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Modeling of Farm Size Dairy Feed Mill in Korea

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ABSTRACT

In order to reduce the production cost and improve the quality of dairy feed , several dairy feed mill model suitable for Korean farm size are developed. Also, capital requirement and operating costs of the model mill are analyzed. And these analyzed data are compared with the commercial feed production cost, in order to test whether the model mills are suitable or not in Korean dairy farm. Also, optimum model is recommended depending on size of dairy farm.

As a result, developed model mill(TMR) is very useful in Korea dairy farm not only reduce production cost up to 78% but also improve the qualities.

Key Word : TMR, TMR Design, Dairy Feed mill

INTRODUCTION

Batch types feed mill produce swine and poultry feed and continuous type feed mill produce dairy feed. In Korea, most of feed mills are batch type feed mill and they produce not only swine and poulty feed but also dairy feed. Since batchtype feed mills are not suitable system for a dairy feed in mass production, they have low efficiency when they produce them. Also, it is one of a major factor to increase the feed production cost.

Once farmers purchase a dairy feed produced from commercial feed mill, they have to add roughages such as wild grass, dried hay and rice strew which can be collected near their farm area and mixed with them before feeding to cow without calculation of optimum nutrient requirements. It causes lack of milk production and shortening the life of dairy cows.

One of the best way to reduce the feed production cost and improve the quality of daily nutrient requirement is to build a suitable feed mill for dairy cow. However, the size of dairy farm in Korea is very small. Average dairy farmer raise the cattle range from 20 to 30 heads. Thus, it is not desirable to construct such as American or European style dairy feed mill in Korea.

The primary objectives of studies are (1) to construct models of dairy feed mills suitable for Korean dairy farm size and (2) to analyze the production cost of the model mills and (3) to have a feasibility test by comparing with production cost produced from commercial batch type feed mill.

MODEL MILLS

Batchtype feed mills are selected for model mill instead of continuous type since model mills produce very small amount of feed compare with commercial feed mills. The model mills produce feed for range from 200 to 1,000 heads of dairy cattle. In order to develop a model mill, typical feed mills are analyzed by dividing 6 subsystems: receiving system; storage system; grinding system; mixing system; bagging system; and miscellaneous system such as dust control systems.

Also, the models having 3 different production capacity are developed 5 ton/day, 15 ton/day and 25 ton/day, respectively. The model mill having 5ton/day production capacity is designed for farms raised around 200 heads of dairy cattle and be able to increase the its capacity up to 15ton/day which is equivalent to 600 heads of dairy cattle by adding and modifying its system. Similarly, the model mills having 15ton/day and 25ton/day production capacity are designed for farms raised around 600 and 1,000 heads of dairy cattle, respectively. Also, they can be entended their capacity up to 25ton/day and 50ton/day. Depending on having of storage system and degree of automation, the model mill which produces 25ton/day is subdivided into 3 models such as TMR1000-1, TMR1000-2 and TMR1000-3. Fig. 1 is a block diagram of overall process of the model mill. Fig.2 is the overall process flow of TMR1000-1 and 1000-2 model. Table 1 is the type of model mills and their specifications.

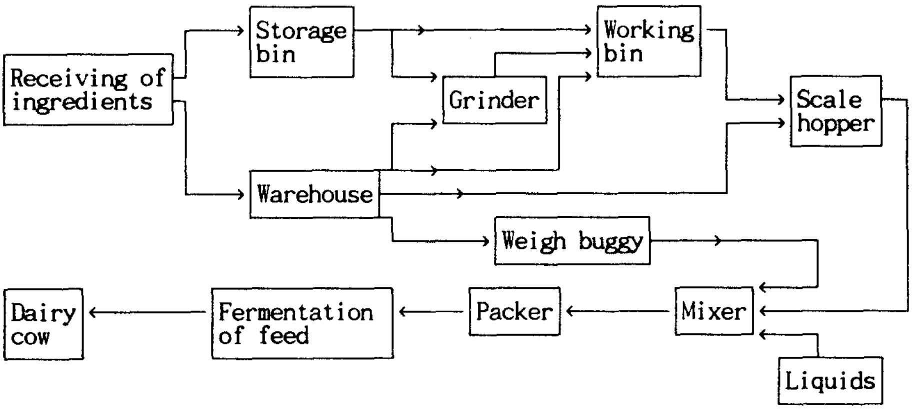

Fig. 1 Block diagram of overall process of the model mills

Table 1. Model mills and their specifications.

Classification	TMR1000-1	TMR1000-2	TMR1000-3	TMR600	TMR200
Storage bin	40ton x 8	40ton x 8	None 1/	None 1/	None 1/
Working bin	$6m^3$ x 9	$6m^3$ x 9	$6m^3$ x 9	$6m^3$ x 6	$6m^3$ x 4
Scale hopper	2 ton	2 ton	2 ton	2 ton	none
Automation	Automatic	Semi-auto	Semi-auto	Semi-auto	Manual
Capacity 2/ (ton/day)	1,000 (25)	1,000 (25)	1,000 (25)	600 (15)	200 (5)
Max. Potnetial capacity 2/	2,000 (50)	2,000 (50)	2,000 (50)	1,000 (25)	600 (15)

1/: Ingredients are being stored at warehouse
2/: Number of dairy cow(upper digit) and operation hour is 4 hr/day(lower digit).

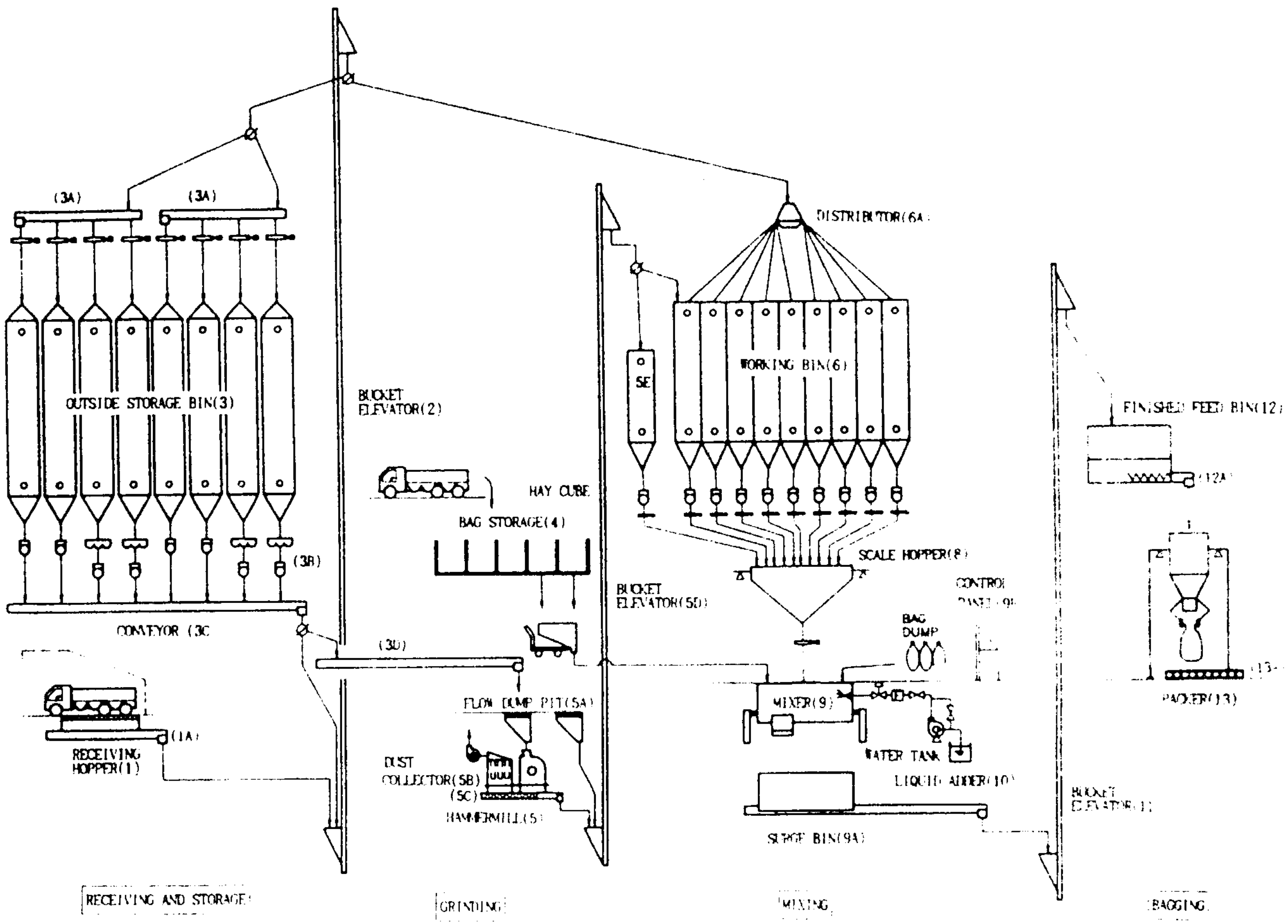

Fig. 2 The overall process flow of TMR1000-1 and TMR1000-2.

1. Basic operation and subsystem of the model mill

Since the quantity of daily feed consumption is very small, the model system does not have to operate whole day. The model mill produces feed during the morning time(4hr/day) and prepares next day operation during the remaining of the day(4hr/day). Thus, in case of TMR1000-1 model mill, pure production capacity is 6.25ton/hr (25ton/day).

Basic operation of the model mill can be described as follows by taking an example of model TMR1000-1 or 1000-2. In this explanation, item # will be cited in Fig. 2.

1-1 Receiving and storage system

Dry ingredients are received either in bulk or bags. The bulk ingredient such as grain, meat and fish meal are delivered by truck in hoppers(#1 in Fig. 2). These ingredients are conveyed(#1A) and elevated(#2) through conveyers and bucket elevator and sent to either working bin(#6) via turn head distributer(#6A) or outside storage bins(#3) via diverter valve and horizontal conveyor(#3A). Whole grain and large volume of soft ingredients are stored in outside storage bins adjacent to the main building. Other soft bulk ingredients stored in working above the mixer. Bagged ingredients are unloaded from truck and stored in the warewhouse.

Outside storage bins, inside working bins and warehouse are provided for storage of the receiving ingredients. The outside bins are provided for a large quantity of materials. These ingredients are to be conveyed(#3C) and elevated(#2), and then distributed into any selected inside working bin(#6) for daily use. An overhead bin cluster is chosen for the ingredients to provide gravity flow, where possible into mixer(#8). The bagged ingredients are stored in the warehouse and then transferred to either these bins or the mixer. Some bulk ingredients which have difficulties being trasnferred or stored in bins are to stored in partitioned room(#4). Premixes with their carrier are stored in the warehouse by bag.

Since model TMR1000-3, 600 and 200 don't have bulk storage bin outside of the building, all ingredients are received by bagged state and are stored in the warehouse till they are processed. Then, they will be elevated and distributed to the inside working bin(#6) through floor dump pit(#5A), bucket elevator(5D) and turn head distributer(6A). These process are descrived in Fig 3, 4 and 5 respectively.

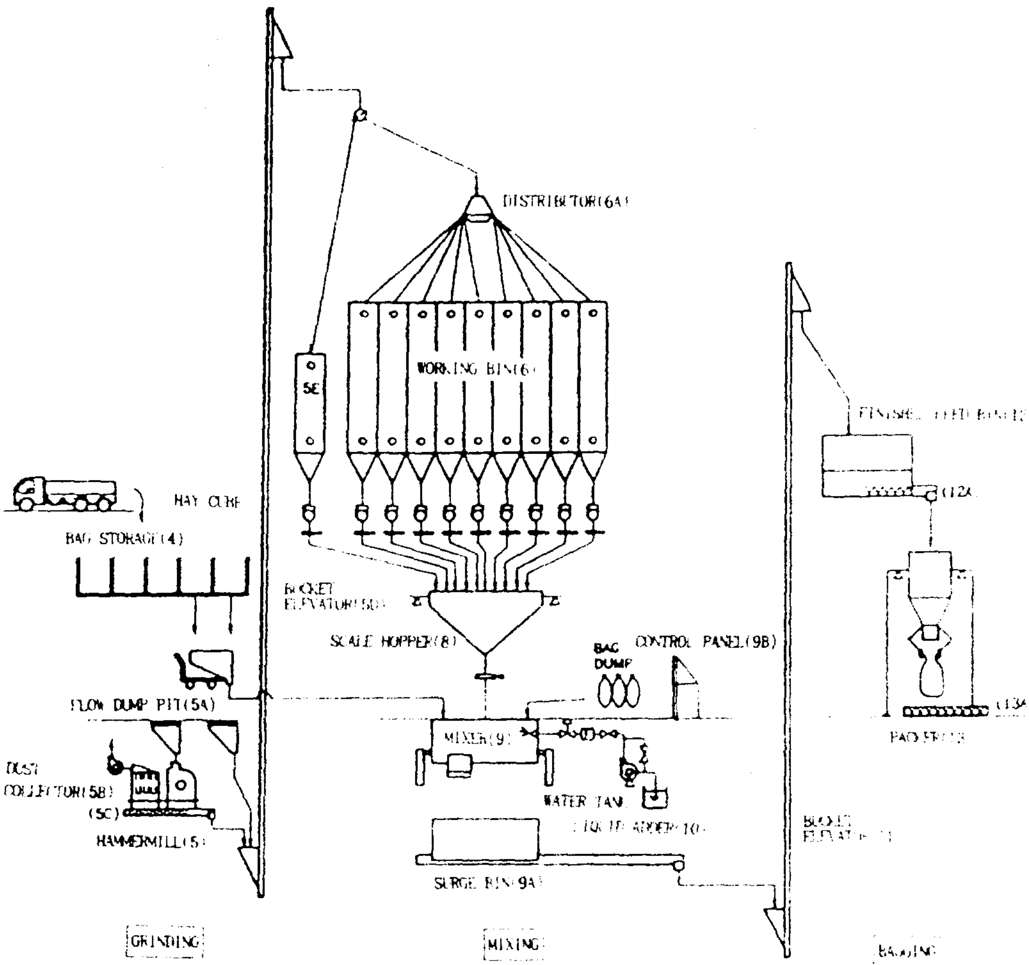

Fig. 3 The overall process flow of TMR1000-3.

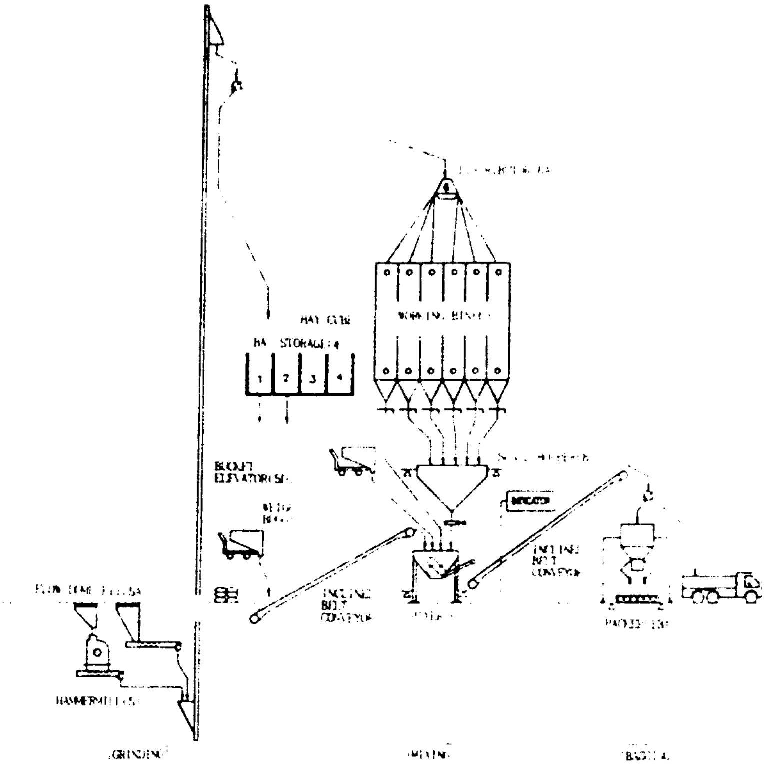

Fig. 4 The overall process flow of TMR600.

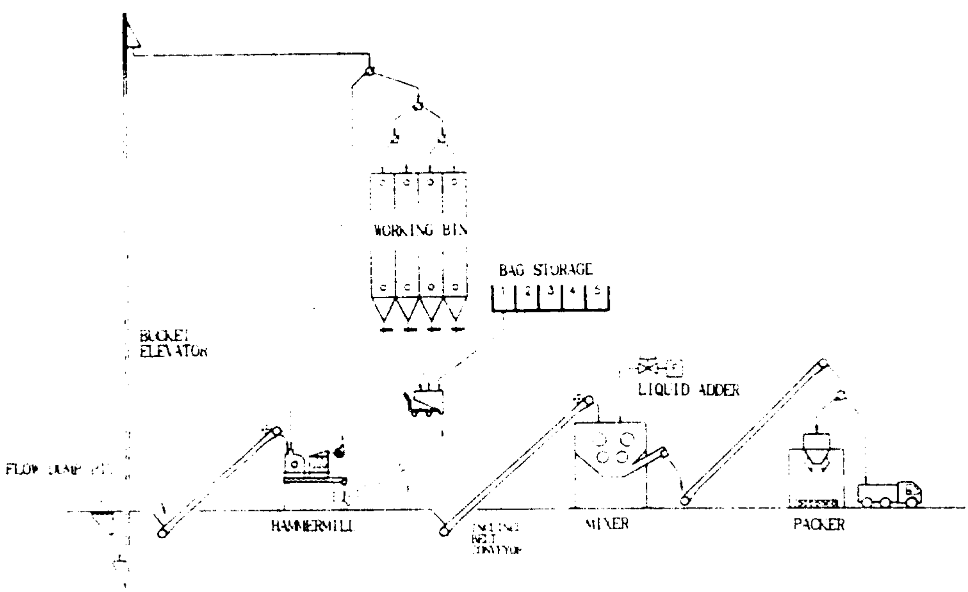

Fig. 5 The overall process flow of TMR200.

1-2 Grinding system

Whole grains to be ground before mixing are transferred(#3C and #3D) from outside storage bin(#3), to hammermill dump pit(5A) located above the hammermill and then conveyed to the hammermill(#5) by screw feeder. Also, hay cube or pellets are dumped(#5A) from warehouse and ground through hammermill(#5). After grind processing is done, the ground ingredients are to be elevated(#5D) and distributed to the working bin(#6). Then these ground ingredients will be blended with other feed ingredients in the mixing system.

1-3 Mixing system

The mash ingredients drawn from working bins are fed into a hopper scale(#8), weighed, and discharged to the mixer(#9) by control from a central control panel(#9B). The ingredients stored in warehouse are brougt to the mixing area, weighed, and dumped into mixer. Liquids such as fat, molasses or water may be added from the liquids pump(#10) through manifold pipe in the mixer. After the mixer, well blended feed is to be discharged through the gate which mounted side of the mixer and moved by a conveyor to the finished feed bin(#12) for loadout before the next batch is ready to dump. The most widely used feed mixers are vertical, horizontal and continuous mixer. In this study, horizontal mixer is selected for the model.

1-4 Bagging system

The finished feed is stored in the finished feed bin(#12) until it is loaded by bagged state beneath the bin. In bagging operation, feed is moved by the feeder and bagged through a scale set to deliver 20 kg or 500 kg, depending on the desired pacakge.

1-5 Micellaneous system

As a miscellaneous system dust collecting system and control system is considered. Dust is collected by bag filter from receiving hopper and hammermill system and control system memories optimum ration of each ingredients and mixing time and operate the whole system without helping of operators. Difference between TMR1000-1 and TMR1000-2 is automatic and semi-automatic system. TMR1000-3, 600 and 200 are semi-automatic system.

2. Layout of the model mill

Fig. 6 is the top view of the first floor of the model 1000-1 and 1000-2. Outside of the building, receiving hoppers and and storage bins are located. At the other side of the building, bagged ingredeint receiving warehouse is showed.

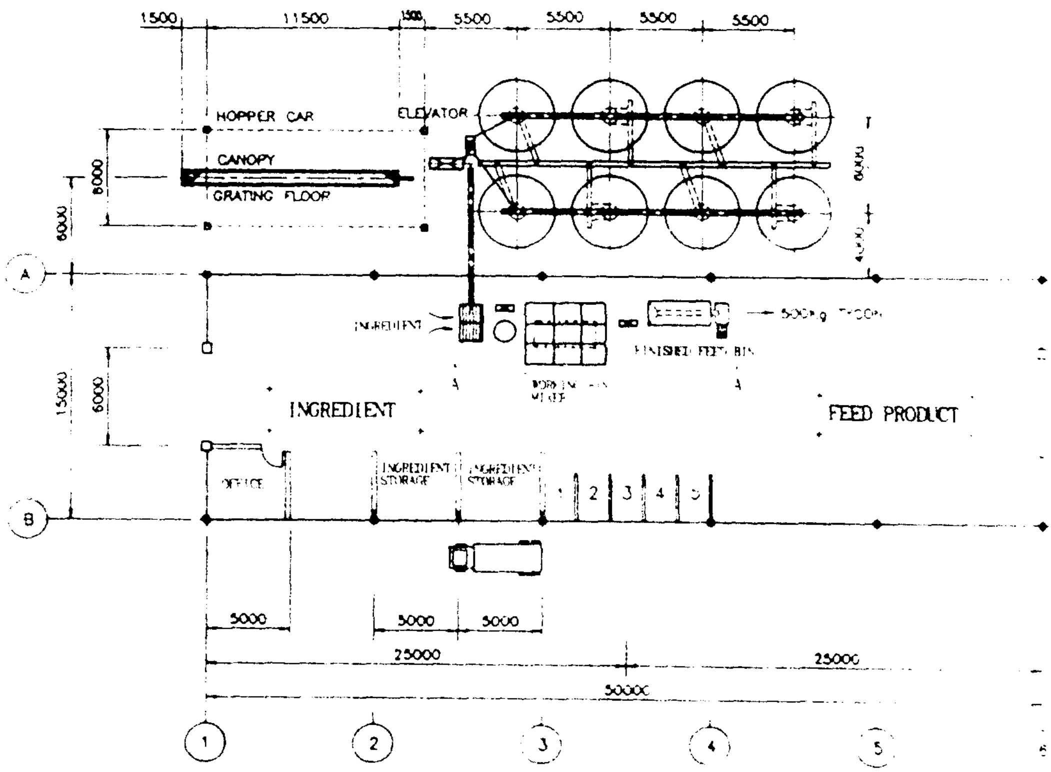

Fig. 6 The top view of the first floor of model TMR1000-1 and 1000-2.

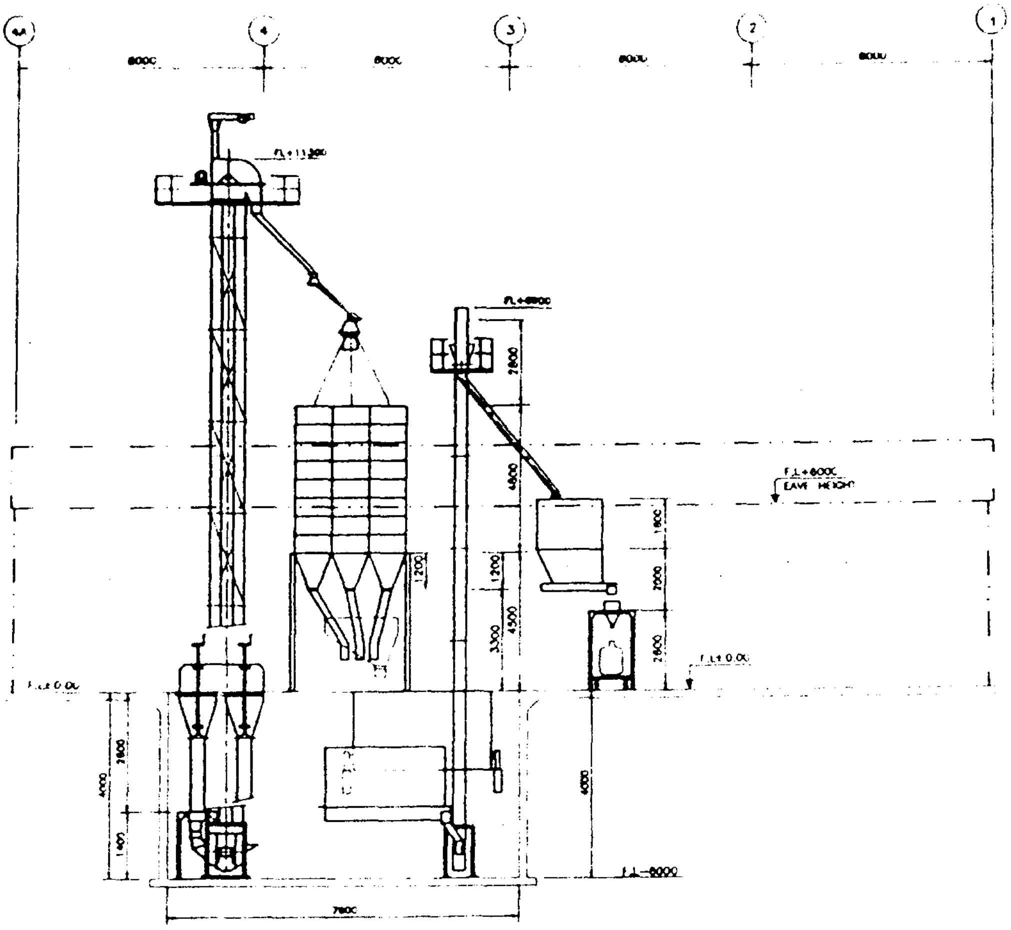

Fig. 7 The side view of mixing, grinding and bagging system(Section A-A).

At the center of the building, mixing system such as scale hopper(first floor), mixer(basement) and working bin(above the scale hopper) is located(refer to Fig 6 and 7). Also, just below the floor dump pit, grinding system such as hammer mill is located. Fig. 7 is the side view of mixing, grinding and bagging system of the model mill.

Equipment layout of the model TMR1000-3, TMR600 and TMR200 are similar to Fig. 6 and 7. However, there are not storage bins at these models, since these models don't have bulk storage system. Also, mixer and grinder are located at the first floor in case of model TMR600 and 200.

3. Batch mixing cycle and capacity of the model mill

One cycle of batch mixer consist of (1)fill time(FT), (2)mix time(MT), (3)emptying time(ET), and (4)dead time(DT). Pfost(1976) expressed the hourly production rate of a single batch mixer as follows:

$$\text{Hourly production} = \frac{60 \times MC \times \varepsilon}{FT \times MT \times ET \times DT}$$

Where MC = working capacity of the mixer, in this model 2 ton
ε = efficiency index, in general 80 %

Based on the equation and typical data, the capacity of each model mill is estimated and presented in table 2.

Table 2. Batch mixing system cycle of the model mill.

	TMR1000-1	TMR1000-2	TMT1000-3	TMR600	TMR200
MC(Mixer Capacity)	2 ton	2 ton	2 ton	2 ton	1 ton
FT(fill time)	1 min.	1 min	1 min	3 min	5 min
MT(mix time)	5 min	5 min	5 min	5 min	5 min
ET(emptying time)	1 min	1 min	1 min	3 min	3 min
DT(dead time)	1 min	1 min	1 min	1 min	1 min
ε(efficiency)	80%	80%	80%	80%	80%
Capacity(ton/hr)	9.6ton/hr	9.6ton/hr	9.6ton/hr	6.8ton/hr	3.2ton/hr

FEASIBILITY ANALYSIS

1. Capital requirement of the model mill

A primary consideration for a future plant owner or a policy maker is the amount of the capital required to build a plant since the major portion of its fixed cost arises from the investment cost. However, the numerous factors are involved for plant investment cost. Major factors to be considered are the size and type of model mill: the type of equipment and its installation: the location of the plant to be; and the type of building and its construction cost.

In this study, equipment cost, land cost, building and its construction cost, electrical system equipment and installation cost are considered. The prices of equipment, costs of installation and others are collected from the feed mill equipment manufactures based on Dec. 1992. The result studied are presented Table 3. Also, specific data for estimation of the study should be refered research report(Park, 1993).

Table 3. Capaital requirement of the model mill.

unit: 1,000 won

Cost Items	TMR1000-1	TMR1000-2	TMR1000-3	TMR600	TMR 200
Land	50,000	50,000	50,000	25,000	10,000
Building and Construction	246,750	246,750	194,750	70,000	36,000
Equipment and Installation	481,735	481,735	238,568	107,928	70,725
Electrical sys. & Installation	109,250	74,750	69,000	12,650	6,900
Others	81,400	80,400	57,400	36,900	16,800
Total	969,135	933,635	609,718	252,478	140,425

2. Cost analysis

The consideration of model mill, whether or not it might be more advantageous than traditional feed mill, is very important for farmers or policy maker. The simple method to determine feasibility of model mill is analyzed comparing of production cost with commercial(traditional) feed mill.

The cost of feed production are divided into fixed cost and variable costs. Fixed costs include depreciation, administrative cost, taxes, insurance and interest. Variable costs consist of labor cost, energy cost, maintenance costs, and supply and miscellaneous costs.

2-1. Fixed cost

Straight line method is used to determine annual depreciation costs for the equipment and buildings. In this analysis, life of the building is assumed to 40 years(Chung, 1976) and most of equipment is assumed to 17 years(Henderson, 1978). However, some equipment such as folklift are depreciated over a 10 year periods.

The annual interest cost is estimated by applying 2.5%(one half of the Agri. Co-operative Union interest rate of 5% for the TMR investment) times total capital investment in equipment and facilities. Annual insurance cost for the model mill is assumed 0.1% of the capital investment.

Taxes are vary widely from one locality to another. In this analysis, tax is assumed to be exempted since the model mill is managed by farmers association authorized and invested by the government.

General management, ingredient purchasing, nutrient formulation and quality, typing and book keeping are administrative duties. These function are usually performed during the day. In this analysis, 2.1% of an annual administrative cost is applied by referring to data obtained from government rice mill.

Total fixed cost is estimated by adding the major fixed cost items described above. One who needs more specific data is required refer to research report(Park, 1993).

2-2. Variable cost

Labor cost, energy cost, maintenance and repair costs and supplies and miscellaneous costs are major items of the variable costs. In order to analyze the labor cost, labor assignment sheet of each model is established as in Table 4.

Table 4. Labor assignment sheet of the model mill.

Classification of operation		TMR1000-1	TMR1000-2	TMR1000-3	TMR600	TMR200
Morning operation	Bag dump	0	0	2	2	1
	Scale	0	0	0	0	1
	Packing	1	1	1	1	1
	Miscellaneous	1	2	2	2	1
	Manager	1	1	1	1	1
Afternoon operation	Ing. receiving	1	1	3	2	2
	Prepare for next days' operation	1	2	3	2	2
	Miscellaneous	1	1	2	3	1
Clerk(woman)		1	1	1	1	0
Summation		4	5	9	8	5

Electrical energy is used mainly for handling and processing equipment by electric motors. The other area is lighting and for service maintenance. Electrical energy usage for the handling and processing equipment is determined by computing the operation hours of individual equipment and their horsepower requirement. Also, since the amount of electrical energy usage of the other areas is very low compare electric motors, energy usages in these area are ignored.

Costs of maintenance and replacement parts for equipment as well as the services hired by the mill to make repairs are variable. They are assumed to be 3% of the total purchase cost of equipment and facilities over the long run.

Supplies and miscellaneous costs includes a number of items which are generally used throughout the plant and pertain to entire production operations. However, it is almost impossible to estimate these costs since this model mill is not built yet and operated. In the analysis, it is assumed 2.1% of total variable cost by referring government rice mill.

2-3 Total cost

Total cost can be explained simply by adding fixed and variable cost items described above. Table 5 is the summary results of production cost each individual model mills. Also, one who wants to need more specific data, refer to research report(Park, 1993)

Table 5. Total production costs.

unit:1,000won

Cost items	TMR1000-1	TMR1000-2	TMR1000-3	TMR600	TMR200
Fixed cost, won/ton	10,619	10,243	6,832	7,756	7,972
Variable Cost, won/ton	2,201	2,615	4,061	6,073	8,970
Total Cost, won/ton	12,820	12,858	10,849	13,829	16,943

Based on the results showed in Table 5, TMR1000-3 is the most economical models in Korea. Aslo, it shows that as the size of mill increases the model mill becomes more economical. This result is the production cost(won/ton) based on 4 hours operation. As the operation rate increase, the production decrease as showed in Table 6.

Table 6. Production costs vs. operation rate.

Operation rate(%)	TMR1000-1	TMR1000-2	TMR1000-3	TMR600	TMR200
40	28,749	28,223	21,096	25,463	28,900
60	19,899	19,687	15,403	19,000	22,257
80	15,475	15,419	15,403	15,768	18,935
100	12,820	12,858	10,849	13,829	16,943
125	10,696	10,809	9,482	12,728	15,347
150	9,280	9,444	8,571	11,244	14,825
175	8,269	8,46 8	7,920	10,505	13,525
200	7,511	7,732	7,432	9,951	12,956

3. Comparison with commercial feed mill

Sale price of commercial dairy feed in Korea are little different depends on type and kinds of feeds. However, average price is around 200,000 won/ton(MC 14%). Raw material cost occupies 60-65 % among them and other portions are direct and indirect production cost equavalent to 70,000 won/ton. If we convert to 40%

moisture content which is the moisture contnnt of TMR feeds, it becomes 48,837 won/ton and is very expensive compared with TMR feed production cost.

Table 7 is the ratio of TMR feed production costs to commercial feed production cost. In case of TMR1000-3, production cost is only 22% compare with commercial feed production costs. Even TMR200 model whose production cost is the most expensive is 35% compare with commmercial feed production cost. This comparison is performed only when operation rate is 100%. If the operation rate increases, then production cost will be downed more. Fig.8 is production cost of the model mills vs. operation rate.

Therefore, TMR model system is very useful in Korea dairy farm not only reduce production cost up to 78% but also improve the qualities.

Table 7. Ratio of TMR feed production cost to commercial feed.

TMR1000-1	TMR1000-2	TMR1000-3	TMR600	TMR200
26%	26%	22%	28%	35%

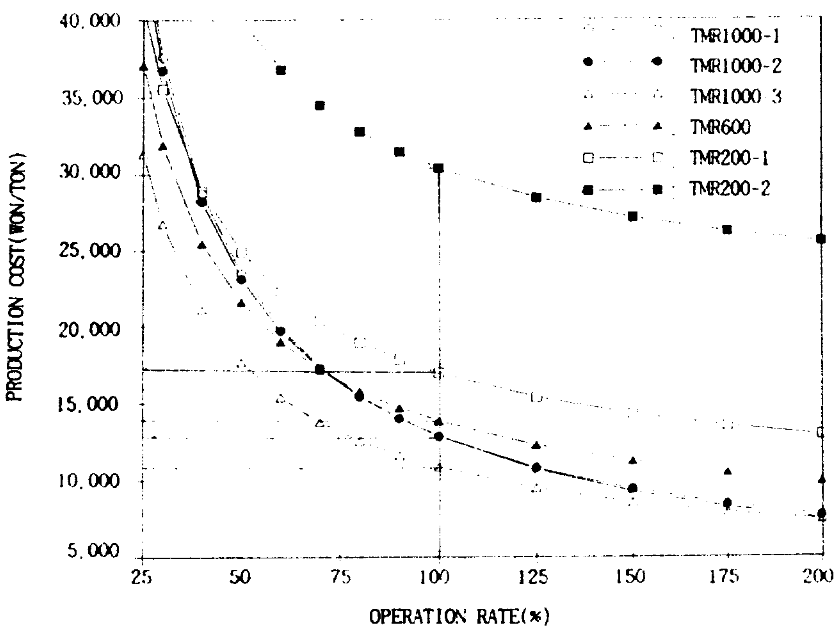

Fig. 8 The production cost of the model mills vs. operation rate.

CONCLUSIONS

In order to reduce the production cost and improve the quality of dairy feed , several dairy feed mill model suitable for Korean farm size is developed. Also, capital requirement and operating costs of the model mill are analyzed. And these analyzed data are compared with the commercial feed production cost, in order to test whether the model mills are suitable or not in Korean dairy farm.

From the study the following results can be concluded:

1. Batch type feed mills are selected for model mill. And the model mill consists of 6 subsystems: (1)receiving system; (2)storage system; (3)grinding system; (4)mixing system; (5)bagging system; and (6)miscellaneous system such as dust control systems.

2. The models having 3 different production capacity are developed 5 ton/day(TMR200), 15 ton/day(TMR600) and 25 ton/day(TMR1000), respectively. The model mill having 5ton/day production capacity is designed for farms raised around 200 heads of dairy cattle. Similarly, the model mills having 15ton/day and 25ton/day production capacity are designed for farms raised around 600 and 1,000 heads of dairy cattle, respectively.

3. TMR1000 model mill which produces 25ton/day is subdivided into 3 models such as TMR1000-1, TMR1000-2 and TMR1000-3.

4. Capital requirement increases as the model size increases. However, unit capital requirement(won/ton) decreases as the size increases.

5. Production costs decreases as the size increases. Among the 5 model mills TMR1000-3 is the most economical model.

6. In comparison with the commercial feed mill production cost, the production costs by model mill ranges only from 22% to 35%.

7. In summary, TMR model system is very useful in Korea dairy farm not only reduce production cost up to 78% but also improve the qualities.

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