CHAPTER III
MANUFACTURING PROCESS ANALYSIS

3.1 Overview of The Rice Operational Process

The overview of the rice operational process of the factory used for this study is shown in Figure 3.1. The capacity of the operational process is about two tons per day. The purpose of this process is to produce paste-coated organic rice from organic rice and ingredient paste. The process of this factory can be divided into 4 main processes as follows:

1) Organic rice loading and dust collection process which starts from uploading organic rice (particularly Jasmine rice) from trucks and finishes at dust collecting process.
2) Rice coating process in which organic rice after dust collection will be coated with ingredient mixer (in the form of ingredient paste). This coating process occurs in a cylinder drum consisting of screw conveyor and brushes that carrying organic rice and distributing paste over the rice situated on the screw conveyor. This unit can be called as drum coating unit.
3) Drying process that dries the coated rice with hot air and then cool down it before sending to packaging process. Rice from coating process will be carried to drying process with screw conveyor.
4) Packing process: dried rice will be filled into bags and the bags will be sewed. Then metal detection will be performed to ensure that there is no metal contaminated with the product. Finally the product will be moved to the warehouse.

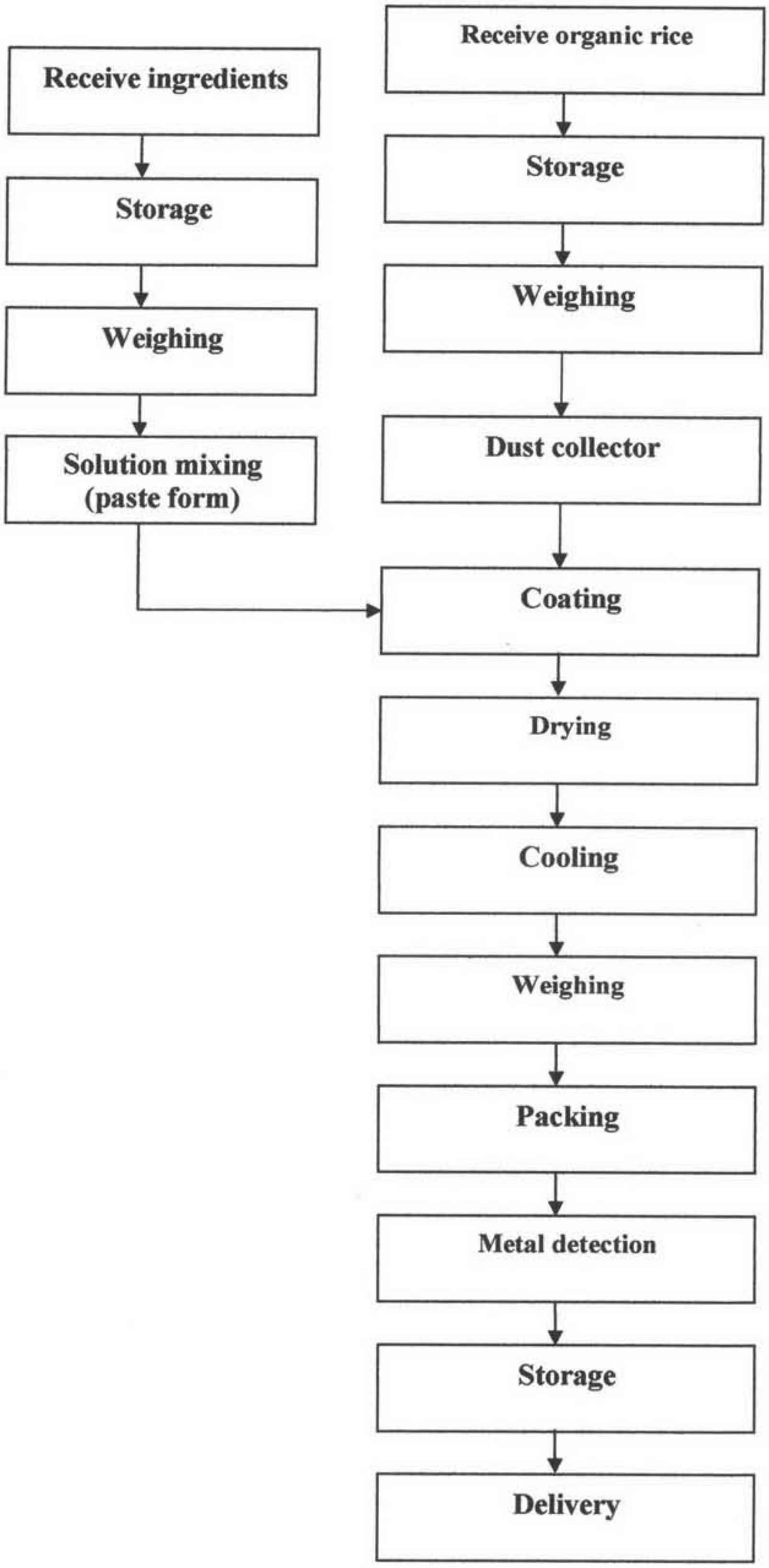

Figure 3.1: Rice operational process of the studied factory

3.1.1 Organic Rice Loading and Dust Collection Process

This process is divided into 2 sub-processes. First is the loading the organic rice from trucks. Organic rice is bought from organic farms mostly in the northeastern part of Thailand. Typically moisture content in the organic rice is about 14% and there are about 1-2% of broken organic rice. The purchased organic rice will be kept in a warehouse before the production is required. When the factory wants to produce paste-coated organic rice according to the orders from the office, the organic rice from the warehouse will be weighed before transferring to a silo (1.5 tons size) in the production process. Weighing is necessary because the coating requires suitable amounts between organic rice and prepared paste. There are several types of pastes used in the production. These include Tom Yum Spices, Holy Basil, Seafood, Yom Kha Spices, Green Curry, Coconut and Pandanus Leaf.

After loading organic rice into a silo, dust collection process begins. Dust collection takes place by connecting a dust collector and a fan at the silo. The dust collector has two suction tubes situated at the top and bottom of the silo. The top suction tube is 3 inches in diameter with the suction power of 170 ft^3/min while the bottom suction tube is 2 inches in diameter with the suction power of 75 ft^3/min. The position of the suction tubes, their diameter sizes, and their connecting angel all have a significant impact on the suction power and the efficiency of dust removal from the organic rice. The dust collector used in the process is UMA 40 MM model which has a filter area of 3.7 m^2. Material used for the filter inside the dust collector is polyester needle felt and this filter needs to be cleaned regularly. The dust collector used in this factory can collect dust up to 20 litres.

After dust collection, organic rice passing through a silo will be fell on a screw conveyor and carried over to the coating drum.

3.1.2 Rice Coating Process

The rice coating process occurs in a cylinder coating drum in which organic rice and prepared pastes are introduced to meet each other at the beginning of the drum. The organic rice after dust removal is carried by a screw conveyor and fed into an intermediate hopper cap which allows only few grains of rice passing through its bottom holes each time in order to gradually feed rice into a coating drum. Rice grains that pass through the hopper cap will be distributed on a screw conveyor inside the coating drum and sprayed with the paste fed from the paste mixing tank. After blending, the mixture of rice and paste is further distributed in the rest of the coating drum in which there are brushes help coating. The section of the coating drum can be called brush dispenser. In this section, brush position, brush size, brush speed and conveyor speed are important parameters that can affect the coating efficiency and amount of broken rice. In general about 10% of feed rice is broken during the coating process. Therefore it is necessary to apply FMEA techniques to this process in order to reduce amount of broken rice occurring in the rice coating process.

Coated rice after passing the coating drum will be carried on a screw conveyor to the drying process. This screw conveyor is also important in distributing coated rice before drying.

3.1.3 Drying Process

Drying process is considered as one of the two most important processes of the factory (the other one is coating process). It has a duty to dry paste-coated organic rice with hot air. There are four drying rooms in use at present and they are used in series. Coated rice will be carried by a screw conveyor from coating process to the top of drying rooms and further carried by a screw conveyor from top to bottom of the drying rooms. During moving from top to bottom, hot air will be introduced at the middle of the drying rooms and blown over the coated rice. Hot air is generated in a hot air tank from burning LPG gas and it is forced to enter the drying room using two blowers. The drying temperature in the drying zone is usually between 55-70°C, depending on initial moisture of the coated rice. Drying time can be adjusted with either the flow rate of hot air blowing or the speed of the screw conveyor. After passing the middle of the drying rooms, coated rice will be carried to the bottom part of the drying rooms in which there is no hot air blowing within this zone. Therefore coated rice will be automatically cooled down. In this cooling zone, temperature of coated rice will reduce to about 25°C. The coated rice that leaves the drying rooms at the bottom will be carried to the packing process using a screw conveyor. In general about 10% of feed rice is broken during the drying process. Therefore it is necessary to apply FMEA techniques to this process in order to reduce amount of broken rice occurring in the drying process.

3.1.4 Packing Process

Dried rice that is carried by a screw conveyor from drying process will be packed into bags with auto pouch filling and sealing machine in a separate packing room. Then the packed rice will be detected for metal contamination using metal detector. Finally the product will be transferred to the warehouse.

3.2 The Current Problems In The Studied Factory

The current problems in all processes of the studied factory are identified in Table 3.1. Since the aim of this research is to reduce the amount of broken rice by using FMEA technique, therefore only causes of broken rice in all processes of the studied factory are analyzed. Pareto analysis, in terms of quality improvement, is employed in order to identify a large majority of broken rice problem (80%) produced by a few key causes (20%). Causes of broken rice in all processes are collected and grouped into 4 groups according to the number of processes in the studied factory. The results are shown in Table 3.2 and Figure 3.2.

Table 3.1: Current problem identification in manufacturing process of paste-coated organic rice.

Process	Problem	Result
Loading and dust collection	Rice contains other impurities other than dust	Coating process effect, e.g. problems at the machine, which in turn cause increased process time
	Rice contains too much moisture	Coating and drying time effect (coating is more difficult and drying time increases)
Coating*	Uncontrolled moisture in the air	Deviation of amount of paste that can be coated
	Uncontrolled quality of rice	Deviation of amount of paste that can be coated
	Inappropriate brush speed	Quantity of broken rice and quality of coated rice
	Uncontrolled viscosity of paste	Deviation of amount of paste that can be coated
	Constant brush position	Inconsistent quality of coated rice depending on types of paste and size of raw material (rice)
	Constant brush size	Inconsistent quality of coated rice depending on types of paste and size of raw material (rice)
	Error of weighing of paste ingredient	Deviation of amount of paste that can be coated
	Improper conveyor space	Amount of broken rice increases
	Improper conveyor speed	Deviation of amount of paste that can be coated
Drying*	Improper distribution of coated rice to be dried	Drying time increase, amount of broken rice increases

	Blowers in drying room are not efficient	Drying time increase and higher energy consumption
	Heat loss from the drying zone to cooling zone in the drying rooms	Higher energy consumption
	Heat loss due to improper insulation of drying rooms	Drying time increase and higher energy consumption
	Poor distribution of hot air	Drying time increase and higher energy consumption
	Nonadjustable blower speed	Higher energy consumption for coated rice with low moisture
	Improper belt speed	Drying time increase and higher energy consumption
	Uncontrolled moisture in the coated rice	Drying time deviation
	Higher cost of LPG fuel	Production cost increases
Packing	Sealing machine is sometime out of order	Longer process time
Warehouse	Fungi formation occurs when products are kept for long time	Product quality impact

Note: * The area to which FMEA techniques is applied.

Table 3.2: Causes of broken rice in all process of the studied factory in year 2006

Process	Amount of broken rice (kg)
Organic rice loading and dust collection	22
Rice coating	215
Drying	181
Packing	5

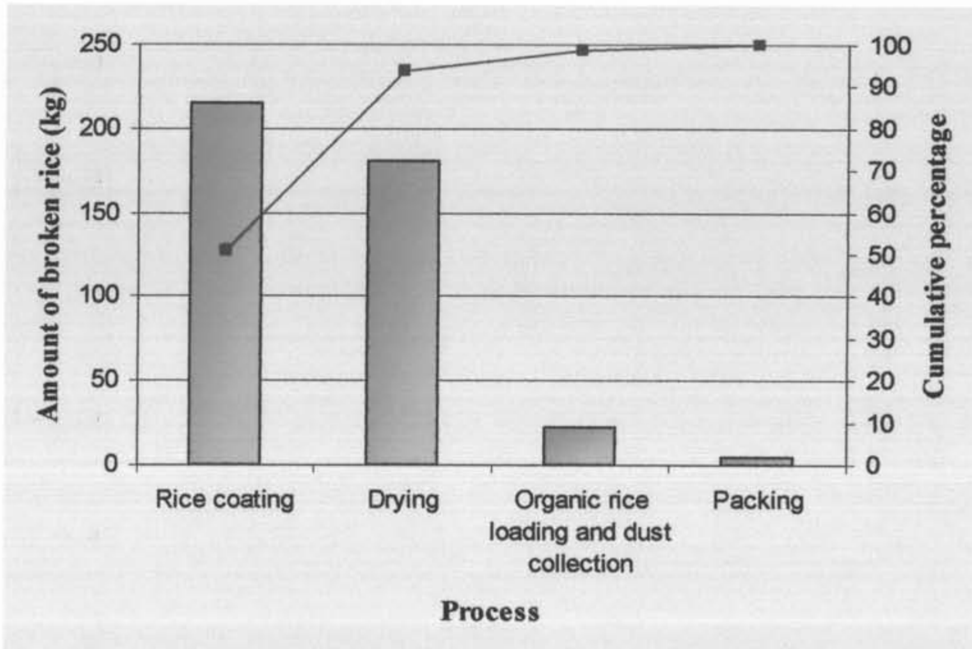

Figure 3.2: Pareto diagram of related factor to broken rice

As can be seen from Pareto diagram in Figure 3.2, main causes of broken rice occur in rice coating and drying processes, therefore FMEA technique will be used to analyze these two processes. In addition, from the rice operational process, coating and drying process are the crucial parts of the production line that creates the value of products. Improper coating cause not only more broken rice but also off-spec products in terms of percent of coating, and problems at the following drying process. The improper drying process will also cause more broken rice and damage final products (e.g. too much moisture in the final product will cause fungi formation). At the moment both coating and drying process cause 10% of broken rice each. In addition, improper coating and drying required double coating and drying, therefore, the process time of coating and drying increases. Introduction of FMEA technique to rice coating and drying processes is expected to reduce amount of broken rice and minimise the process time of coating and drying.

The cause and effect diagram (fish-bone diagram) for broken rice and long process time of the overall process is shown in Appendix I. According to Figure A1.1, the cause and effect diagram of the overall process shows that two main causes of broken rice problem are the non-optimized rice coating process and non-optimized drying process since both together are accounted for 20% of amount of broken rice and both cause major effects. In addition, previous Pareto analysis has added that both coating and drying processes are processes that cause major problem of broken rice to the overall process. Therefore coating and drying processes are taken into consideration for the cause and effect analysis and implementation of FMEA technique.

When considering cause and effect analysis of coating process, it is found that main causes of broken rice and long process time are involved with 4 M (material, machine, method, men). For coating process, it is found that non-suitable quality of rice for coating, non-suitable quality of paste for coating, solidification of paste for coating, inaccurate temperature during coating, wrong weighing of materials, uncleanness of paste mixing tank and coating brush, inhomogeneous paste in mixing tank, improper brush speed and improper conveyor speed are controllable causes and these causes create major effects on the amount of broken rice and long process time. Therefore these causes were further analyzed with fish-bone diagram as shown in Figure A1.7-A1.16.

When considering cause and effect analysis of drying process, it is found that main causes of broken rice and long process time are involved with 4 M (material, machine, method, men). For drying process, it is found that non-suitable temperature in drying rooms, inaccurate temperature in drying rooms, poor distribution of coated rice, long drying time, inaccurate temperature at gas burners, and insufficient heat generation from gas burner are controllable causes which create major effects on the amount of broken rice and long process time. In addition, these causes are a result from other several causes. Therefore these causes were further analyzed with fish-bone diagram as shown in Figure A1.17-A1.22.

The historical data and average values of quantity of broken rice from coating and drying processes and the process time of the rice coating and drying processes are shown in Table 3.3.

Table 3.3: The average quantity of broken rice from coating and drying processes and the process time (coating and drying time) in year 2006

Month/Year	Initial quantity of organic rice (kg)	Quantity of broken rice (kg)	Percentage of broken rice (%)	Process time (minutes)
January 2006	1956	465	23.8	192
February /2006	1830	354	19.3	128
March 2006	1765	332	18.8	189
April 2006	2014	390	19.4	157
May 2006	1874	406	21.7	168
June 2006	1911	488	25.5	190
July 2006	1977	390	19.7	176
August 2006	2007	455	22.7	173
September 2006	2135	395	18.5	193
October 2006	1941	387	19.9	166
November 2006	1805	371	20.6	179
December 2006	1733	322	18.6	150
Average	**1912**	**396**	**20.7**	**172**

As can be seen from Table 3.3, the present average percentage of broken rice from coating and drying processes is 20.7% and the average coating and drying time (process time) is 172 minutes. This research has aimed to employ FMEA technique to define, identify, and eliminate the problems occurred in the coating and drying process in the studied factory in order to reduce the percentage of broken rice and process time.