CHAPTER III
MANUFACTURING PROCESS ANALYSIS

3.1 Overview of the studied maize drying process

Figure 3.2 represents the maize drying process in the factory that is selected as a case study in this research. The objective of the maize drying process is to dry maize sheaths and produce maize seeds that meet specification required by customers. There are 6 major workstation units in the manufacturing process. These include (i) loading and inspection workstation unit which is based on the material handling system such as conveyer belts, (ii) drying room workstation unit which consists of 24 identical pattern rooms, (iii) furnace or fuel burner workstation unit that is operated by a worker per shift (two shifts per day), (iv) maize milling workstation unit, (v) maize packing workstation unit, and (vi) warehouse unit.

3.1.1 Loading and inspection workstation unit

This unit is responsible for loading maize sheaths purchased from farmers through the purchase department of the factory. Typically purchased maize sheaths have humidity about 30-60 % by weight. In this unit, maize sheaths are loaded from a truck through a conveying belt. Then size and defection selection will be carried out manually. Operators select defect maize sheaths and impurities out of the loaded maize sheaths on the conveying belt. Only good maize sheaths are passed to the next workstation unit (drying room work station unit). For bad maize sheaths, they are typically thrown away from this workstation unit and used as fuel at the furnace workstation unit.

Figure 3.1: Maize loading unit and conveyor belts

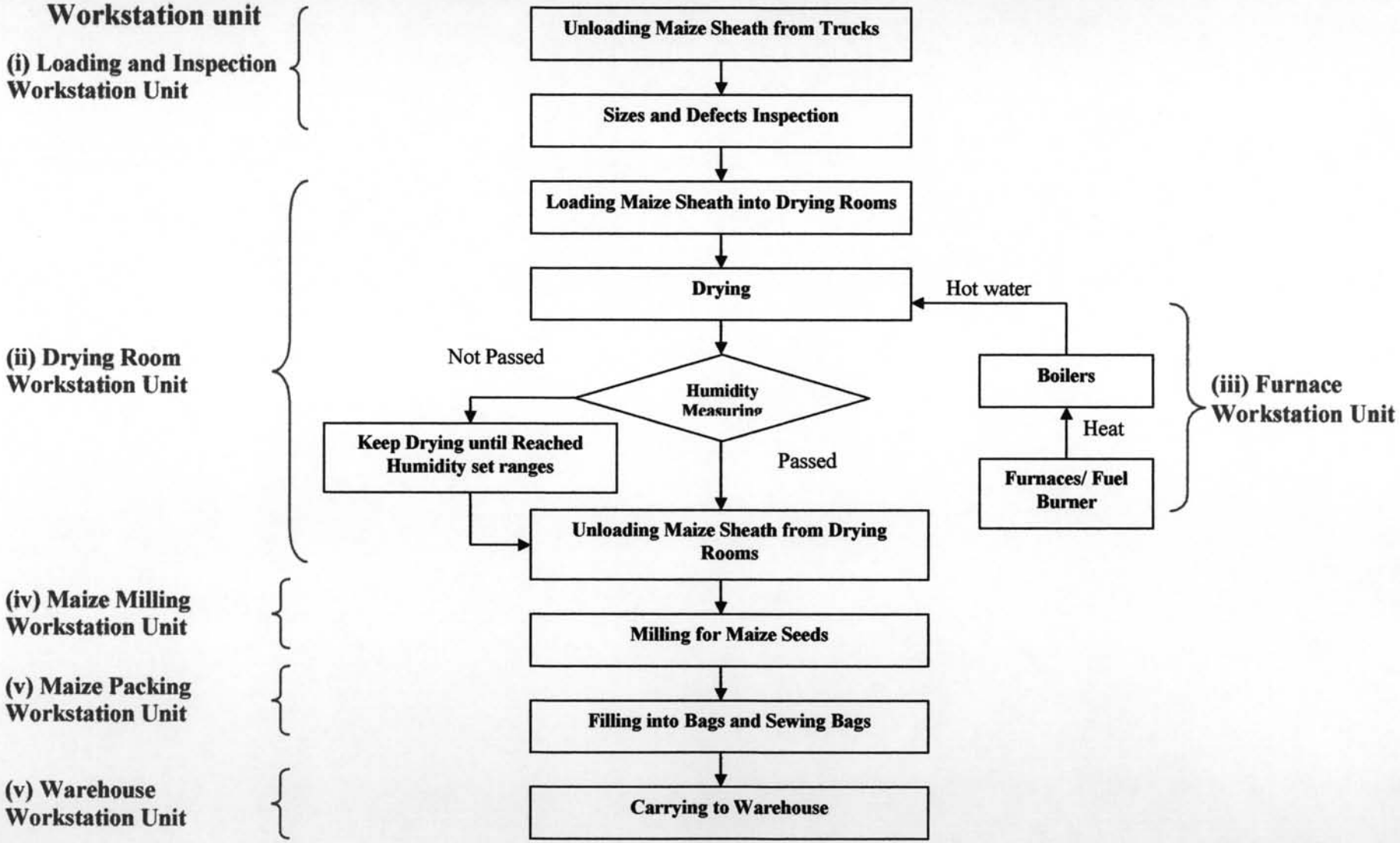

Figure 3.2: Maize drying process of the studied factory

3.1.2 Drying room workstation unit

This unit is considered as the most important unit of the factory. It has a duty to dry maize sheaths from initial humidity about 30-60% to the required humidity about 12-13%. The drying time is varied according to the initial and final humidity required. The drying takes place in 24 identical drying rooms. In each room, maize sheaths are loaded in trays and placed inside the room. Hot water is pumped and flows into pipes located in each drying room. Hot water is generated from furnace workstation unit. Each room has blowers inside and the blowers are responsible for blowing, distributing and circulating heat in the room.

Figure 3.3: Drying room, containers that fill maize sheaths, blowers in drying room and hot water pipe in drying rooms.

Typically temperature in drying rooms ranges between 35-45 °C and drying time is about 100-150 hours. Samples are taken from the drying rooms at various time intervals and sent to QC (Quality control department) to measure the humidity. If the dried maize sheaths have humidity within the required range, drying will stop and next batch of maize sheaths will be uploaded into the drying rooms. Otherwise drying will continue until required humidity in maize sheaths is achieved.

3.1.3 Furnace or fuel burner workstation unit

This unit is needed to produce hot water, a medium which is necessary for drying in the drying rooms. There are 2 furnaces at the studied factory. Typically one furnace is used and the other furnace is spared for emergency case. Several types of fuel such as fuel oil, lignite, firewood, corncobs and diesel are fed into the furnace. The fuel is loaded to the furnaces by a conveyor and there are two blowers (F1 and F2) equipped with the furnace system as shown in Figure 3.5. Blower F1 has a duty to blow the hot air to the boiler and consumes 7 kW, while blower F2 also has a duty to pull the hot air but consumes 15 kW. Blower F1 is located inside the furnace but blower F2 is located on the exit line of air released to atmosphere. Both blowers simultaneously operate when the hot water temperature to the drying rooms falls below 70 °C. Therefore when both blowers operate, the used total energy is 22 kW.

Figure 3.4: Furnace (fuel burner), boiler station unit, cyclone tank and fuels (firewood and corncobs)

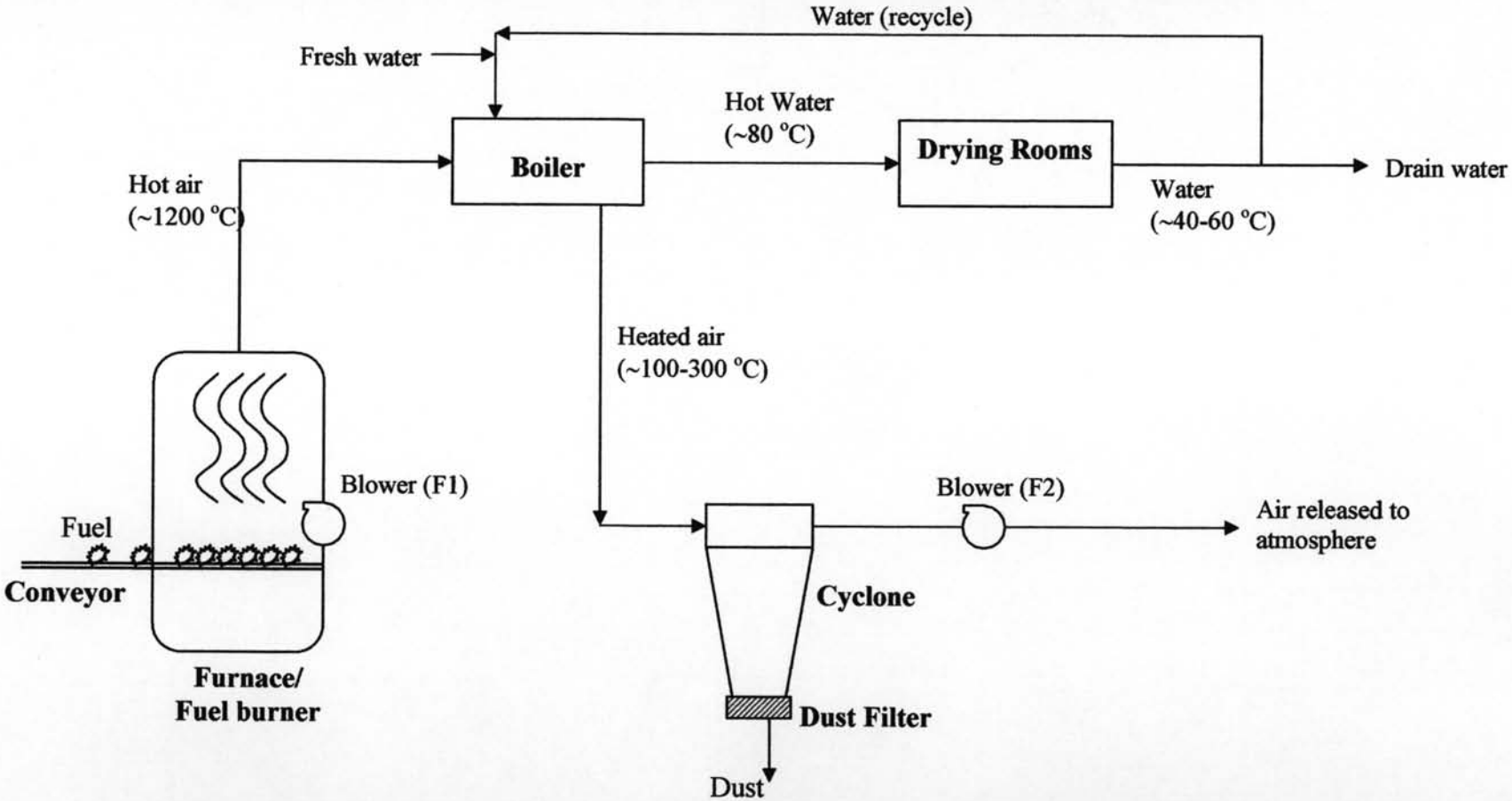

Figure 3.5: Furnace (Fuel burner) workstation unit

Furnaces are operated by a worker per shift and there are two shifts a day. Fuel oil, lignite, corncobs, diesel and firewood are used as burning fuel but corncorbs, a byproduct obtained from maize milling workstation unit, is mostly employed as the typical fuel for furnaces for economical reason.

3.1.4 Maize milling workstation unit

The dried maize sheaths that have required humidity from drying room workstation unit are passed to milling station in order to remove maize seeds from their corncobs. After milled, maize seeds are inspected to remove light seeds, corncobs, or over-sized seeds using an air screen cleaning unit. Then the seeds go to size selection unit with screens to classify the seeds into 3 types: medium (M), small (S) and very small (SS). Although the seeds now are divided into 3 sizes, each size may have different weighted seeds. Therefore, the next unit is to remove light-weighted seeds or imperfect seeds which usually have very light weight from normal seeds. This can be done through size selection by weighting. Finally the dried maize seeds go to packing unit. For the purpose of selling maize seeds to farmers to plant, the dried seeds need to be coated with pesticides to prevent insects.

Figure 3.6: Maize milling equipments

3.1.5 Maize packing workstation unit

In this unit, dried seeds or pesticide coated dried seeds are packed in a bag (50 kg bag) and taken to be stored in a warehouse before selling to customers. During packing process, samples will be randomly taken to check the final humidity in the dried maize seeds and germination.

Figure 3.7: Maize packing unit

3.1.6 Warehouse

Warehouse of the factory can accommodate 100 tons of dried maize seeds. The warehouse of the factory is a closed system consisting of roof and walls. However there is no humidity and temperature control in the warehouse since inventory time is typically less than one week.

3.2 The current problem at maize drying process of the studied factory

The main problem found at maize drying process of the studied factory is the high energy consumption which leads to high energy cost. In addition, other two problems that are related to the energy consumption are observed: long drying time and large quantity of maize seeds rejected by QC. Maize seeds that have humidity higher than the required humidity certainly are rejected by QC and need to be re-dried. This causes higher energy consumption and longer drying time. In addition, if the maize sheaths are dried too much, energy is wasted and also drying time is longer than what it should be. Therefore energy consumption is the most important problem at the studied factory.

Since each workstation unit consume different energy levels, therefore it is necessary to determine energy consumption and energy cost in each unit and focus on those consume most of the energy. To achieve this objective, Pareto chart is employed.

3.2.1 Pareto chart

Owing to that the purpose of this research is to improve the efficiency and productivity of the case study factory in term of improvement of the energy and fuel consumption by applying FMEA technique, main causes of high energy and fuel

consumption are first required. These can be achieved with the help of Pareto analysis which states that a large majority of problems (80%) are produced by a few key causes (20%). Targeting these "major causes" for elimination results therefore is the most cost-effective improvement scheme.

Average amount of energy consumption and fuel cost in each workstation unit of each month in year 2006 is summarized in Table 3.1. When energy consumption is converted to energy cost and combined with fuel cost, total cost is obtained as shown in the Table.

Table 3.1: Average amount of energy consumption and fuel cost in each workstation unit of each month in year 2006

Workstation unit	Amount of energy consumption (kw-h)	Energy cost (Thousand baht)	Fuel cost (Thousand baht)	Total cost (Thousand baht)
Loading and inspection	3013	30.13	0	30.13
Drying room	32226	322.26	0	322.26
Furnace or fuel burner	7208	72.08	278	350.08
Maize milling	6013	60.13	0	60.13
Maize packing	2203	22.03	0	22.03
Warehouse	1826	18.26	0	18.26

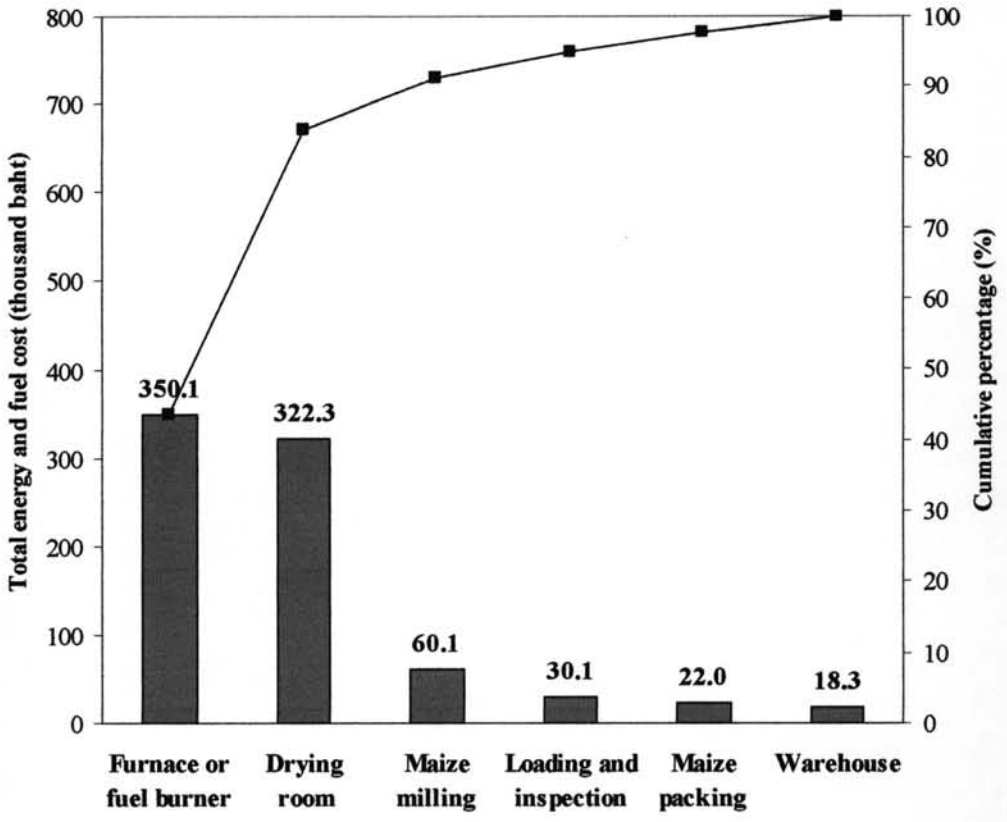

Figure 3.8: Pareto chart to analyze units that cause high energy and fuel cost

Pareto chart in Figure 3.8 shows that main causes of high energy and fuel cost come from furnace or fuel burner workstation unit and drying room unit, therefore FMEA technique will be specifically used to analyze these two workstation units. In addition, from the overall manufacturing process, drying process is considered to be the most important part of the process that creates the value to the products. Drying directly affects the quality of maize product. Insufficient drying can cause off-spec products and cause maize seeds having humidity higher than required and the seeds germinate. This in turn leads to a high quantity of dried maize seeds that do not pass the quality control. In opposite, too much drying cause high energy cost and lost profitability. Therefore introduction of FMEA technique to drying room and furnace workstation units is expected to reduce the energy consumption and fuel cost accordingly.

3.2.2 Average fuel cost, drying time and quantity of maize seeds rejected by QC before FMEA implementation

The status of the average fuel cost, drying time and quantity of maize seeds rejected by QC in year 2006 before FMEA implementation is reported in Table 3.2. The average fuel cost per month of the year 2006 was 94.7 thousand baht, the average drying time per batch was 7150 minutes, and quantity of dried maize seeds rejected by QC was 615 kilograms per month.

Table 3.2: The average fuel cost, the drying time and quantity of maize seeds rejected by QC in year 2006

Month	Average fuel cost (thousand Baht)	Average Drying time per batch (minutes)	Average Quantity of maize seeds rejected by QC (kg)
January	104	7510	671
February	99.5	6580	607
March	96.7	6780	715
April	85.0	7420	789
May	91.5	6150	577
June	92.8	6930	593
July	100.3	7500	465
August	88.5	7230	532
September	99.3	7100	602
October	98.4	6980	615
November	90.3	7660	539
December	89.9	7900	679
Average	**94.7**	**7150**	**615**

As previously evidenced by Pareto chart that the main causes of high energy and fuel cost come from furnace and drying room workstation units, therefore FMEA technique will be applied to these two units in order to reduce the average fuel cost, drying time and quantity of maize seeds rejected by QC.