CHAPTER I
INTRODUCTION

This chapter contains the background, problem formulation, research objective, assumption, and outline of the report.

1.1 Background

Scheduling is a process of machine resource allocation to select a set of task within a certain period. This concept can be explained into two different meanings. First, scheduling is a function of decision-making, which is to determine the most appropriate schedule. Second, scheduling is a theory that contains a set of principles, models, techniques, and logical conclusions in the decision-making process (Baker and Trietsch, 2009). Scheduling in the world industry, both the manufacturing and services industry has an important role as a decision-making. The company seeks to have the most effective and efficient scheduling by increase the productivity with minumum total cost and time. Modern manufacturing systems prioritize effective and efficient production floors. One aspect to improve it, by increasing the performance of production output. Then, scheduling for each machine must be done effectively and efficiently (Kaban, et al., 2012).

PT Semen Padang is one of the manufacturing industries engaged in the cement industry. The total production capacity of PT Semen Padang reaches 8.9 million tons/year. PT Semen Padang currently has five operating plants, namely, Indarung II with a production capacity of 720,000 tons/year, Indarung III amounted to 860,000 tons/year, Indarung IV amounted to 1,920,000 tons/year, Indarung V of 3,000,000 tons/year, Indarung VI of 1,500,000 tons/year, CM Dumai 900,000 tons/year (Annual Report of PT Semen Padang, 2017). The production process in PT Semen Padang is generally divided into three stages: Raw Mill stage (RM), Kiln Coal Mill stage (KCM), and Cement Mill stage (CM). The raw materials used in the cement production are limestone, silica, clay, sand,

and iron. The raw material will be mixed at RM stage and produce the rawmix, then enter to the second stage (KCM stage). At KCM stage, material that comes from the RM stage will be burned in the combustion tool called Kiln. Kiln has fuel in the form of residual oil and natural gas (pulverized coal). PT Semen Padang uses coal in combustion rawmix that will produce clinker at KCM stage. Coal as fuel is still in the form of raw coal. Coal Mill machine is needed to destroy raw coal into small parts and dry them to become a fine coal. Each plants of PT Semen Padang at least have a Coal Mill to support the coal grinding process. **Table 1.1** is specification of Coal Mill machine for Indarung II/III and IV.

Table 1.1 Specification of Coal Mill Machine for Indarung II/III and IV

Machine	Plant	Design Capacity	Max. Total Moisture (TM) of Raw Coal	Max. Ash Content of Raw Coal
Coal Mill 2K1	Indarung II/III	15 tons/hour	5-8 %	5-8 %
Coal Mill 3K2				
Coal Mill 4K2	Indarung IV	50 tons/hour	30 %	17 %

Table 1.1 shows that each Coal Mill have different specification. The design capacity of Coal Mill is the theoretical maximum output of the system at a given period with ideal conditions. For example, Coal Mill 2K1 and Coal Mill 3K2 in Indarung II/III has a design capacity of 15 tons/hour to produce the clinker if the maximum total moisture and ash content of raw coal amounted to 5-8 %. The actual capacity will decrease if the total moisture and ash content are more than its specification. Currently, the specification of raw coal in PT Semen Padang is 28% of total moisture and 15% of ash content. This specification make Coal Mill 2K1 and 3K2 can not produce the fine coal as much as its capacity. To optimize the plants, Coal Mill 4K3 present in Indarung IV in 2013 with design capacity is 75 tons/hour, total moisture of raw coal is 30% and maximum ash content of raw coal is 17%. Moreover, Coal Mill 4K3 can produce the fine coal with maximum total moisture of fine coal is 12%, this value is smaller than the fine coal produced from Coal Mill 4K2, which is 20%. Fine coal which has a

lower total moisture is a better fine coal. With design capacity and advantages in producing fine coal, Coal Mill 4K3 is expected to be able to fulfill the amount of fine coal required in Indarung II/III and IV, so the Coal Mill 2K1, 3K2, and 4K2 do not need to operate and minimize the company's operational costs.

Coal Mill machine produce fine coal which will be used as fuel in the Kiln machine. The amount of fine coal requirements in KCM stage depends on the number of Corporate Budget Work Plan of clinker or *Rencana Kerja Anggaran Perusahaan klinker* (Clinker's RKAP). The theoretical fine coal quantity can be determined using the **Equation 1.1**.

$$FC = \frac{HC \times K}{CV} \quad \text{... (1.1)}$$

FC is theoretical fine coal quantity, HC is the heat consumptions of Kiln, K is the number of clinker's RKAP, and CV is the calorific value of fine coal. When the material (raw coal) is good, the calorific value will also be large, and reduce the amount of fine coal requirements, because the material is easy to burn. According to the **Equation 1.1**, theoretical fine coal quantity has linear relation with the clinker's RKAP, and the linearity can be proofed by compered the theoretical fine coal quantity and clinker's RKAP. Comparison between clinker's RKAP and theoretical fine coal quantity in Kiln Indarung II/III and IV can be seen in **Table 1.2**.

Table 1.2 Comparison Between Clinker's RKAP and Theoretical Fine Coal Quantity in Kiln Indarung II/III and IV
(Source: PT Semen Padang, 2019)

Month	Indarung II		Indarung III		Indarung IV	
	Clinker's RKAP (ton)	Theoritical Fine Coal Quantity (ton)	Clinker's RKAP (ton)	Theoritical Fine Coal Quantity (ton)	Clinker's RKAP (ton)	Theoritical Fine Coal Quantity (ton)
Jan-19	0	0	37,800	5,400	103,500	16,634
Feb-19	0	0	33,600	4,800	9,000	1,447
Mar-19	0	0	0	0	126,000	20,250
Apr-19	43,200	6,172	0	0	121,500	19,527
May-19	44,800	6,400	0	0	126,000	20,250
Jun-19	43,200	6,172	0	0	121,500	19,527
Jul-19	44,800	6,400	44,800	6,400	126,000	20,250

Coal Mill 4K3 produces fine coal which will be transferred to the Kiln in Indarung II/III and IV. This transfer is carried out by the Central Control Room (CCR) operator. The operator will transfer the fine coal and fill the Kiln bin (a fine coal shelter as fuel in the Kiln) with an incorrect time and amount. The operator will estimate the time and number of transfers without a certain scheduling. This results in troubleshooting, which causes the actual fine coal transferred does not match with theoretical fine coal quantity. This difference causes the clinker produced to be incompatible with the clinker's RKAP. The total of the deviation between actual and theoretical fine coal quantity, and the impact of the deviation between clinker production and clinker's RKAP in Indarung II/III and IV can be seen in **Table 1.3** to **Table 1.5**.

Table 1.3 Deviation in Indarung II PT Semen Padang

Month	Indarung II				Deviation
	Clinker's RKAP (ton)	Theoretical Fine Coal Quantity (ton)	Actual Fine Coal Quantity (ton)	Clinker Production (ton)	
Jan-19	0	0	0	0	0
Feb-19	0	0	0	0	0
Mar-19	0	0	287	2,003	100%
Apr-19	43,200	6,172	4,497	31,478	27%
May-19	44,800	6,400	5,747	40,227	10%
Jun-19	43,200	6,172	0	0	100%
Jul-19	44,800	6,400	0	0	100%
Average					**48%**

Table 1.4 Deviation in Indarung III PT Semen Padang

Month	Indarung III				Deviation
	Clinker's RKAP (ton)	Theoretical Fine Coal Quantity (ton)	Actual Fine Coal Quantity (ton)	Clinker Production (ton)	
Jan-19	37,800	5,400	7,352	51,459	36%
Feb-19	33,600	4,800	3,986	27,898	17%
Mar-19	0	0	4,826	33,782	100%
Apr-19	0	0	0	0	0%
May-19	0	0	0	0	0%
Jun-19	0	0	0	0	0%
Jul-19	44,800	6,400	0	0	100%
Average					**36%**

Table 1.5 Deviation in Indarung IV PT Semen Padang

Month	Indarung IV				Deviation
	Clinker's RKAP (ton)	Theoretical Fine Coal Quantity (ton)	Actual Fine Coal Quantity (ton)	Clinker Production (ton)	
Jan-19	103,500	16,634	21,580	134,270	30%
Feb-19	9,000	1,447	2,292	14,260	58%
Mar-19	126,000	20,250	15,191	94,516	25%
Apr-19	121,500	19,527	11,255	70,029	42%
May-19	126,000	20,250	20,304	126,332	0%
Jun-19	121,500	19,527	12,984	80,789	34%
Jul-19	126,000	20,250	11,161	69,442	45%
Average					**33%**

Table 1.3 to **Table 1.5** shows that the theoretical and actual fine coal quantity is not same which will cause the amount of clinker production not in accordance with the clinker's RKAP. Lack and excess production occur either on Indarung II/III or Indarung IV, and make deviation about 48% in Indarung II, 36% in Indarung III, and 33% in Indarung IV. The deviation make some disadvantages for company, the lack of production will have an impact on demand and consumer satisfaction, while excess production will also impact on the increase in inventory costs, especially when the demand is decrease. Because of the impact, company should minimize the number of deviation between theoretical and actual fine coal quantity, to make the amount of clinker production in accordance with clinker's RKAP. The way to achieve that, by create the fine coal transfer scheduling model from Coal Mill 4K3 machine to Kiln Indarung II/III and IV in PT Semen Padang that will be used by the operator.

1.2 Problem Formulation

Problem formulation in this research is how to make a fine coal transfer scheduling model from Coal Mill 4K3 machine to Kiln Indarung II/III and IV in PT Semen Padang to minimize the number of deviation between theoretical and actual fine coal quantity, so the amount of clinker production in accordance with clinker's RKAP.

1.3 Research Objective

The objective of this research is to propose a fine coal transfer scheduling model from Coal Mill 4K3 machine to Kiln Indarung II/III and IV in PT Semen Padang to minimize the number of deviation between theoretical fine coal quantity and actual fine coal quantity, so the amount of clinker production in accordance with clinker's RKAP.

1.4 Assumption

The assumptions in this research are as follows:

1. Coal Mill 4K3 and Kiln machine always under normal circumstances, not any disruption or damage.
2. Coal Mill 4K3 always stand by without stopping.

1.5 Outline of the Report

This final project report consists of six chapters as follow:

CHAPTER I INTRODUCTION

The first chapter introducing the subject to be discussed. The chapter contains of background, problem formulation, research objective, assumption, and outline of the report.

CHAPTER II LITERATURE REVIEW

The second chapter provides an overview and justification to the necessary and make this subject as basic research in finding answers to questions that arise. This chapter contains theories that support and previous research such as, scheduling (scheduling objectives, the term in scheduling, and types of scheduling), linear programming (introduction of linear programming, the term in linear programming, general form of linear programming, linear programming solving techniques, and result of linear programming), integer programming, nonlinear programming, system modeling (stage of system modeling, problem situation, influence diagram, process of modeling, and mathematical modeling), Lingo, and previous research.

CHAPTER III RESEARCH METHODOLOGY

The third chapter discusses the research framework and methodology. Discussions focus on the conceptual framework and research methodology used in this study. This chapter contains the steps in carrying out the research started from preliminary study and literature study, problem identification, scheduling model formulation (system characteristic, using forecasting to get input data, determination of forecasting to get input data, influence diagram, mathematical model formulation, determining decision variables, determining the objective function, determining the constraint, model verification and validation), application of the model using Lingo software, analysis, and conclusion.

CHAPTER IV MATHEMATICAL MODEL FORMULATION

The fourth chapter explains the problem overview, system characteristic, influence diagram, notations, symbols, and units used in the mathematical model, formulation of the mathematical model, verification and validation of the mathematical model.

CHAPTER V APPLICATION OF THE MODEL AND ANALYSIS

The fifth chapter contains the application of the model and analysis. Application of the model performed to estimate the practical value of the model using Lingo software. The analysis of results presented in this chapter.

CHAPTER VI CONCLUSION

The sixth chapter contains the conclusion of the research and suggestion for further research.