constant operation lead times. In turn these constant lead times are used for determining accurate planned release dates. The planned release date of an order is calculated as its due date minus the planned lead times for its operations. Thus, the urgency of orders in the pool can be compared. Orders in the pool are considered for release in the sequence of their planned release dates. The order being considered is added to the release selection as long as its release will not cause any workload norm to be exceeded. Otherwise, the order will have to wait in the pool until the next release opportunity. An order with a later planned release date may be selected when it does fit in the norms. After this procedure is completed, the selected orders are released to the shop floor. They remain on the floor until all the operations have been finished.

The decision to allow an order for release depends on the shop floor situation, which is reflected in workloads. In the literature, two different concepts for calculating the workloads are discussed (e.g. Graves *et al*. 1995). Bechte (1984) derives a 'projected workload' over the planning horizon. A capacity groups' projected workload consists of its direct load plus the 'discounted' indirect load. The direct load is the amount of work actually queuing or in process at the capacity group. The indirect load is the released work upstream the regarded capacity group (Jendralski 1978). The discount factor can be used to derive the probability that an order that is upstream will reach the capacity group during the release period.

The second approach is developed by Bertrand and Wortmann (1981). They calculate the workload as an aggregate of individual processing times. To determine the 'aggregate workload', the central planner counts up (at the beginning of a release period) the processing times of orders waiting in front of a capacity group (direct load) and those of orders upstream (indirect load) (figure 2.2). The present paper will adopt this approach to a more realistic situation of feedback information.

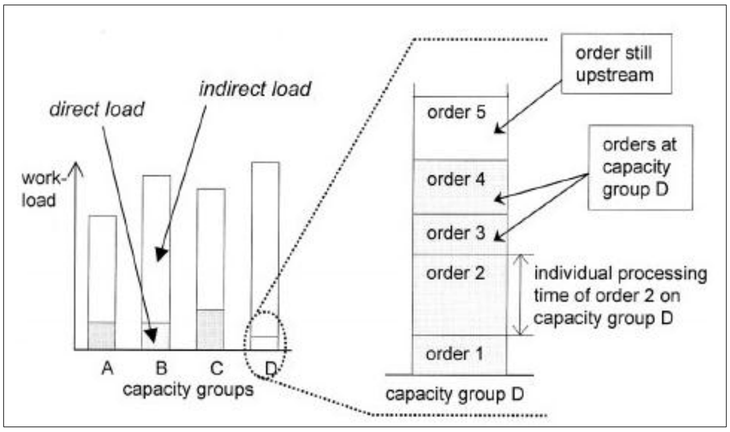

Figure 2.2 Use of aggregate loads to estimate the work per capacity group

2.4 Grouping Machine

Based on the different machine characteristics we discuss the most common grouping choices and show that the grouping decision cannot be seen independently from the resulting routing alternatives, based on several 'similar' machines on the floor. We draw to a close by relating the prior discussion to the question of parameter setting, within WLC. The concept of capacity groups within WLC is embedded into the control mechanism of releasing orders from the pool to the shop floor. Within this section we describe the WLC aspects related to capacity groups and their influence on order release. For a more complete and detailed description of WLC we refer to Kingsman (2000), Henrich *et al*. (2004a) and Land (2004a).

2.5 Simulation Model

A model is similar to but simpler than the system it represents. One purpose of a model is to enable the analyst to predict the effect of changes to the system. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. On the other hand, it should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity (Benson, 1997). Simulation practitioners recommend increasing the complexity of a model iteratively.

Simulation is conducted in research because of some factors. To apply the research result, trial-error approach requires much time and cost beside thus approach also impair the current system, involve designing equipment that has a high risk especially in the investment cost. Simulation provides evident of the research objectively to making decision, and eliminates the emotional factor of the process. Simulation is used before an existing system is altered or a new system built, to reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize system performance (S. Andradóttir. *et al*. 1997).

CHAPTER III

RESEARCH METHODOLOGY

This chapter explains the research methodhology such as research object definition, mathematical model, data requirement, and research frameworks. Detail steps of the research which is arranged in sub-chapters as below:

3.1 Research Object

The study was conducted in bamboo furniture business "Muda Kreatif" is bamboo craft enterprise located in the hamlet Sendari, Cebongan Kidul RT. 04 RW.02 Tlogodadi, Mlati, Sleman, Yogyakarta.

3.2 Mathematical Model

a. Work Load

$$\boldsymbol{WL_{s,t}^{aggr}} = \sum_{i \epsilon J} \boldsymbol{p_{is}}\ \mathbf{I}\ \mathbf{(t)}_{[} t_i^1,\ t_{is)}^3 \quad \text{(Henrich et. al.)} \tag{3.1}$$

Where:

J = Number of all orders

P_{is} = Time to process order i at capacity group s

$I(t)_{[\dots]}$ = Indicator: 1 if the interval is known (otherwise 0 if not known

t_i^1 = Early release time in order i

t_{is}^3 = Time of completion work order process i at capacity group s.

b. Homogeneity Test

Homogeneity test conducted on operation process chart data.

$$\bar{X} = \frac{\sum Xi}{N} \tag{3.2}$$

Where:

$\bar{X}$ = Mean

Xi = Data tested

N = Number of data

c. **Standard Deviation**

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N-1}} \tag{3.3}$$

Where:

σ = Deviation

x_i = Data tested

$\bar{X}$ = Mean

d. **Uniformity Test**

$$UCL = \bar{X} + k.\sigma \tag{3.4}$$

$$LCL = \bar{X} - k.\sigma \tag{3.5}$$

Where:

UCL = Upper control limit

LCL = Lower control limit

$\bar{X}$ = Mean

K = Constant

σ = Deviation

e. **Cycle Time**

$$T_c = \frac{\sum Xi}{N} \qquad (3.6)$$

f. **Normal Time**

$$T_n = T_c \times P \qquad (3.7)$$

Where:

T_n = Normal Time

T_c = Cycle Time

P = Allowance

g. **Standard Time**

$$Ts = Tn \left[\frac{100\%}{100\% - \%Allowance} \right] \qquad (3.8)$$

Where:

Ts = Standard Time

Tn = Normal Time

h. ***Work Load Analysis***

$$WLA = \frac{P \; x \; Ts}{AWH} \; x \; 1 \; worker \qquad (3.10)$$

Where:

WLA = Workload Analysis

P = Allowance

Ts = Standard Time

AWH = Average work hour

3.3 Data Requirement

3.3.1 Primary Data

Data obtained from observation, observation, measurement and recording directly in the company, including

The data required are as follows:

1. Production Data
2. Message Time
3. When the production process

3.3.2 Secondary Data

The data didn't collected by the researchers themselves. These data have been provided by the company.

a. Company History

b. Production

c. Labor

d. Raw Materials

e. Machine

f. The production process

3.4 Data Collection Method

a. Observation

It is a study done by direct observation and measurement conditions, activities, ways of working and recording.

b. Interview

It is the collection of data by doing a question and answer directly about the problems associated with research on the company.

c. Literature review

Studies and research literature / literature is still needed because of other information in addition to data obtained from research in the field of books, journals or other information. This literature is used to get an idea of the basic theory can be applied in real research in order to get the results of scientific research.

3.5 Tools

This research conduct using several tools to help the researcher to processing the data. Microsoft excel to calculate the data, QS 3.0 to forecasting the demands, and ProModel 7.5 Student Version to modelling the system.

3.6 Framework to resolve the problems

Framework to resolve the problem in this study are as follows.

1. Literature review, intended to seek knowledge or information to be used in research.

2. The formulation and the problem definition. After the completion of the review of the literature, followed by formulating what the problem constraints in the case study.
3. Determining the object of research. Problems in research must comply with the problems faced by the company. Thus the determination of the proper object of study is needed.
4. Collecting data in this study carried out by direct observation in the field, including observation, measurement and recording of data and direct interviews it takes to get the information required.
5. After the required data is obtained, then the next step is to test for uniformity of data.
6. Then calculate the workload.Kemudian menghitung beban kerja.
7. The next step is a discussion that includes analysis of the results of the calculation of WLC.
8. Conclusions and recommendations.
9. Completed.

3.7 Research Flowchart

The research steps are required to be organized properly in order to simplify the composing of research report. The following Figure 3.1 is the presentation of the research steps.

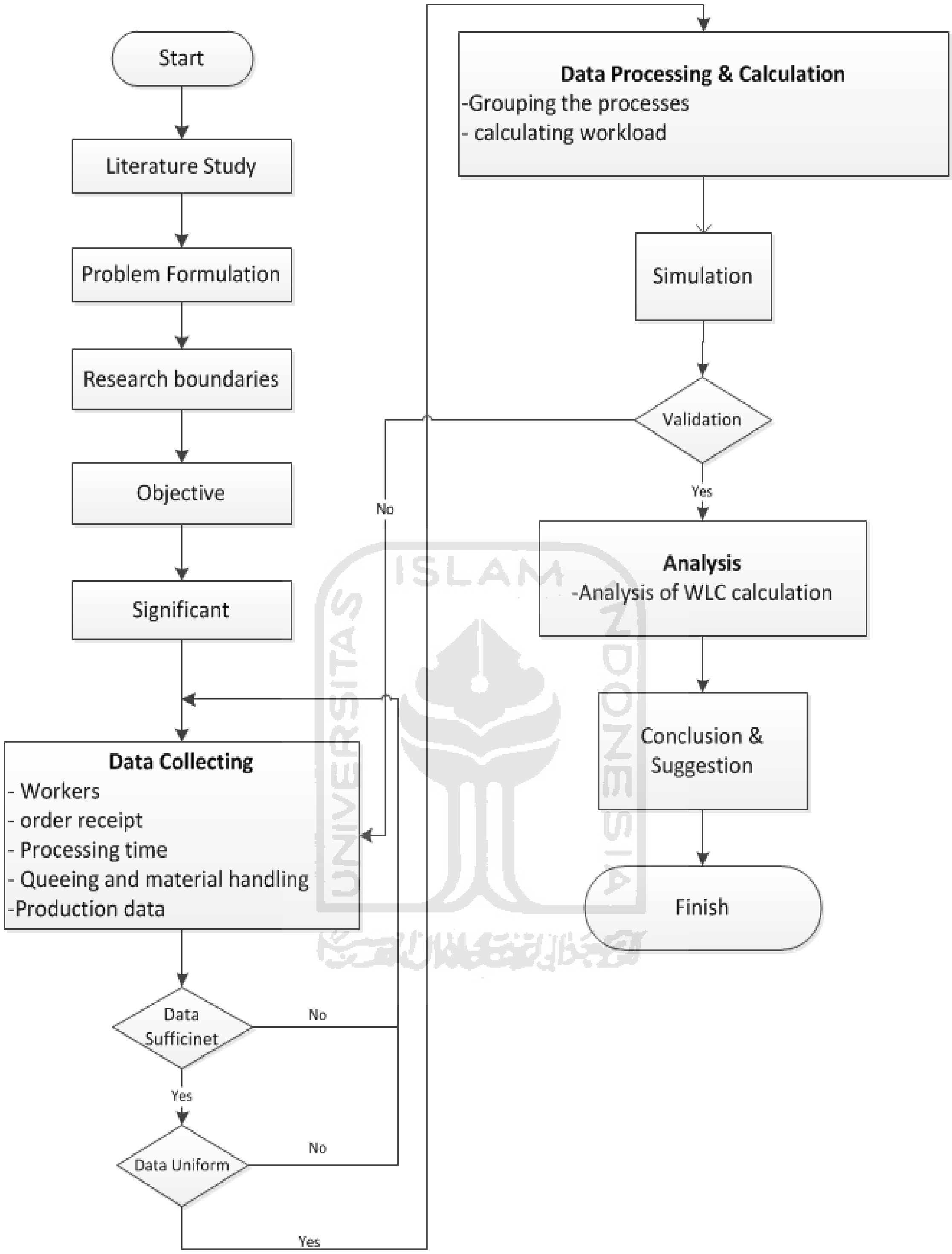

Figure 3.1 Research Flowchart

CHAPTER IV
DATA COLLECTING AND PROCESSING

4.1 Company Overview

This research using data which collected from "Muda Kreatif" bamboo craft industries lies on Sleman, Yogyakarta.

4.2 Collecting Data

In workload control, we need several data to conduct the calculation. The data in bamboo crafts are employment data, operation process chart, and time measurement data of the production process of each process. The additional data to calculate the cost minimizing are work hour data, employee wage, and several other data.

4.2.1 Employee data

The number of workers in the bamboo furniture business "Muda Kreatif" are 10 people which all of them are male with the working day Monday to Saturday and work hour from 08.00 am until 16.00 pm and an break from 12.00 am until 13.00 pm.

Number of Workers in Each Workstation

The number of workers at each work station is as follows:

Table 4.1 Workers Data

No	Workstation	Number of workers
1	Bamboo cleaning	2
2	Making frame	3
3	Binding	1
4	Back rest assembly	2
5	Finishing (sanding & varnishing)	2
Total		10

4.2.2 Process time Data

As said before, the study only research on chair production. So the following data are the chair process time.

A. Workstation I (Cleaning)
B. Workstation II (Frame)
C. Workstation III (binding)
D. Workstation IV (Back rest assembly)
E. Workstation V (Sanding and varnishing)

Process times in each workstation are shown as below:

Table 4.2 Process time data

No	Cleaning	Frame						
	Washing bamboo	Back Measure	Back Cutting	Back assemble	Legs Measure	Legs cutting	Legs assemble	Back & legs assemble
1	236	140	333	1336	76	186	303	1474
2	251	147	346	1357	81	157	309	1458
3	241	155	338	1369	92	139	314	1449
4	279	166	352	1398	102	167	352	1468
5	306	158	367	1368	87	156	363	1447
6	263	149	342	1357	94	149	377	1509
7	328	156	365	1376	79	208	329	1521
8	308	144	358	1353	82	182	339	1476
9	247	148	347	1362	102	176	362	1518
10	325	168	338	1383	88	199	339	1468
11	323	157	351	1359	94	191	373	1477
12	255	146	338	1345	81	173	314	1498
13	243	143	344	1387	97	203	348	1458
14	243	155	338	1428	75	174	368	1479
15	245	176	349	1402	89	205	372	1488
16	267	166	363	1356	96	214	339	1512
17	274	158	351	1368	102	178	348	1503
18	251	150	339	1389	81	139	383	1511
19	267	163	362	1418	92	165	378	1479
20	261	174	349	1378	87	192	339	1458
21	245	147	359	1393	83	152	362	1522
22	271	154	338	1391	90	193	339	1517
23	285	143	368	1382	97	159	328	1508
24	318	161	352	1358	91	168	372	1492
25	303	144	335	1411	88	149	303	1513
26	300	156	324	1376	96	187	368	1498
27	300	166	321	1366	83	209	387	1487
28	245	175	336	1399	77	168	328	1529
29	261	138	341	1407	86	128	372	1468
30	289	144	367	1409	89	153	389	1498
31	289	152	338	1428	80	172	302	1483
32	292	163	343	1403	97	158	353	1508
33	287	139	365	1369	78	152	363	1477
34	245	148	339	1378	95	167	394	1522
35	206	162	305	1366	89	148	338	1475
36	242	150	335	1359	84	178	352	1467
37	304	149	356	1308	99	193	361	1478
38	257	172	349	1398	101	202	349	1502
39	284	166	333	1368	96	177	338	1477
40	321	158	368	1389	88	137	312	1493
41	272	168	347	1411	79	153	302	1498

Table 4.2 Continued

Binding			Back rest			Finishing	
Rattan measure	Cutting	assemble	Measure	Cut	Assemble	Sanding	Varnish
227	84	1393	162	592	1946	515	882
232	105	1423	151	578	1984	508	922
242	99	1437	178	565	2054	554	902
229	82	1465	177	608	1965	543	898
219	94	1444	188	579	2112	561	926
252	102	1453	204	568	1978	505	932
237	123	1457	138	577	2037	563	903
239	91	1436	156	592	2065	519	870
209	98	1427	168	586	2042	528	912
228	102	1464	203	614	2027	552	894
239	87	1463	171	586	2105	526	932
209	99	1433	183	576	1955	575	876
241	102	1431	214	557	1906	506	888
228	93	1455	167	564	1993	515	912
249	112	1425	183	588	2042	566	867
234	123	1398	204	567	2028	541	914
253	119	1425	163	574	1967	510	878
238	105	1438	155	577	2115	552	928
242	99	1487	194	611	1968	573	875
262	112	1438	167	586	2012	516	899
268	112	1468	206	612	1982	562	912
226	98	1498	182	587	2041	519	889
236	118	1484	155	575	1894	567	913
215	158	1408	241	636	1993	518	897
232	99	1399	181	567	1967	528	948
246	92	1418	179	589	1984	567	933
207	98	1498	172	597	1948	542	867
227	107	1479	183	603	2115	519	948
229	102	1497	168	574	1991	539	913
253	112	1478	162	586	1983	543	888
237	107	1462	209	606	1937	572	954
217	113	1437	168	585	2092	529	869
228	98	1469	189	612	2134	564	912
219	102	1443	177	589	1968	510	885
272	133	1471	178	575	1905	552	912
255	103	1448	159	593	2185	532	889
234	89	1557	218	615	1963	548	867
241	107	1504	169	586	1976	519	888
208	90	1487	208	590	1993	563	914
226	107	1524	184	554	1957	549	928
245	98	1512	168	574	1984	535	914

4.2.3 Queeing time and material handling

There is queeing time or material handling time if the distance between one process to the next process.

Table 4.3 Queeing time

No	Proc. 1 to proc 2	Proc. 2 to proc 3	Proc. 3 to proc 4	Proc. 4 to proc 5	Proc. 5 To proc 6
1	2845	11	7	5	6
2	2616	7	9	6	5
3	2752	5	10	7	6
4	2508	8	8	5	4
5	2819	8	6	6	5
6	2678	8	7	7	4
7	2914	7	9	5	6
8	2692	5	7	6	5
9	2736	10	4	6	4
10	2878	7	8	4	6
11	2909	6	5	5	5
12	2736	8	7	6	4
13	2781	5	8	4	6
14	2968	9	4	6	7
15	3162	9	9	5	6
16	2919	7	6	4	5
17	2624	6	7	5	6
18	2817	5	9	6	5
19	2758	8	8	6	7
20	2863	7	9	5	5
21	2696	6	8	7	6
22	2792	9	5	6	5
23	3236	6	9	5	7
24	3402	5	5	7	4
25	2934	7	7	4	5
26	2818	5	5	6	6
27	2554	7	7	4	5
28	2872	9	8	7	7
29	3108	8	6	6	6
30	2999	10	7	5	5
31	2744	7	9	5	6
32	2872	8	7	6	5
33	2879	7	6	7	6
34	2750	6	8	6	7
35	2534	8	7	8	6
36	2846	6	9	6	5
37	2704	9	7	7	8
Sum	104715	269	267	211	206
mean	2830,135	7,270	7,216	5,703	5,567

Table 4.3 continued

Proc. 6 to proc 7	Proc. 7 to proc 8	Proc. 8 to proc 9	Proc. 9 to proc 10	Proc. 10 proc 11
5	11	937	6	43
6	13	1248	7	51
5	12	771	5	87
4	10	1079	6	46
5	12	702	6	68
6	10	687	7	61
4	8	807	5	58
5	12	971	6	45
6	9	1118	5	52
6	13	1193	7	72
5	12	948	5	55
6	14	697	6	82
5	13	1196	7	49
5	12	998	6	69
6	14	1069	6	51
5	12	771	5	43
6	11	1119	6	56
5	10	1040	5	95
6	11	697	4	62
5	12	1189	5	47
6	9	807	6	72
5	11	979	4	58
5	10	1110	5	85
5	12	148	5	72
6	13	696	4	47
5	13	921	6	58
7	12	637	5	73
5	8	1133	4	58
5	10	1110	5	85
5	12	148	5	72
6	13	696	4	47
5	13	921	6	58
7	12	637	5	73
5	8	1133	4	58
6	9	1009	4	47
7	10	685	5	68
6	12	1056	6	58
5	11	1171	4	81
6	10	989	5	78
8	11	1023	6	65
7	9	1154	8	83
6	12	1077	7	79
7	11	998	6	93
208	414	34830	205	2367
5,622	11,189	941,351	5,541	63,973

Table 4.3 continued

Proc. 11 to proc 12	Proc. 12 to proc 13	Proc. 13 to proc 14	Proc. 14 to proc 15	Proc. 15 to proc 16
1058	6	6	1108	94
935	5	7	1041	81
1166	5	5	15.52	48
1291	6	6	931	112
1131	5	7	1198	84
1221	5	5	1003	72
1338	6	6	879	68
1192	5	7	1472	83
1117	6	6	771	48
1189	6	5	923	79
1258	5	7	1174	83
1303	7	6	1238	78
1231	6	5	1281	80
1168	5	7	828	58
1252	6	8	1189	84
1314	7	7	1110	101
1199	5	6	1309	87
1114	6	7	1121	118
1167	5	5	1351	49
1296	6	7	1174	43
1258	7	6	1296	72
1166	6	7	1161	89
1491	5	7	1429	54
1169	6	6	1351	87
1233	7	7	1283	51
1270	8	6	1181	45
1362	6	7	1117	72
1429	6	6	1298	84
1179	4	5	1362	56
1272	6	6	1179	47
1423	5	8	1336	62
1284	5	7	1173	71
1179	8	8	1275	89
1087	6	9	1187	79
1268	9	6	1056	91
1107	7	7	1178	84
1274	8	6	1209	79
45391	222	239	42187.52	2762
1226,784	6	6,459	1140,203	74,648

4.2.4 Historical data

The historical data needed for the demand forecasting for certain period. The historical data for chair demand from August 2009 until July 2010 as follow:

Table 4.4 Historical Data

No	Year	Month	Demand
1	2009	August	57
2		September	63
3		October	71
4		November	60
5		December	65
6	2010	January	58
7		February	72
8		March	62
9		April	70
10		May	55
11		June	65
12		July	59

4.3 Production Process

The production process at the company consists of many processes. More Stages and processes of this production process can be explained as follows:

a. Cleaning

   First process of the production is washing the bamboo in order to make the bamboo clan, and remove the branches, also remove the itchy layer of the bamboo.

b. Back measuring

   Next process is back measuring. To cut the bamboo so can be formed as the pattern.

c. Back cutting

After measure the bamboo as according to the back size, then cut it.

d. Back assembly

After the back parts have been cut, then assembly the parts become back of the chair.

e. Legs Measuring

Measure the bamboos according to the leg size.

f. Making the chair frame.

The function of frame is the basic form of the products, in chair, frame is the strongest part of the product. From the frame, we will know the design of the product we will make.

g. Workstation 3 : Binding

The meaning of binding process here is tied the frame using rattan winding as decorative function because it covers the nails. It is also to avoid the bamboo cut edges harm the skin.

h. Workstation 4 : Making the back rest

In this process, we apply the back rest to the framework. The back rest itself made of bamboo layer as the base of the chair to sit down or put goods.

i. Workstation 5 : Sanding and varnishing

In sanding and varnishing process aim for get soft and shiny surface of the product.

4.3.1 Production Tools

Tools used on the bamboo furniture business "Muda Kreatif" is simple tools. The tools that used such as:

1. Saw
2. Wedge
3. Hammer
4. Sickle
5. Measuring tape
6. Sandpaper

4.3.2 Raw Materials

The raw materials used in the production process are:

1. Bamboo
2. Rattan
3. Nail
4. Glue
5. Varnish

4.3.3 Product Specification

Products produced by SMEs are in the form of furniture such as: chairs, tables, the curtain, partition boxes and others. In this study, the product researched is only chair. The other products assumed have the same processing time.

4.4 Chair Operation Process Chart

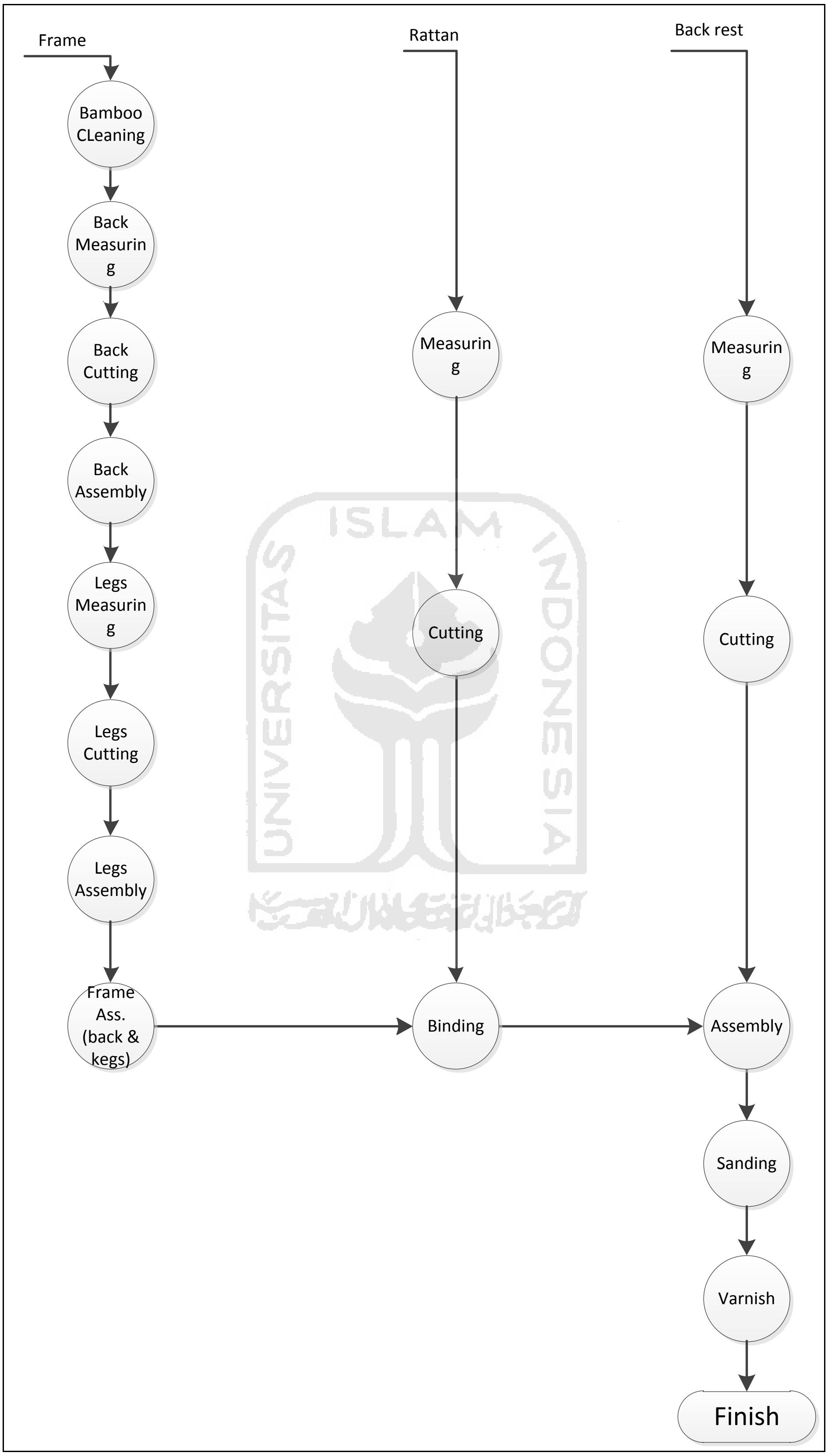

Figure 4.1 Chair Operation Process Chart

4.5 Data Calculation

Data calculation

All data collected will calculated and used in this section.

4.5.1 Homogeneity Test

Homogeneity test conducted on operation process chart data. For example, the test conducted on back cutting process.

a. Calculating mean of the chair back cutting process

$$\bar{X} = \frac{\sum Xi}{N} \quad (3.1)$$

$$\bar{X} = \frac{14189}{41}$$

$$\bar{X} = 346,073$$

b. Calculating the standard deviation of chair back rest cutting process time:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N-1}} \quad (3.2)$$

$$\sigma = \sqrt{\frac{7687,78}{41-1}}$$

$$\sigma = 13,863$$

c. Determine the upper control limit and lower control limit

$$UCL = \bar{X} + k.\sigma \quad (3.3)$$

$$UCL = 346,073 + 2(13,863)$$

$$= 373,798$$

LCL $= \overline{X} - k.\sigma$ (3.4)

d. LCL = 346,073 - 2(13,863)

= 318,348

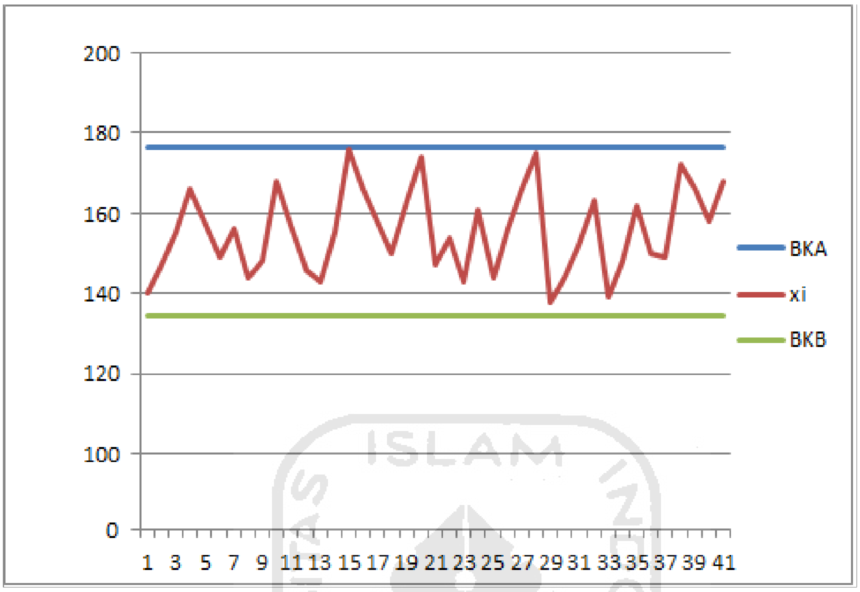

Figure 4.2 Control Chart of chair back cutting process time

Since the data out of the control limit, we can say that these data is not homogeny. For the overall process time homogeneity test, the test result shown below:

Table 4.5 Data Uniformity Test

No	Process	UCL	$\overline{X}$	LCL	Information
1	Cleaning	333,037	273,878	214,718	Out of control
2	Measure. bamboo	176,463	155,463	134,463	In control
3	Cut bamboo	373,798	346,073	318,348	Out of control
4	Ass. Back	1430,032	1379,463	1328,894	Out of control
5	Measure. Legs	104,560	88,854	73,146	In control
6	Cut Legs	216,664	172.097	127,531	In control
7	Ass. Legs	400,442	347,829	295.216	In control
8	Ass. Back and legs	1533,25	1489,41	1444,43	In control
9	Measure rattan	266,167	234,878	203,588	Out of control
10	Cut rattan	131,995	104,244	76,492	Out of control
11	Ass. Rattan	1528,61	1456,90	1385,19	Out of control
12	Measure back	222,129	180,048	137,968	Out of control
13	Cut Back	621,838	586,585	551,332	Out of control
14	Ass. Back	2139,809	2007,146	1874,483	Out of control
15	Sanding	582,472	539,146	495,820	In control
16	Varnish	951,182	903,658	856,134	In control

After conducting the data uniformity test, there are 4 observations which are out of control. So we ignore these 4 data and we use the other 37 data to the next step.

The observation result after conducted the data uniformity test.

Table 4.6 process time data after uniformity test

No	Cleaning	Frame						
	Washing bamboo	Back Measure	Back Cutting	Back assemble	Legs Measure	Legs cutting	Legs assemble	Back & legs assemble
1	236	140	333	1336	76	186	303	1474
2	251	147	346	1357	81	157	309	1458
3	241	155	338	1369	92	139	314	1449
4	279	166	352	1398	102	167	352	1468
5	306	158	367	1368	87	156	363	1445
6	263	149	342	1357	94	149	377	1509
7	328	156	365	1376	79	208	329	1521
8	308	144	378	1353	82	182	339	1476
9	247	148	347	1362	102	176	362	1518
10	325	168	338	1383	88	199	339	1468
11	323	157	351	1359	94	191	373	1477
12	255	146	338	1345	81	173	314	1498
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14	243	155	338	1428	75	174	368	1479
15	245	176	349	1402	89	205	372	1488
16	267	166	363	1356	96	214	339	1512
17	274	158	351	1368	102	178	348	1503
18	251	150	339	1389	81	139	383	1511
19	267	163	362	1418	92	165	378	1479
20	261	174	349	1378	87	192	339	1458
21	245	147	359	1393	83	152	362	1522
22	271	154	338	1391	90	193	339	1517
23	285	143	368	1382	97	159	328	1508
24	303	144	335	1411	88	149	303	1513
25	300	156	324	1376	96	187	368	1498
26	300	166	321	1366	83	209	387	1487
27	245	175	336	1399	77	168	328	1529
28	261	138	341	1407	86	128	372	1468
29	289	144	367	1409	89	153	389	1498
30	289	152	338	1428	80	172	302	1483
31	292	163	343	1403	97	158	353	1508
32	287	139	375	1369	78	152	363	1477
33	245	148	339	1378	95	167	394	1522
34	257	172	349	1398	101	202	349	1502
35	284	166	333	1368	96	177	338	1477
36	321	158	368	1389	88	137	312	1493
37	272	168	347	1411	79	153	302	1498

Table 4.6 continued

Binding			Back rest			Finishing	
Rattan measure	Cutting	assemble	Rattan measure	Cutting	assemble	Sanding	Varnishing
227	84	1393	162	592	1946	515	882
232	105	1423	151	578	1984	508	922
242	99	1377	178	565	2054	554	902
229	82	1465	177	628	1965	543	898
219	94	1444	188	579	2112	561	926
252	102	1453	204	568	1978	505	932
237	123	1457	138	577	2037	563	903
239	91	1436	156	592	2065	519	870
209	98	1427	168	586	2042	528	912
228	102	1464	203	614	2027	552	894
239	87	1463	171	586	2105	526	932
209	99	1433	183	576	1955	575	876
241	102	1431	214	557	1906	506	888
228	93	1455	167	564	1993	515	912
249	112	1425	183	588	2042	566	867
234	123	1398	204	567	2028	541	914
253	119	1425	163	574	1967	510	878
238	105	1438	155	577	2115	552	928
242	99	1487	194	611	1968	573	875
262	112	1438	167	586	2012	516	899
268	112	1468	206	612	1982	562	912
226	98	1498	182	587	2041	519	889
236	118	1484	155	575	1894	567	913
232	99	1399	181	567	1967	528	948
246	92	1418	179	589	1984	567	933
207	98	1498	172	597	1948	542	867
227	107	1479	183	603	2115	519	948
229	102	1497	168	574	1991	539	913
253	112	1478	162	586	1983	543	888
237	107	1462	209	606	1937	572	954
217	113	1437	168	585	2092	529	869
228	98	1469	189	612	2134	564	912
219	102	1443	177	589	1968	510	885
241	107	1504	169	586	1976	519	888
208	90	1487	208	590	1993	563	914
226	107	1524	184	554	1957	549	928
245	98	1512	168	544	1984	535	914

4.5.2 WLC Method

After we obtain the data, then we calculate the data using WLC method, we have to conduct some steps to obtain the total workload of the system. The steps of the WLC method as follow:

a. Standard Time Calculation

Before determining the time standard predetermined adjustment factor and allowance. The calculation below is one example of the calculation.

1. Adjustment factor
2. Determination of the adjustment factor using the Westing house method because in that method the considered factors are more complete so the results are more accurate.
3. Back cutting process
4. Skill = Advance (A1) = +0,15
5. Effort = Good (C1) = +0,05
6. Condition = Average (D) = 0,00
7. Consistence = Good (C) = +0,01
8. Total = +0,21

So the adjustment factor is = 1 + (0,21) =1,21

1. Allowance

Allowance factor is for personal needs and fatigue

Table 4.7 Allowance factors

Factor		Allowance (%)
Energy released	1	6
Work attitude	2	1
Work motion	2	3

Table 4.7 continued

Eyes Fatigue	2	6
Environment temperature	4	4
Atmosphere condition	3	6
Environment condition	4	4
Personal needs		2,5
Total		32,5

2. Cycle Time

$$T_c = \frac{\sum Xi}{N} \qquad (3.6)$$

$$= \frac{12871}{37} \qquad = 402{,}219 \text{ seconds}$$

3. Normal Time

$$T_n = T_c \times P \qquad (3.7)$$

$$= 402{,}219 \times 1{,}21 \qquad = 486{,}685 \text{ seconds}$$

4. Standard Time

$$Ts = Tn \left[\frac{100\%}{100\% - \%Allowance} \right] \qquad (3.8)$$

$$= 486{,}685 \left[\frac{100\%}{100\% - 32{,}5\%} \right]$$

$$= 721{,}014 \text{ seconds}$$

For the standard time of each process, we can see the table below:

Table 4.8 Standard Time

No	Process	Standard time
1	Cleaning bamboo	569.092
2	Measure bamboo	322.219
3	Cut back	721.014
4	Ass. Back	2866.3
5	Measure legs	183.741
6	Cut legs	356.782
7	Ass. Legs	719.166
8	Frame Assembling	3089.365

Table 4.8 continued

9	Measure rattan	484.784
10	Cut rattan	212.366
11	Ass. Rattan	3013.180
12	Measure back rest	368.938
13	Cut back rest	1211.176
14	Ass. Back rest	4159.207
15	Sanding	1117.85
16	Varnishing	1875.780

The total standard time is 21,271 s

b. Calculate the workload

Calculate the total workload of the overal processes, include the queeing time and material handling time.

$$\boldsymbol{WL_{s,t}^{aggr}} = \sum_{i\epsilon J} \boldsymbol{p_{is}}\ \mathbf{I\ (t)}_{[}t_i^1,\ t_{is}^3{}_{)} \quad (3.9)$$

Where:

J = Number of all orders

P_{is} = Time to process order i at capacity group s

$I(t)_{[...]}$ = Indicator: 1 if the interval is known (otherwise 0 if not known)

t_i^1 = Early release time in order i

t_{is}^3 = Time of completion work order process i at capacity group s.

$$\boldsymbol{WL_{s,t}^{aggr}} = \sum_{i\epsilon J} \boldsymbol{p_{is}}\ \mathbf{I\ (t)}_{[}t_i^1,\ t_{is}^3{}_{)} \quad (3.9)$$

WL = ∑(569,092 + 2830,135 + 322,219 + 7,270+721,014 + 7,216 +2866,3 + 5,703 + 183,741 + 5,567 +356,782 + 5,622+719,166 + 11,189 + 3089,365 + 941,351 + 484,784 + 5,541 + 212,366 + 63,973 + 3013,180 +

1226,784 + 368,938 + 6+1211,176 + 6,459 + 4159,207 + 1140,203 + 1117,85 + 74,648 + 1875,780) $^{I\,(t)[10.00,14.00)}$

= 27608,621 x 1

= 27608,621 seconds/unit

= 460.144 minutes/unit

c. Grouping machine based on OPC

In WLC method, the production line is general flowshop, not pure flowshop. The difference between these line is in general flowshop, the workstation can conduct several process in 1 workstation. If in pure flowshop, the process line is pure only one process in one workstation.

Grouping the Worktation in this research is to minimize the time of the material handling to minimize the workload. Based on OPC, queeing time of the entire process are from washing to next process, back & legs assembly to next process, binding to next process, and final assembly to the next process. Total queeing time is 2843.8125 + 11.28125 + 61.53125 + 1133.82875 = 4050.45375 s.

Based on process similarity, queeing time of the entire process are from washing to the next process, measuring to the next process, cutting to the next process, back & legs assembly to the next process, binding to the next process, and final assembly to the next process. Total queeing time is 2843.8125 + 1233.625 + 11.28125 + 61.53125 + 4.3125 = 4154.5625 s.

Based on the queeing time, the best grouping is based on OPC.

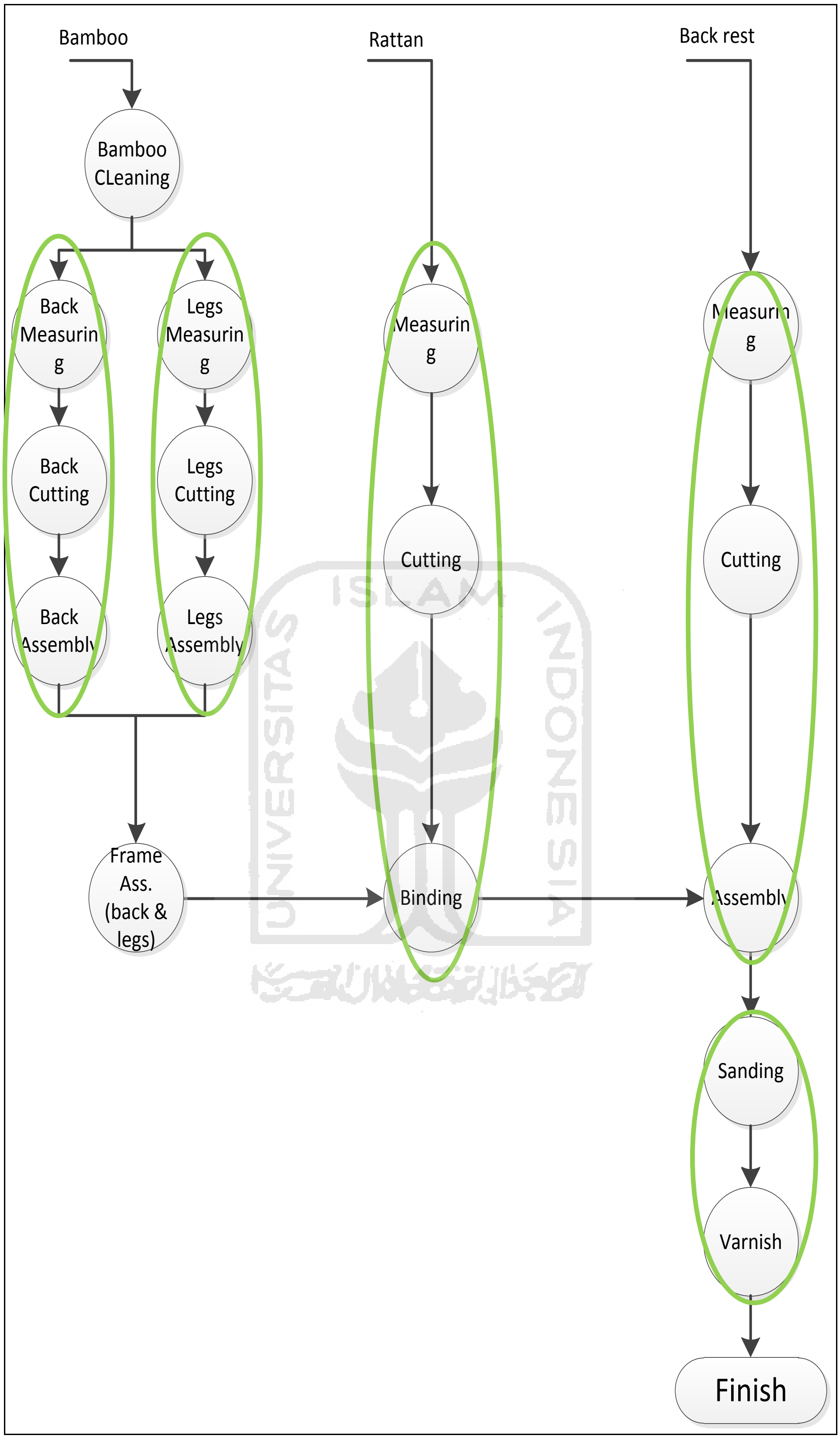


Figure 4.3 Capacity Group based on OPC

Table 4.9 Capacity Group

No	Capacity Group	Process
1	Capacity Group 1	Cleaning bamboo
2	Capacity Group 2	Measure bamboo
3		Cut back
4		Ass. Back
5	Capacity Group 3	Measure legs
6		Cut legs
7		Ass. Legs
8	Capacity Group 4	Ass. Frame
9	Capacity Group 5	Measure rattan
10		Cut rattan
11		Binding
12	Capacity Group 6	Measure back rest
13		Cut back rest
14		Ass. Back rest
15	Capacity Group 7	Sanding
16		Varnishing

Capacity group 1 consists of washing bamboo =569.092 s

Capacity Group 2 Consists of back measuring, back cutting, back assembling, = 5654,0053 s

Capacity Group 3 consists of leg measuring, legs cutting, and legs assembling = 1259.689 s

Capacity group 4 consists of frame assembling = 3089.365 seconds

Capacity group 5 consists of rattan measuring, rattan cutting, and binding = 3710,3305 seconds

Capacity Group 6 consits of back rest measureing, back rest cutting, back rest assembling = 5739.321 s

Capacity group 7 consists of sanding, and varnishing = 2993.63 seconds

Work load calculation after grouping the capacity

Capacity group 1 consists of washing bamboo.

Capacity Group 2 Consists of back measuring, back cutting, back assembling.

Capacity Group 3 consists of leg measuring, legs cutting, and legs assembling.

Capacity group 4 consists of frame assembling.

Capacity group 5 consists of rattan measuring, rattan cutting, and binding.

Capacity Group 6 consits of back rest measureing, back rest cutting, back rest assembling.

Capacity group 7 consists of sanding, and varnishing.

WL = ∑(569,092 + 322,219 + 721,014 + 2866,3 + 183,741 + 356,782 + 719,166 + 3089,365) + 941,351 + (484,784 + 212,366 + 3013,180) + 1226,784 + (368,938 + 1211,176 + 4159,207 + 1117,85 + 1875,780) x $I^{(t)[10.00,14.00)}$

= 23439,094 x 1

= 23439,094 s/unit

= 390,652 minutes/unit

4.5.3 Costs Efficiency

a. Demand Forecasting

Demand forecasting provides the major inputto the other functions operation planning and control system. Then we can convert this forecast into material requirement, labor requirement, schedules, and other decision.

Historical data

The data we gain from the company is from August 2009 until july 2010. The historical data as follow:

Table 4.10 Historical Data

Month	Year	Demand
August	2009	57
September		63
October		71
November		60
December		65
January	2010	58
February		72
March		62
April		70
May		55
June		65
July		59

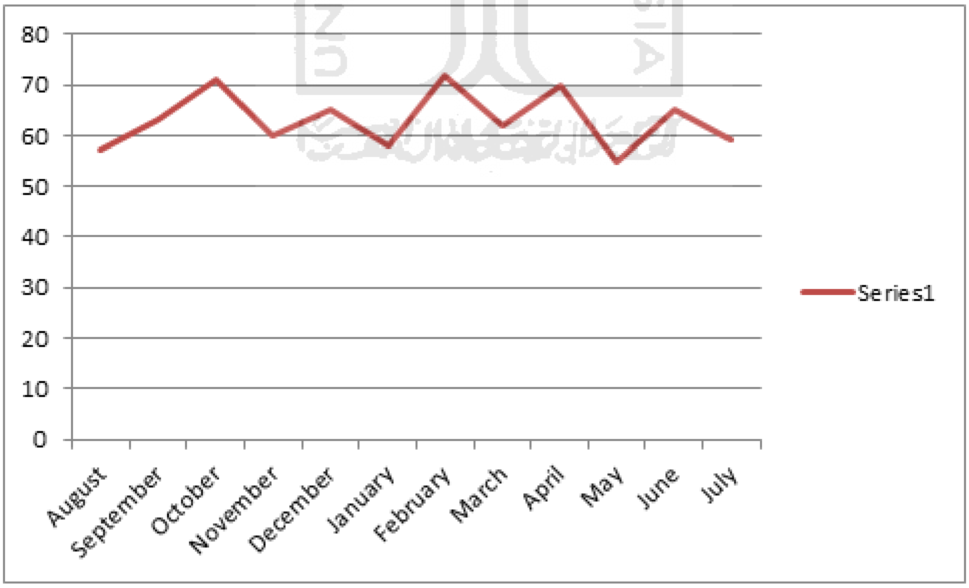


Figure 4.4 Historical Data Pattern

The historical data pattern shows that the data is horizontal or constant. From the historical data pattern, we can use some forecasting method which proper with the data pattern. For constant data, the proper method are simple average (SA), single moving average, or commonly known as moving average (MA), Weighted Moving Average (WMA), Single Exponential Smoothing (SES), and Double Exponential Smoothing (DES). Then after we conduct those method, we decide the best method used based on the Mean Square Error (MSE) and Mean Absolute Deviation (MAD). Demand Forcasting using QS. Software version 3.0.

From the result of data calculation using QS. Software version 3.0, we get the next 6 month demand forecasting. And from the Mean Square Error (MSE) and Mean Absolute Deviation (MAD), we can conclude the best method used for the data is Simple Average (MA) and the demand is 63 units per month.

Table 4.11 Demand Forecasting

No	Method	MAD	MSE	TS	Demand Forecasting (unit)	Best Method
1	(SA)	5,579	40,814	2,304	63,08	(SA)
2	(MA) - 3	5,704	47,580	-1,987	59,67	
3	(MA) - 5	5,914	42,737	-1,318	62,2	

b. Labour Requirement

To know wether the amount of the workers is optimal or not, we need to calculate using Work Load Analysis method.

Table 4.12 Standard Time on Each Capacity Group

No	Capacity Group	Process	Standard time
1	Capacity Group 1	Cleaning bamboo	569.092
2	Capacity Group 2	Measure bamboo	322.219
3		Cut back	721.014
4		Ass. Back	2866.3
5	Capacity Group 3	Measure legs	183.741
6		Cut legs	356.782
7		Ass. Legs	719.166

Table 4.12 continued

8	Capacity Group 4	Ass. Frame	3089.365
9	Capacity Group 5	Measure rattan	484.784
10		Cut rattan	212.366
11		Binding	3013.18
12	Capacity Group 6	Measure back rest	368.938
13		Cut back rest	1211.176
14		Ass. Back rest	4159.207
15	Capacity Group 7	Sanding	1117.85
16		Varnishing	1875.78

Now we calculate the labour requirement capacity group 1

$$\text{WLA} = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker \quad (3.10)$$

$$\text{WLA} = \frac{63\ x\ (\frac{569.092}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 2.45}{168}\ x\ 1\ worker$$

$$= 0.06\ workers \sim 1\ worker$$

Labour requirement in capacity group 2

$$\text{WLA} = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker \quad (3.10)$$

$$\text{WLA} = \frac{63\ x\ (\frac{5654,0053}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 1.03}{168}\ x\ 1\ worker$$

$$= 0.58\ worker \sim 1\ worker$$

Labour requirement in capacity group 3

$$\text{WLA} = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker \quad (3.10)$$

$$\text{WLA} = \frac{63\ x\ (\frac{1259.689}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 2.43}{168}\ x\ 1\ worker$$

$$= 0.135\ worker \sim 1\ worker$$

Labour requirement in capacity group 4

$$WLA = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker \quad (3.10)$$

$$WLA = \frac{63\ x\ (\frac{3089.365}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 2.43}{168}\ x\ 1\ worker$$

$$= 0.321\ worker \sim 1\ worker$$

Labour requirement in capacity group 5

$$WLA = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker$$

$$WLA = \frac{63\ x\ (\frac{3710,3305}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 2.43}{168}\ x\ 1\ worker$$

$$= 0.39\ worker \sim 1\ worker$$

Labour requirement in capacity group 6

$$WLA = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker \quad (3.10)$$

$$WLA = \frac{63\ x\ (\frac{5739.321}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 2.43}{168}\ x\ 1\ worker$$

$$= 0.60\ worker \sim 1\ worker$$

Labour requirement in capacity group 7

$$WLA = \frac{P\ x\ Tst}{AWH}\ x\ 1\ worker \quad (3.10)$$

$$WLA = \frac{63\ x\ (\frac{2993.63}{3600})}{168}\ x\ 1\ worker$$

$$= \frac{63\ x\ 2.43}{168}\ x\ 1\ worker$$

$$= 0.31\ worker \sim 1\ worker$$

Recent workers of the "Muda Kreatif" are 10 persons. Based on calculation, the labour requirement of workers is 7 person.

The wage for the workers is idr 30,000/day. Recent wages for all workers is:

$$\frac{10\ x\ 30{,}000\frac{idr}{day}x\ 24day}{month} = idr\ 7{,}200{,}000/month$$

Based on the WLA calculation, the labour requirement only 7 workers, so the wage si:

$$\frac{7\ x\ 30{,}000\frac{idr}{day}x\ 24day}{month} = idr\ 5{,}040{,}000/month$$

We can reduce the production cost idr 7,200,000 – idr 5,040,000 = idr 2,160,000/month

4.6 Model Simulation

The simulation using ProModel 7.5 student version.

4.6.1 Locations

Assume the locations in this simulation represent the processes. There are 17 locations means there are 17 processes.

Locations

Icon	Name	Cap.	Units	DTs...	Stats	Rules...
	bamboo_cleaning	inf	1	None	Time Series	Oldest
	back_measuring	200	1	None	Time Series	Oldest
	back_cutting	250	1	None	Time Series	Oldest
	back_assembly	100	1	None	Time Series	Oldest
	legs_measuring	200	1	None	Time Series	Oldest
	legs_cutting	250	1	None	Time Series	Oldest
	legs_assembly	200	1	None	Time Series	Oldest
	frame_assembly	1000	1	None	Time Series	Oldest
	measuring_rattan	inf	1	None	Time Series	Oldest
	cutting_rattan	600	1	None	Time Series	Oldest
	binding	1000	1	None	Time Series	Oldest
	measuring_back_rest	200	1	None	Time Series	Oldest
	cutting_back_rest	300	1	None	Time Series	Oldest
	assembly	1000	1	None	Time Series	Oldest
	sanding	1500	1	None	Time Series	Oldest
	varnish	2000	1	None	Time Series	Oldest
	finish	inf	1	None	Time Series	Oldest

Figure 4.5 Locations

4.6.2 Entities

There are 7 kinds of result after each process, until the result is chair or finish product.

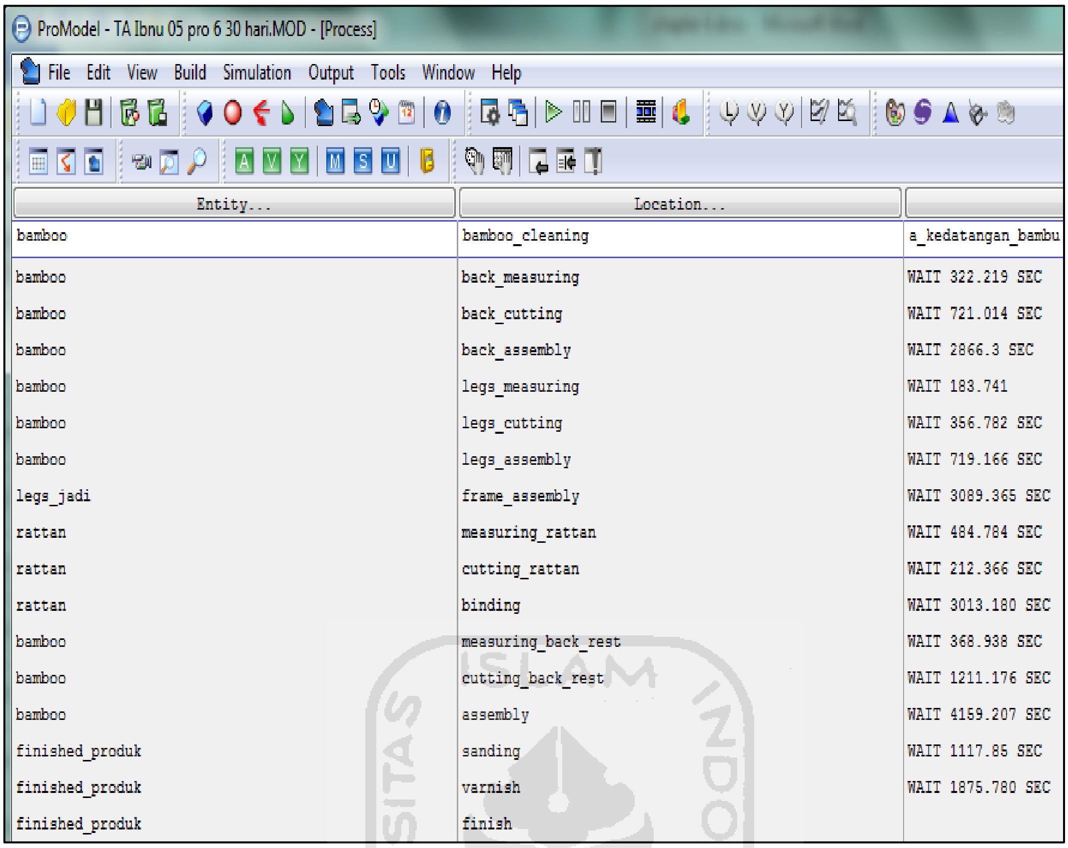
Entities

Icon	Name	Speed (mpm)	Stats
	bamboo	150	Time Series
	rattan	150	Time Series
	back_rest	150	Time Series
	back_jadi	150	Time Series
	legs_jadi	150	Time Series
	frame	150	Time Series
	wip	150	Time Series
	finished_produk	150	Time Series

Figure 4.6 Entitites

4.6.3 Process

Each entitites process requires different time. The data taken from table 4.2 for the process time.



ProModel - TA Ibnu 05 pro 6 30 hari.MOD - [Process]

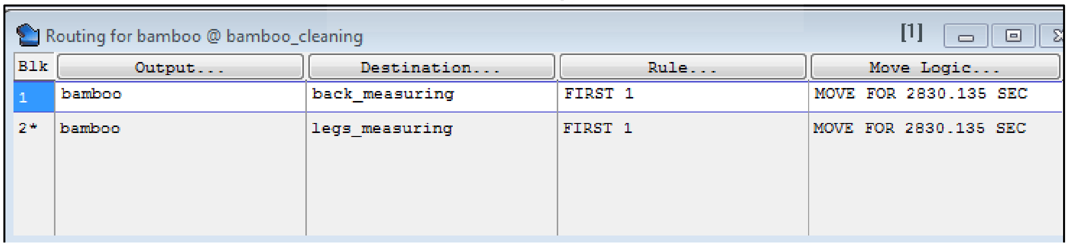
File Edit View Build Simulation Output Tools Window Help

Entity...	Location...	
bamboo	bamboo_cleaning	a_kedatangan_bambu
bamboo	back_measuring	WAIT 322.219 SEC
bamboo	back_cutting	WAIT 721.014 SEC
bamboo	back_assembly	WAIT 2866.3 SEC
bamboo	legs_measuring	WAIT 183.741
bamboo	legs_cutting	WAIT 356.782 SEC
bamboo	legs_assembly	WAIT 719.166 SEC
legs_jadi	frame_assembly	WAIT 3089.365 SEC
rattan	measuring_rattan	WAIT 484.784 SEC
rattan	cutting_rattan	WAIT 212.366 SEC
rattan	binding	WAIT 3013.180 SEC
bamboo	measuring_back_rest	WAIT 368.938 SEC
bamboo	cutting_back_rest	WAIT 1211.176 SEC
bamboo	assembly	WAIT 4159.207 SEC
finished_produk	sanding	WAIT 1117.85 SEC
finished_produk	varnish	WAIT 1875.780 SEC
finished_produk	finish	

Figure 4.7 Process

4.6.4 Routing

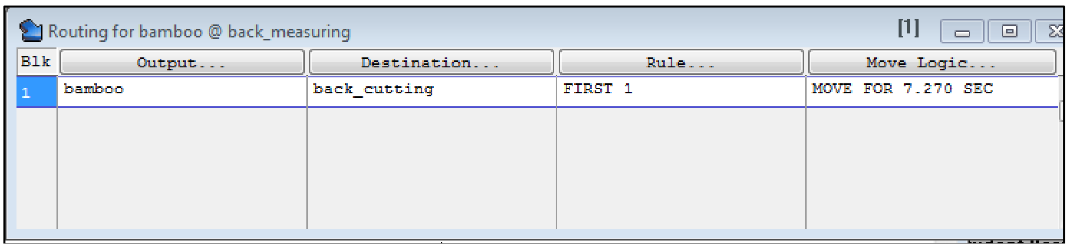
The routing for the model simulation using queei and material handling data in table 4.3.



Routing for bamboo @ bamboo_cleaning [1]

Blk	Output...	Destination...	Rule...	Move Logic...
1	bamboo	back_measuring	FIRST 1	MOVE FOR 2830.135 SEC
2*	bamboo	legs_measuring	FIRST 1	MOVE FOR 2830.135 SEC

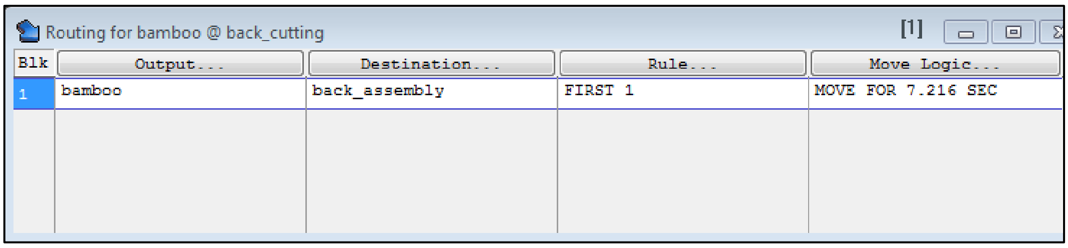
Figure 4.8 Routing to back measuring



Routing for bamboo @ back_measuring [1]

Blk	Output...	Destination...	Rule...	Move Logic...
1	bamboo	back_cutting	FIRST 1	MOVE FOR 7.270 SEC

Figure 4.9 Routing to back cutting



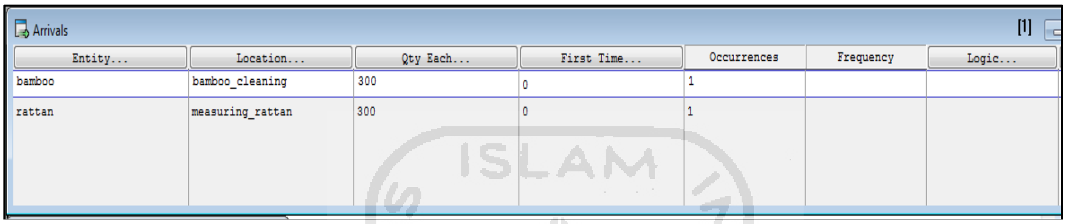
Routing for bamboo @ back_cutting

Blk	Output...	Destination...	Rule...	Move Logic...
1	bamboo	back_assembly	FIRST 1	MOVE FOR 7.216 SEC

Figure 4.10 Routing to back assembly

4.6.5 Arrivals

The arrivals is for the raw materials, in this case is for bamboo and rattan.



Arrivals

Entity...	Location...	Qty Each...	First Time...	Occurrences	Frequency	Logic...
bamboo	bamboo_cleaning	300	0	1		
rattan	measuring_rattan	300	0	1		

Figure 4.11 Arrivals

4.6.6 Simulation run

After build all element of the simulation and isert the data, the we run the simulation.

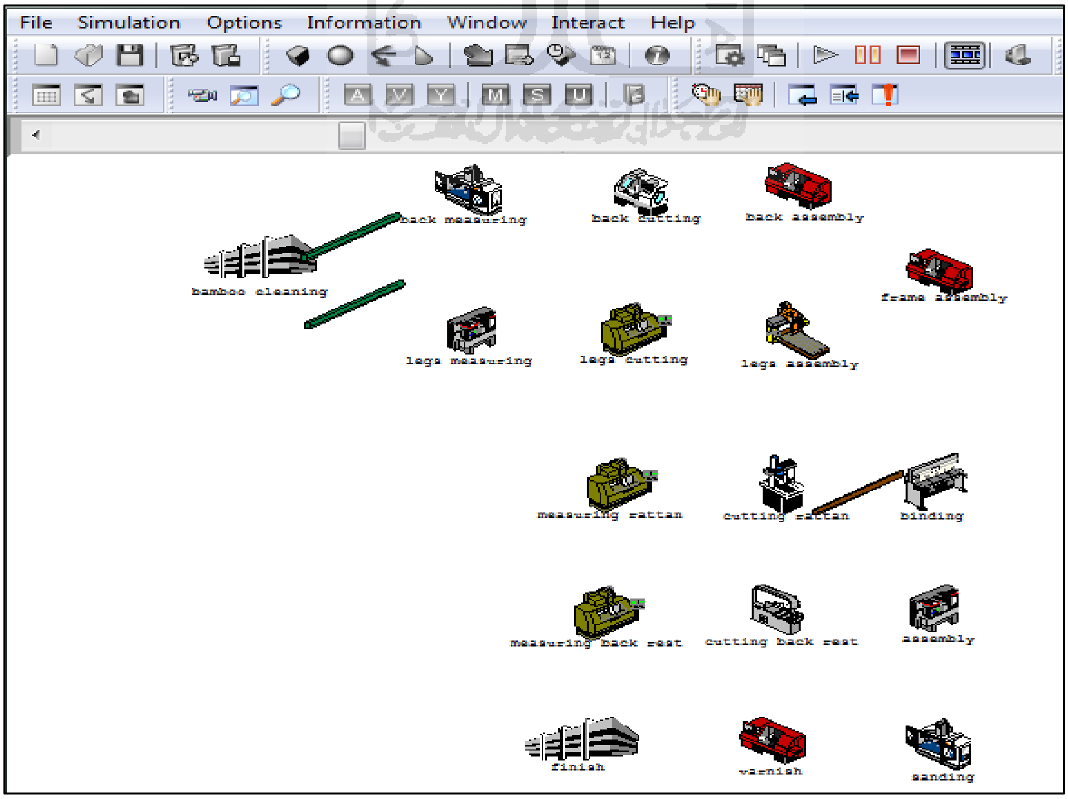


Figure 4.12 Simulation Run

4.6.7 Reports

The result of the simulation after we build the model and input the data is shown as follow:

General Report (Normal Run - Rep. 1)

General | Locations | Location States Multi | Entity Activity | Entity States

TA Ibnu 05 pro 6 30 hari.MOD (Normal Run - Rep. 1)

Name	Total Exits	Current Qty In System	Avg Time In System (MIN)	Avg Time In Move Logic (MIN)	Avg Time Waiting (MIN)	Avg Time In Operation (MIN)
bamboo	0.00	24.00	0.00	0.00	0.00	0.00
rattan	0.00	208.00	0.00	0.00	0.00	0.00
back rest	0.00	0.00	0.00	0.00	0.00	0.00
back jadi	92.00	0.00	375.27	47.50	0.00	74.64
legs jadi	0.00	0.00	0.00	0.00	0.00	0.00
frame	92.00	0.00	390.95	68.61	0.09	262.65
wip	92.00	0.00	391.06	21.61	307.60	61.84
finished produk	92.00	0.00	461.21	74.00	232.18	155.03

Figure 4.13 Reports

CHAPTER V

DISCUSSION

Reduce the workload on workload centre based on mathematical model formulation has been built in previous that used in on workload centre analysis. Thus mathematical model not instantly can be applied in real condition at Karya Muda SME because have to change and effects current system which is running, so the simulation is conducted. The mathematical modeling to minimize the workload centre by grouping some processes into several workstation which have function similarities based on operation process chart, so that will eliminate some routes and reduce the workload in the system. Some routes eliminated in the system for example from back measuring to back cutting, and from back cutting to back assembly, will reduce the material handling and transfer time. There are many routes eliminated because of the grouping, and reduce more times. From 19 locations, the grouping converts them into 7 capacity groups. Before conduct the grouping the processes into several capacity groups, the workload for the whole processes is 460,144 minutes / unit, and after grouping the capacity group, the workload for the whole processes is 390,652 minutes/unit.

Main objective of a commercial company is profit, and one way to maximize the profit is by minimize the cost. The research accomplished using workload control method by grouping the processes based on operation process chart makes workstation in the system is lesser than current system and also makes the workload reduce. The effect is the number labour requirement on the workshop. After calculating the workload and use it to find the optimal number of worker using workload analysis. The number of the worker available in current system is 10 workers, after calculate the optimal number of worker considering the workload after grouping the processes is 7 persons using WLA calculation, so the labor cost can be reduce from 10 person wage become 7 persons wage. In the case of Muda Karya SME, the labor cost reduce from 7,200,000 idr / month become 5,040,000 idr / month. The production cost is reduce as much as 2,160,000 idr/ month from reducing labor cost only. If we consider the transfer and material handling cost, the minimizing will be greater.

CHAPTER VI

CONCLUSSION AND RECOMMENDATION

6.1 Conclusion

According to the discussion in chapter V, some conclusions can be established is as follow:

To determine the employee requirement is to consider and calculate the workload in the workstation. To reduce the workload in flowshop manufacturing SMEs, we can use workload control (WLC) method. One of the ways to conduct WLC method is by grouping some processes into capacity groups based on operation process chart, in order eliminate minimize the route of the material handling from one workstation into another workstation in the workshop. Before grouping, the workload is 460,144 minutes / unit and after grouping, the workload is 390,652 minutes/unit.

The employee requirement number in this research after conducting the Workload Control is 7 employees, compared with the actual employees of 10 persons. From the labor cost itself the SME can reduce labor cost for 2,160,000 idr / month.

6.2 Recommendation

Some recommendations after conducting this research described as follow:

1. The grouping in this research is based on the operation process chart. The other researcher can consider other option such as based on the material handling cost or based on the workshop layout.

2. For further research find the alternative way to conduct the WLC method besides grouping the processes into several workstations. For example how to manage the information feedback in order to make the information flow fluently, indirectly minimize the workload.

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APPENDICES

Appendix Simulation Validation

data hitoris	
Mean	63.08333333
Standard Error	1.635118073
Median	62.5
Mode	65
Standard Deviation	5.664215156
Sample Variance	32.08333333
Kurtosis	-1.08778264
Skewness	0.34022914
Range	17
Minimum	55
Maximum	72
Sum	757
Count	12
Largest(1)	72
Smallest(1)	55
Confidence Level(95.0%)	3.598870613

data simulasi	
Mean	63.25
Standard Error	1.059766984
Median	64
Mode	64
Standard Deviation	3.671140521
Sample Variance	13.47727273
Kurtosis	-0.084559319
Skewness	-0.754896794
Range	12
Minimum	56
Maximum	68
Sum	759
Count	12
Largest(1)	68
Smallest(1)	56
Confidence Level(95.0%)	2.332531405

Delsim Laboratory

PENGUMPULAN DATA DAN ESTIMASI DISTRIBUSI

Hari	Produk
1	57
2	63
3	71
4	60
5	65
6	58
7	72
8	62
9	70
10	55
11	65
12	59

Frekuensi Relatif Untuk Produk Box

Produk Box	Comulative Frequency	Relative Frequency
55	1	1
57	2	1
58	3	1
59	4	1
60	5	1
62	6	1
63	7	1
65	9	2
70	10	1
71	11	1
72	12	1
Total	70	12

Hasil Simulasi Promodel 6.0

Hari	Produk
1	67
2	60
3	56
4	64
5	62
6	65
7	64
8	64
9	64
10	68
11	67
12	58

Frekuensi Relatif Untuk Produk Box

Produk Box	Comulative Frequency	Relative Frequency
56	1	1
58	2	1
60	3	1
62	4	1
64	8	4
65	9	1
67	11	2
68	12	1
68	12	0
Total	62	12

c. Z Hitung

$$Sp^2 = \frac{(n_1-1)\,V_1^2 + (n_2-1)\,V_2^2}{n_1 + n_2 - 2}$$

Sp^2 = 22.78030303

$$Z\ hitung = \frac{Mean\ 1 - Mean\ 2}{\sqrt{Sp^2 * (1/n_1 + 1/n_2)}}$$

Z hitung= 0.00581993

d. Kesimpulan

Karena - Z 0.025 < Z hitung < Z 0.025

Yaitu

- Z 0.025 < 0.00581993 < Z 0.025

Maka Ho tidak ditolak, berarti tidak cukup bukti untuk menyimpulkan bahwa rata - rata pada sistem nyata berbeda dengan rata - rata hasil simulasi

c. F Hitung

$$F\ Hitung = \frac{V_1\ ^\wedge 2}{V_2\ ^\wedge 2}$$

F Hitung = 0.420071

d. Kesimpulan

Karena F Tab 0,975 < F hitung < F tab 0,025

Yaitu

0.288 < 0.420071 < 3.474

Maka Ho tidak ditolak, berarti tidak cukup bukti untuk menyimpulkan bahwa variansi pada sistem nyata berbeda dengan variansi hasil simulasi

Produk Box	Relative Frequency	
	Historis (Expected)	Simulasi (Actual)
55	1	0
56	0	1
57	1	0
58	1	1
59	1	0
60	1	1
62	1	1
63	1	0
64	0	4
65	2	1
67	0	2
68	0	1
70	1	0
71	1	0
72	1	0
Total	12	12

Produk Box	Relative Frequency	
	Historis (Expected)	Simulasi (Actual)
55-62	6	4
63-72	6	8
Total	12	12

Probabilitas	0.2482
Chi Kuadrat Hitung	4.1256
Chi Kuadrat Tabel	7.8147

ANALISA HASIL

H_0 : Data Hasil Simulasi Sesuai dengan Data Sistem Nyata

H_1 : Data Hasil Simulasi Tidak Sesuai dengan Data Sistem Nyata

Jika X2 Hitung < X2 Table, H0 Diterima

Jika X2 Hitung > X2 Table, H0 Ditolak

KESIMPULAN

Data Hasil Simulasi **accepted** **Data Sistem Nyata**

UNIVERSITAS ISLAM INDONESIA

Delsim Laboratory

Kepada Yth :
Kepala Laboratorium Pemodelan dan Simulai Industri (DELSIM)
Teknik Industri
Universitas Islam Indonesia
Di tempat

Perihal : Permohonan Penelitian di Laboratorium

Assalamu'alaikum Wr.Wb.

Dengan hormat,

Dengan ini saya yang bertanda tangan di bawah ini :

Nama : Ibnu Sandy Ardiansyah

NIM : 05 522 151

Judul Penelitian : Calculating workload Control to minimize cost

Alat : Komputer + Software ProModel 7 (license)

Bermaksud untuk meminjam fasilitas Laboratorium DELSIM dan Asisten Pembimbing Lab.DELSIM dalam rangka T A mulai 31 Maret s/d 04 April 2011.

Saya bersedia untuk mengikuti segala peraturan yang telah di tetapkan di Laboratorium DELSIM. Atas perhatiannya tidak lupa saya ucapkan banyak tarima kasih.

Wassalamu'alaikum Wr.Wb.

Mengetahui,
Kepala Lab.DELSIM

Nur Cahyo

(Winda Nur Cahyo,ST,MT)

Hormat saya,
Yogyakarta,30 Maret 2011

(Ibnu Sandy Ardiansyah)