APPLICATION OF MULTIAGENT SIMULATION MODELING TO FORECAST MILK RECEIVING PROCESS

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KEYWORDS

simulation modeling, multiagent modelling, food production facilities, milk receiving, production processes, AnyLogic.

ABSTRACT

This research paper discusses the application of multiagent simulation model of production processes by reference to milk receiving and storage. The paper describes basic parameters for general models, and presents the experiment results obtained during the model processing, as well as the approach towards implementation of the multiagent system employing AnyLogic simulation environment.
The introduction of general technique to plot multiagent simulation models allows to use digital tools to create a virtual copy of the true-life processes with the possibility to provide forecast and identification of the food production industries.
The employment of simulation modeling enables refinement of the production process under study, identification of its weaknesses, and provision of the expert opinion on improvement of production processes and as regards the results of virtual testing thereof.

INTRODUCTION

The outdated production facilities in the Russian Federation often do not cope with the tasks the resolution of which is necessary in the context of contemporary production specifics (Sirota, 2006). Nowadays, the impact from external factors, and the demands from industrial customers result in the search for advanced means of production planning or its modernization (Sovetov, 2007).
The most relevant and feasible approach to the virtual representation of the real-life production processes is the employment of multiagent simulation modeling (Gabrin 2004; Karpov 2005; Blagoveschenskaya 2010). This type of modeling aims at carrying out experiments in order to determine the optimum parameters of production processes, to forecast and visualize the results in a user-friendly format, and to identify the weak points and find relevant managerial solutions for their elimination at the design stage without any costly procedures at real enterprises.
One of the production processes under study, for which the application of simulation modeling is relevant, is the milk receiving line (Lisin, 2009). The techniques currently available to analyse (Ponomarev et al., 2006) production processes do not always meet the requirements of both enterprises and business integrators. The multiagent simulation methods allow to evaluate the feasibility of the drafted production plan, calculate the process execution expectancy, predict the production output figures, and identify internal processes in the course of the system modeling, as well as providing guidelines on how to update the target parameters when it comes to the production process advancement.

THEORETICAL BACKGROUND

The automatization flowchart and production processes at the enterprise were reviewed and taken into account (Boev, 2011; Nazoykin, 2019) in the course of multiagent production model elaboration.
The research study is concerned with the milk processing line consisting of three sections: milk receiving area, milk storage, and milk processing area.
The subject of the study is the milk receiving area, as well as the milk tank vehicle supplier and certain varying parameters required to design the model and carry out further experiments. The following varying parameters were identified: number of incoming milk tank vehicles and their volume; time between arrivals of milk tank vehicles; pumps capacity; volume of the tank located at the milk receiving area.
The automatization flowchart and the afore mentioned parameters provide the basis for multiagent production model elaboration.
The principle of operation of the milk receiving module is described by means of the automatization flowchart.
Upon arrival, milk tank vehicles get connected to the milk receiving area by hose pipes (Ilyukhin et al., 2006). Then, raw milk from milk tank vehicles feeds tank *MRT01* located at the milk receiving area. After tank *MRT01*, milk enters cooler *MRE01*, where it gets cooled down to the required temperature for its further transportation to the storage area by means of the filling line. Milk enters the manifold valve through cooler *MRE01*. The manifold, in fact, changes the route, and fills or empties the tanks located in the milk storage area.
Having described the flowchart of the milk receiving area, it is possible to have it implemented in the simulation modeling environment of AnyLogic and employing the multiagent approach.

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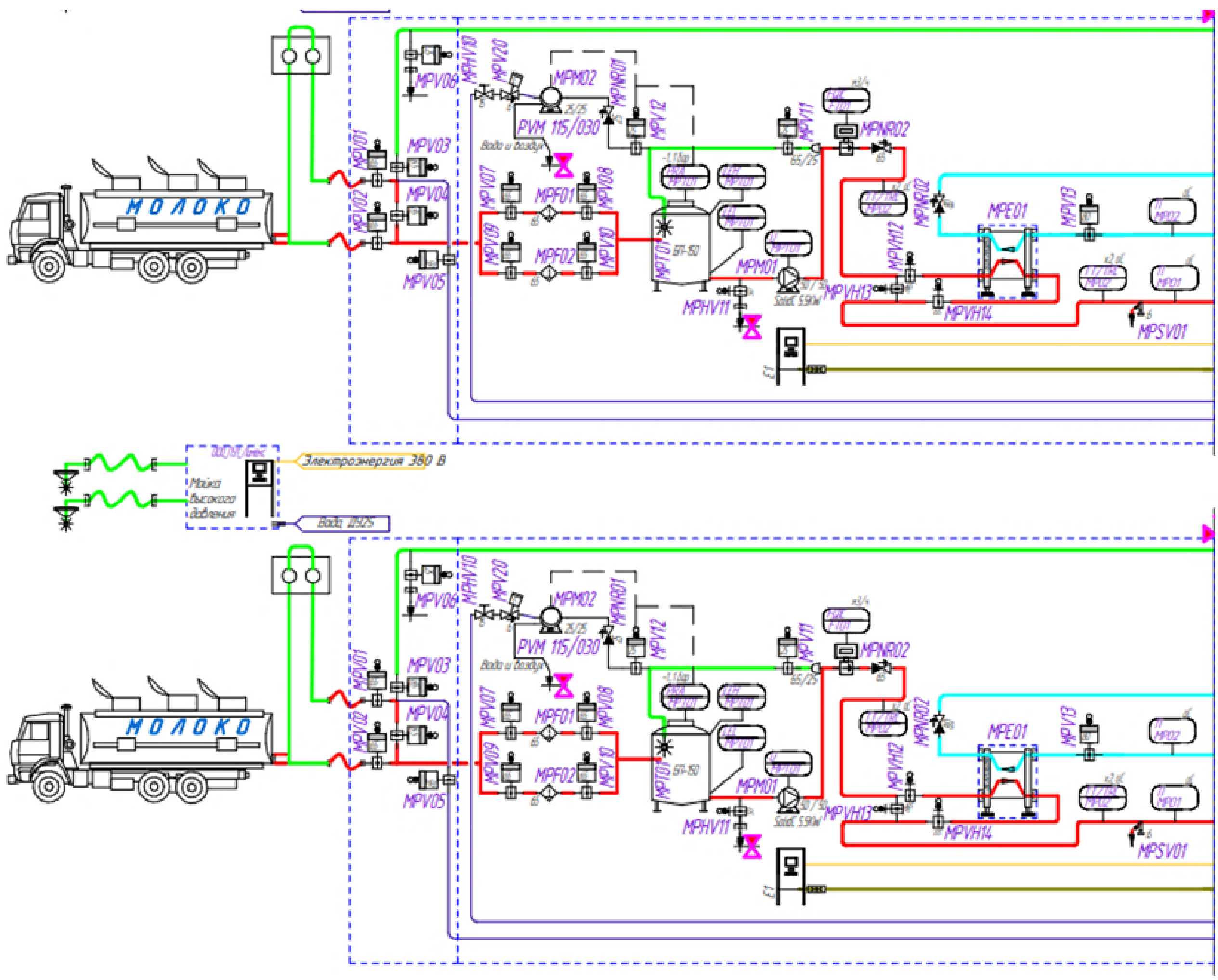

*Молоко – Milk
Мойка высокого давления – Power-wash cleaning; Электроэнергия 360 В – Electricity 360 V; Вода Д925 – Water D925

Fig. 1. Flowchart of receiving area

RESEARCH STUDY

The purpose of this research is to create a multiagent milk receiving model and milk transportation by tank vehicles in line with the production process under study. In the context of the objectives of the study, it is compulsory to use dynamically varying parameters in order to conduct virtual experiments and to identify weak points in any particular data set. Consequently, this contributes to the rational use of production resources.

AnyLogic software and built-in libraries for discrete event simulation and flow modeling are used for the purposes of simulation model elaboration within the milk receiving module.

The following constituents of the milk receiving module are available for modeling, i. e. milk tank vehicle supplier, converter of milk tank vehicle agent into flow, tank *MRT01*, cooler *MRE01*. According to the process description (Nazoykin, 2018) of creating multiagent models for production processes, the milk tank vehicle supplier and the milk receiving module are different agents independent of each other. Thus, it is compulsory to ensure a more flexible configuration, as well as providing for the ability to incorporate the obtained agents into other projects.

Agent *MilkCarProvider* (Fig. 2) acts as a milk tank vehicle supplier imitating the arrival of a certain number of milk tank vehicles of a given volume at time intervals as stated by the input simulation parameters. The agent possesses 3 varying parameters, i. e. *carCount* (number of milk tank vehicles), *carRemainingInParking* (number of milk tank vehicles at stand-by in the parking lot, and *timeBetweenArrivals* (frequency of arrivals). Item *milkCarSource* is used to generate milk tank vehicles. Among its properties, parameter *timeBetweenArrivals* is assigned to this item so that the item is aware of the frequency of milk tank vehicles generation. Likewise, parameter *carCount* is used to generate items in a given number. When the milk tank vehicle agent leaves item *milkCarSource*, parameter *carRemainingInParking* is incremented; this means that the generated milk tank vehicle enters the parking lot and is waiting for connection to the milk receiving module. The generated items line up to wait and make *carQueue*. Then, the items enter area *nextFreeMilkCar*, which is accessed by the agent of receiving module, and the agent takes milk tank vehicles for use. When the milk tank vehicle agent leaves item *nextFreeMilkCar*, parameter *carRemainingInParking* is decremented. This means that the generated milk tank vehicle leaves the parking lot. Further-on, parameter *carRemainingInParking* is visually displayed for the agent to show the number of remaining milk tank vehicles.

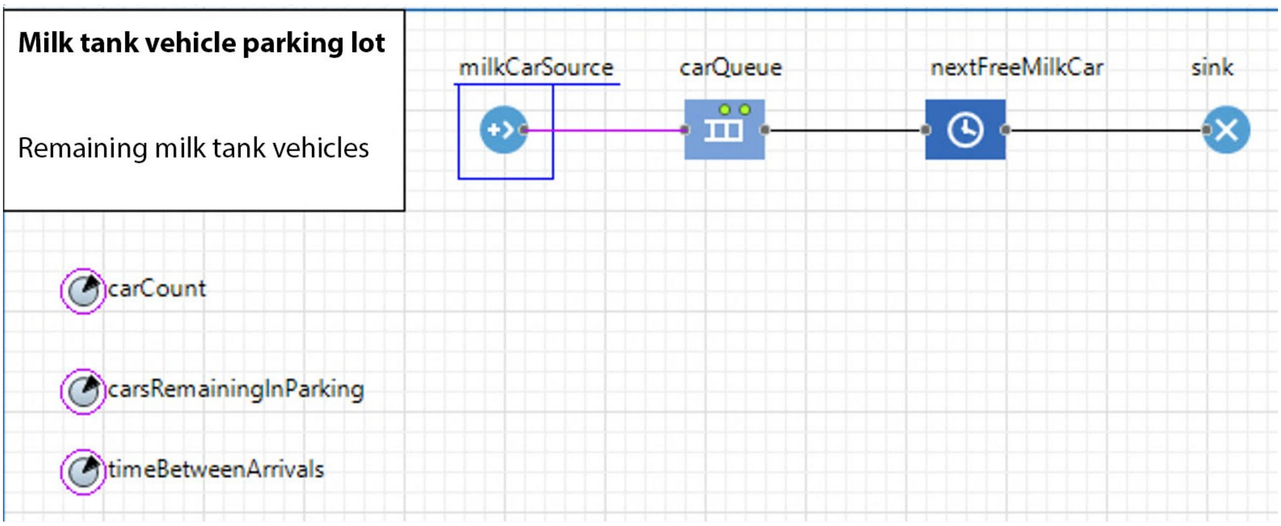

Fig. 2. Model of milk tank vehicle supplier and its visual representation

The task of *MilkReceivingStation* (milk receiving area) is to take item *milkCarSource* from agent *MilkCarProvider*, convert it into the volume of milk, select a free line and, using the selected line, fill the tank located in the milk storage area. Agent *MilkReceivingStation* possess 7 varying parameters as follows: *id* (identifier), *milkCarSize* (volume of one milk tank), *statusIndex* (current status), *statusStr* (line representation of status), *outputSpeed* (pump capacity), *tankSize* (volume of *MPT01* tank), *fillingLine* (reference to the filling line agent). Item *carSource* in this case does not generate the items of milk tank vehicle; instead, it gets filled in by calling command *inject()*. This command invokes the stage of the statechart, using which it is possible to transfer the logic of agent activities to AnyLogic software. The statechart is given in Fig. 3. Area *waitMilkCar* (waiting for a milk tank vehicle), Java code is exercised addressing to agent *MilkCarProvider* to request from item *nextFreeMilkCar* the next milk tank vehicle provided the value *carRemainingInParking* is more than 0. After the agent receives the next milk tank vehicle for unloading, the stage of the statechart called *connectingPipes* gets activated and lasts for 15 minutes simulating the connection of hose pipes to the milk tank vehicle. Item *agentToFluid* is used to convert the items of milk tank vehicle into a particular volume of liquid. This item obtains parameter *milkCarSize* to define the capacity of one milk tank vehicle. Using *Pipeline* facilities, milk is supplied first to *milkSource* (simulation of tank *MPT01*) and then to *freezingTank* (simulation of cooler *ME01*). The cooled raw milk enters area *FluidExit*. The case frames from flow simulation library *FluidExit* and *FluidEnter* are made to implement a dynamic network of flows. In this model, these case frames are needed to simulate the distribution manifold valve. FluidExit includes method *connect*, to which item *FluidEnter* is connected. This method links *FluidExit* with *FluidEnter*. Then, the flow from *FluidExit* goes to *FluidEnter*; and this allows to dynamically convert the network of flows depending on the required configuration.

SIMULATION MODELING RESULTS

Item *Simulation* is used to do the initialization of input parameters. Command *getIntValue()* assists in choosing the integer values from the filled-up text boxes, command *getDoubleValue()* helps to choose the floating-point values. These values are applied to the previously discussed parameters in agent *Main*.

Besides, the simulation modeling environment of AnyLogic offers tools to plot different charts. In this case, a time-base chart from the available collection is selected, and the statechart for equipment is plotted. By doing so it is possible to analyse the states currently relevant for agents, and took managerial decisions. For instance, analysing the chart given in Fig. 4, it can be seen that the receiving module is in operation for only 1 hour, with the subsequent hours being idle. This means that under the set parameters the milk receiving module is able to process larger volumes of the supplied raw material.

Therefore, by carrying out the experiment with the model, it is possible to adjust the parameters of all production processes, and do the real-time tracking of the mode of operation for the equipment in order to prevent the equipment idle time, as well as identifying the system in its entirety.

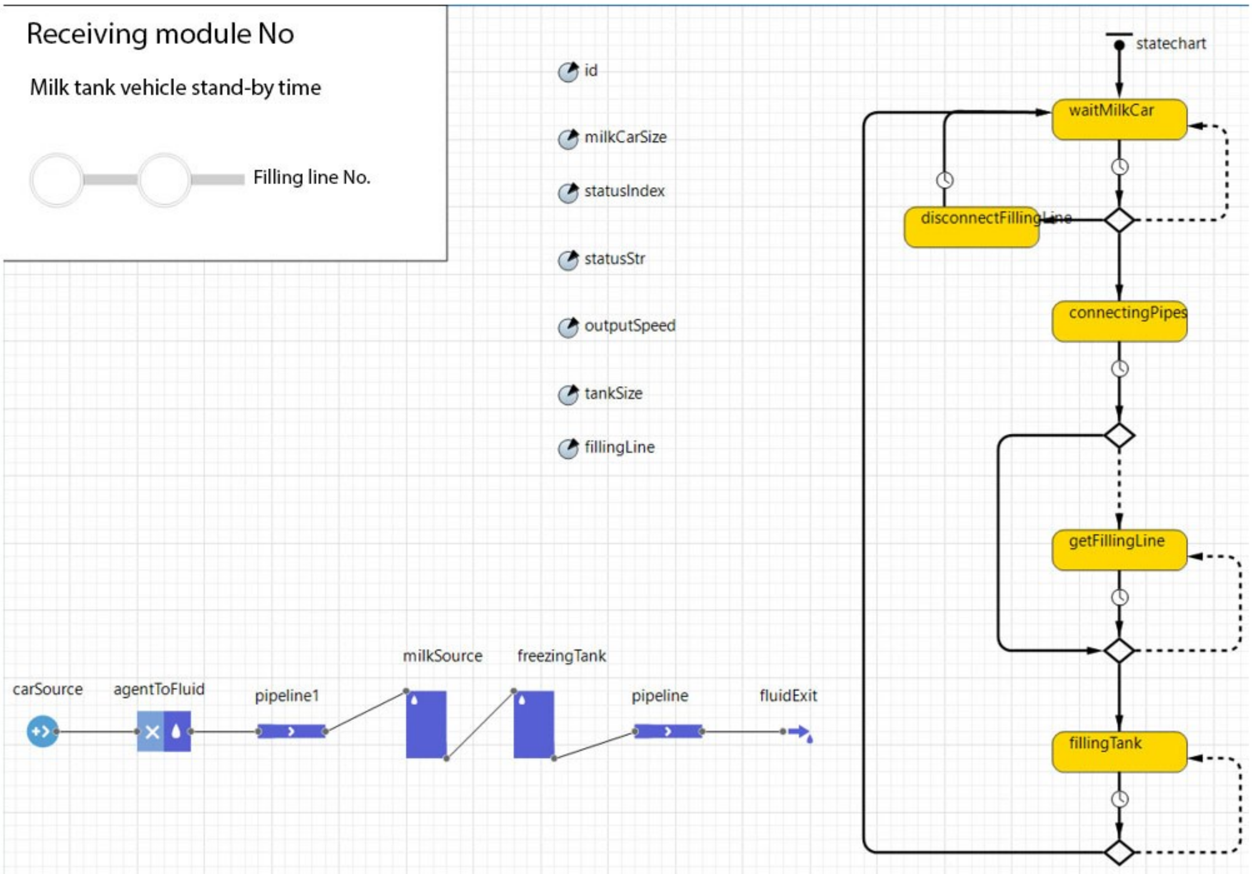

Fig. 3. Model of receiving module, its visual representation and statechart

Consequently, with the model undergoing the experiments, it is possible to select the appropriate equipment to achieve the target performance indicators.

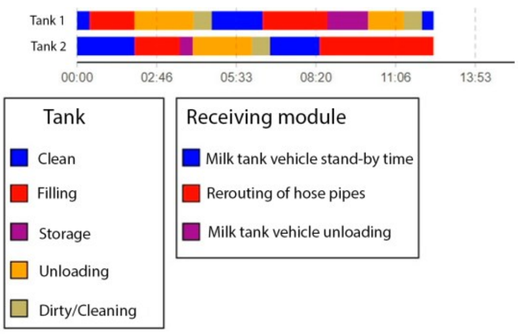

Fig. 4. Time-base chart

CONCLUSIONS

Based on the analysis of the production processes and using the equipment at the production facility, it is possible to elaborate the multiagent simulation model of the milk receiving area and the model of the milk tank vehicle supplier in the simulation modeling environment of AnyLogic.

Application of this agent-oriented model allows as follows:

- to identify the milk receiving processes at the production facility;
- to introduce the possibility of modifying the parameters for the purposes of conducting experiments;
- to employ the time-base chart to detect weak points of the production performance.

Using the designed simulation model makes it possible to test various equipment configurations by selecting relevant parameters.

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