CHAPTER 1
INTRODUCTION

This chapter explains the background of this research including the short review on previous researches and their differences to this research in economic lot scheduling problem (ELSP) context. This chapter also explains the formulation of the problem and the objectives of this research in order to solve the problem. Later in this chapter is also explained about the scope of the research and the limitations that narrow the scope.

1.1. Background

According to Bomberger (1966), economic lot scheduling problem (ELSP) is a problem of scheduling production of several different items over the same facility on a repetitive basis. ELSP has been around since 1950's and is continually being the focus of researchers because of its complexity. Elmaghraby (1978) has defined ELSP as a problem to accommodate cyclical production patterns based on Economic Manufacturing Quantity calculations when several products are made on a single facility. Elmaghraby (1978) also noticed that there are two main approaches on ELSP researches which are analytic and heuristic. The analytical approach provides *optimum* solution of a restricted version of the original problem while the heuristic approach provides *good* solution of the original problem.

Chan *et al*. (2012) have shown that recent researches on ELSP have been diversified into several focuses such as imperfect production process, return and flexible rate. This happens as the result of difficulties found to develop the research towards analytical approach. Researchers have released some of the assumptions of ELSP such as the deterministic nature of demand and production rate, single facility to be multiple facilities, or even the imperfection of the product produced. McKay (1999) dissertation on economic lot scheduling with stochastic demands and lost sales was an example of ELSP research which released the deterministic assumption of ELSP demand rate. Tang and Teunter (2006) emphasized the ELSP trend with return.

In the ELSP in imperfect production system context, there are factors influencing the production process to shift from in-control to out-of-control condition. This research focuses on imperfect production system that causes defected produced item. This defected item raises quality-related cost. Ben-Daya and Hariga (2000) have done the research on ELSP with imperfect production system in a single facility. Moon, Giri and Choi (2002) have also expanded the research of ELSP on imperfect production system and setup times. Both researches took into account the effect of imperfect quality of the product to the production schedule.

To specify the scope, this research considers two key modules (KMs) over an infinite planning horizon. This consideration of two key modules has never been discussed before in the ELSP context. Key module refers to a certain subsystem of the production system such as the electrical subsystem or mechanical subsystem. These key modules are imperfect; or in other words, may shift from in-control to out-of-control state. It is assumed that each key module has its own probability to shift from in-control to out-of-control condition following a certain probability function at a random time. This research contributes to the operation management science by releasing the perfect production system assumption with two key modules. Three common ELSP approaches used in this research are the Independent Solution (IS) as the Lower Bound to the solution, Common Cycle (CC) as the upper bound to the solution and Basic Period (BP). These three approaches are modeled in the spreadsheet to give better illustration.

1.2. Problem Formulation

The problem of this ELSP research is to find production cycle time (T_i) for *n* number of items produced on two key modules (KMs) in imperfect production system that minimize the expected total cost *C* while satisfying the demand.

The objective is to minimize expected total cost *C* which covers:

- Setup cost
- Holding cost
- Quality-related cost including cost of producing defective product

where:

i	item index, i=1, 2,…, N
d_i	demand rate in units per unit time, assumed to be deterministic
p_i	production rate in units per unit time, assumed to be constant
ρ_i	$\rho i = \frac{d_i}{p_i}$
τ_i	$\tau_i = \rho_i T_i$, processing time per lot
σ_i	$\sigma_i = s_i + \tau_i$, total production time per lot

s_i	setup time per unit of time per production lot, independent of sequence
A_i	setup cost per production lot
h_i	holding cost per unit per unit time
u_i	constant cost of producing defective product
T_i	cycle time for item *i*.

There are basically four states that may occur on the two KMs, which are:

a. State O

This state occurs when both KMs are in-control.

b. State A

When the shock comes from the first KM, it becomes out-of-control and is shifted from the state O to the state A. The first KM may shift to state A at a random time with the time-to-shift (X) is an exponentially distributed random variable with mean $1/\mu$.

c. State B

When the shock comes from the second KM, it becomes out-of-control and is shifted from state O to the state B. The second KM may shift to state B at a random time with the time-to-shift (Y) is an exponentially distributed random variable with mean $1/\gamma$.

d. State AB

State AB happens when the third shock comes from either the first or second KM given that the other KM has been out-of-control.

The assumptions employed in this problem are (Bomberger, 1966):

a. only one item can be processed by the facility
b. setup cost and setup time are required for producing each item, and they are known and independent of the production sequence
c. holding cost is known and constant
d. demand rate and production rate are constant and known over an infinite planning horizon, and
e. backorder is not allowed which means all demand must be satisfied.

1.3. Objectives

The objectives of this research are:

a. To model the effect of imperfect production system on lot sizing decision in economic lot scheduling problem with two key modules (KMs)

b. To develop spreadsheet model to solve the economic lot scheduling problem in perfect production system, imperfect production system with one key module and imperfect production system with two key modules (KMs)
c. To formulate the formula to calculate the cycle time *T* for imperfect production system with two key modules (KMs) under the Independent Solution (IS) and Common Cycle (CC) approaches.

1.4. Scope and Limitations

The scope and limitations of this research are as follows:

a. Production and demand rate are known and assumed deterministic.
b. Setup cost and setup time are independent of production sequence.
c. The economic lot scheduling problem in this research is assigned for production system with two key modules (KMs).
d. The outputs of the problem analysis by using IS, CC and BP approach are the cycle time T_i for each item
e. The data used for the model explanation in perfect production system is taken from Bomberger's stamping problem (Bomberger, 1966).
f. The data used for the model explanation in imperfect production system with one key module is the modification from Bomberger's stamping problem (Bomberger, 1966) by considering imperfect production system parameters.
g. The data used for the model explanation in imperfect production system with two key modules is the modification from Bomberger's stamping problem (Bomberger, 1966) by considering imperfect production system parameters with two key modules.
h. Time to shift of first and second key module in imperfect production system with two key modules context are assumed to be independent to each other.
i. The approaches used for obtaining the solutions in perfect system are Independent Solution (IS) as the Lower Bound, Common Cycle (CC) as the Upper Bound and Basic Period (BP).
j. The approaches used for obtaining the solutions in imperfect system with one and key modules are Independent Solution (IS) as the Lower Bound and Common Cycle (CC) as the Upper Bound..