CHAPTER VI[1]

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This study focused on the modeling of grain storage facilities, taking into consideration the randomness of factors that might affect their performance. A simulation toolset for the construction of models that replicate the dynamic behavior of grain storage facilities was introduced to address these factors and to support facility evaluation and feasibility analyses.

The simulation toolset was developed from a conceptualized model in which the grain storage facility environment was separated into sectors (receiving, pre-cleaning, drying, cleaning, storage, and dispatching), equipped, structured, and logically linked by conveyors. The harvest process and market demand were considered the most relevant external stochastic factors. They were modeled to generate events related to the arrival of trucks at the receiving and dispatch sectors.

To develop the simulation toolset, called "*Grain Facility*," Extend™ software, version 4.1.3C, was employed. The toolset works as an Extend™ library and contains a set of blocks. These blocks were programmed for the simulation of the grain facility's: (*i*) receiving and dispatch activities, (*ii*) grain processing unit operations, (*iii*) operational decisions, (*iv*) system constraints, (*v*) electric energy consumption, and (*vi*) fuel consumption in the drying process. The structured models built by using "*Grain Facility*" are classified as dynamic, stochastic, and discrete.

Three models were introduced. They were used in the system performance, verification, and validation studies. The data for their elaboration were obtained from the Brazilian "*Cooperativa Agropecuária Mourãoense Ltda.*" (COAMO), an agricultural cooperative headquartered in Campo Mourão, Paraná State, Brazil. The verification and validation analyses, considering the

[1] Silva, L. C. 2002. Stochastic Simulation of The Dynamic of Grain Storage Facilities. Ph. Dissertation. Universidade Federal de Viçosa. Viçosa, MG. Brazil

models' domains, lead to the conclusion that model outcomes and system outcomes where in good agreement, which indicates the *Grain Facility'* toolset's significant problem solving potential. The introduced models were demonstrated to be valuable tools.

Grain storage facility models developed using the *"Grain Facility"* toolset can be used to: (i) conduct grain storage facility feasibility analyses, (ii) as a teaching tool to clarify cases under study, (iii) estimate electrical energy and fuel uses, and (iv) analyze existing and planned systems and assist in facility expansion, remodeling, and technological updating. In addition, according to characteristics of the simulation language Extend™, the developed models can support decision makers working in the grain handling area by supplying them with pre-assembled simulation models of systems under their management. This will minimize risks when defining strategies to reduce operational costs. The simulation tool also allows engineers and designers to model existing or proposed systems, contributing to facility evaluations and feasibility analyses.

Models developed using Extend™ in conjunction with the "*Grain Facility"* library offer a great variety of output information, which, according to the user's background and study purpose, can be selected for numerous applications.

Analysis of the implemented models suggests the following possibilities for future investigation in this area:

1 – Time spent in simulation needs to be decreased

It was observed that the time spent running a simulation is strongly linked with the amount of quantities of raw product received at the facility. For example, using a Pentium™ 500 Mhz microcomputer to simulate the handling of 75,000 t of raw product, approximately 3.5 hours is spent in simulation. Possibly, the defined relationship of one tonne of raw product corresponding to one item should be improved. However, this relationship is now needed to ensure the model's accuracy.

2 - A method to improve characterization of raw products should be investigated

Moisture and foreign material content information needs to be obtained more rigorously and described by means of an adequate distribution, considering the harvest time period progress. This is especially important for

moisture content since it directly affects dryer operations and, thereby, the consumption of electric energy and fuels.

3 – Simulation time could be extended beyond 12 months

The time routine controls needs to be updated in order to allow a simulation covering more than 12 months of operational activities.

4 – Hierarchical blocks could be modeled as code blocks

Blocks that simulate receiving pits, dryers, and arrival and dispatch generators are hierarchical blocks; they should be transformed into code blocks. This could reduce the time for simulation and make model use more flexible.

5 – Other products and operations should be considered

The developed models only consider the possibility of grain storage facility systems that handle corn, soybeans, and wheat. More product options are needed. In addition, the modeling procedures are exclusively focused on grain handling unit operations, ignoring the impact of other storage facility operations, such as foreign material handling, storage, and dispatch; therefore, precluding the study of processes that affect electric energy consumption.

6 – Economic variables should be added

In order to meet the needs of decision makers more effectively, new item attributes should be introduced into the simulation to allow the determination of all costs related to unit operations. In addition, other variables should be added to support the elaboration of economic feasibility analyses.