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SIMULATION STUDY OF PRODUCTION PROCESS IN THE SAWMILLING INDUSTRY

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Abstract: The production processes in primary sawmilling consist of a series of time-related technological operations, where logs are processed into lumber. The basic machines involved in these processes are power saws and band saws with great processing capacities, as a result of which bottle-necks and discontinuities may occur in further processing. In practice in the wood industry, problems of this kind are resolved during the design of the technological process where the known methodology is most efficiently used [8]. This work suggests an additional methodology simulation study, whose results will be used as corrective arguments during the final decision making. The simulation study enables us to observe how the given technological process operates in due time and the influence of relevant factors on the operations and dynamics of the system based on results obtained in several experiments. The simulation language GPSS/FON is used for the performance of the observed model. Results are presented in tables and graphs.

Keywords: Primary sawmilling, power saw, production standard, operation time, simulation, GPSS/FON simulation language.

1. INTRODUCTION

The commencement of sawmilling in Serbia can be traced to the beginning of the 18th c. The main sawmilling centres in Serbia are on the mountains of Goč, Jastrebac, Zlatar, Kopaonik and Tara. In the Tara region there were 13 saw-mills and by the end of 1865 the number had already grown to 39. They employed about 195 workers and produced some 9,750 cubic meters of lumber per year. The number of saw-mills grew over the years and in 1913 they numbered 270 with 1,350 employees. In the 1880's big industrial saw-mills were built, the first being in Valjevo in 1882, and later on in Belgrade in 1890. From 1901 to 1905 four steam saw-mills were built, the biggest of which was the one owned by the Transfer Bank - Stock Company.

By the beginning of World War I this saw-mill was very modern. It started production with merely three power saws and six band saws and on the eve of the War it had five power saws and twelve band saws. Annual production of 20,000 to 30,000 cubic meters of conifer logs was recorded. The total number of saw-mills in Serbia in 1913 reached 295, with 2,657 employees and production capacities of some 2,226,050 cubic meters [1].

Primary processing as well as other industrial capacities were mainly destroyed in World War I. After the War came a time that could be described as a period of new sawmilling. Due to the great demand for lumber intensive development took place in sawmilling. According to statistics from 1938, the capacities of existing saw-mills expanded to 772,920 cubic meters of logs. Some 363,080 cubic meters were processed in the same year standing for the usage of 46,97%.

In 1946, following even further devastation during World War II, 86 saw-mills were reconstructed and put to work in Serbia, with a total of 125,400 cubic meters of lumber, of which 111,000 were conifer and merely 14,000 cubic meters were deciduous logs.

Saw-mills are very important for wood processing in Serbia even today. In 1991 they accounted for 1.95% of the country's total gross production and 83.58% of wood industry production. Exports of these products reached some 2% of total exports from Serbia and between 45 and 50% of total exports in the wood industry as a whole [2].

A modern scientific and technological approach is required today to resolve problems in primary wood processing. This fact lies behind the basic motivation for the application of the methodology described in this paper. Due to the larger scope of the study in which almost all jobs in primary sawmilling are mentioned, this paper describes just one part: the possibility of using GPSS/FON simulation language in order to obtain more accurate standards in processing and use the of basic machines.

2. RESEARCH GOAL

Standardization represents the basis of the planned production and scientific organization of processes within a company. Technical standards are among the most important and most efficient means to improve work quality, economical efficiency and profitability. They are the basis for the regular rewarding of employees too.

Regular scientific standardization and setting of technical standards, i.e. achievement of the best set effects, is a serious problem for many of companies. This problem occurs because of the experience standards usually used in practice. They can barely follow modern scientific and technical achievements and cannot possibly be used in our surroundings.

The basic purpose of this paper is to set accurate standards for "rough" log processing made by a power saw. In order to do so, the simulation model translated into GPSS/FON language is used as the starting point [5]. The simulation is applied to different uses of operating time during a working day. According to the results expressed in the tables and graphs, a processing standard can be determined for any operating time in any department.

3. DESCRIPTION OF THE REAL SYSTEM

Production processes in primary sawmilling consist of a series of time-related technological operations, where logs are processed into lumber. The basic machines involved in these processes are power saws and band saws with great processing capacities as a result of which bottle-necks and discontinuities may occur in further processing. For the simulation of such processes the most important fact is the total permeable capacity of an observed system that depends on the individual permeable capacities of its elements. Thus an attempt should be made to equalize as much as possible the permeable capacities of all elements, as an increase in only one part is of no use [9].

Log processing by a power saw may be done in one or two passes.One pass when a log is turned into a lumber (Fig. 1), produces a rough variation while two passes produce a "prismatic" variation. Simulation of the process described in this paper concerns just the first variant.

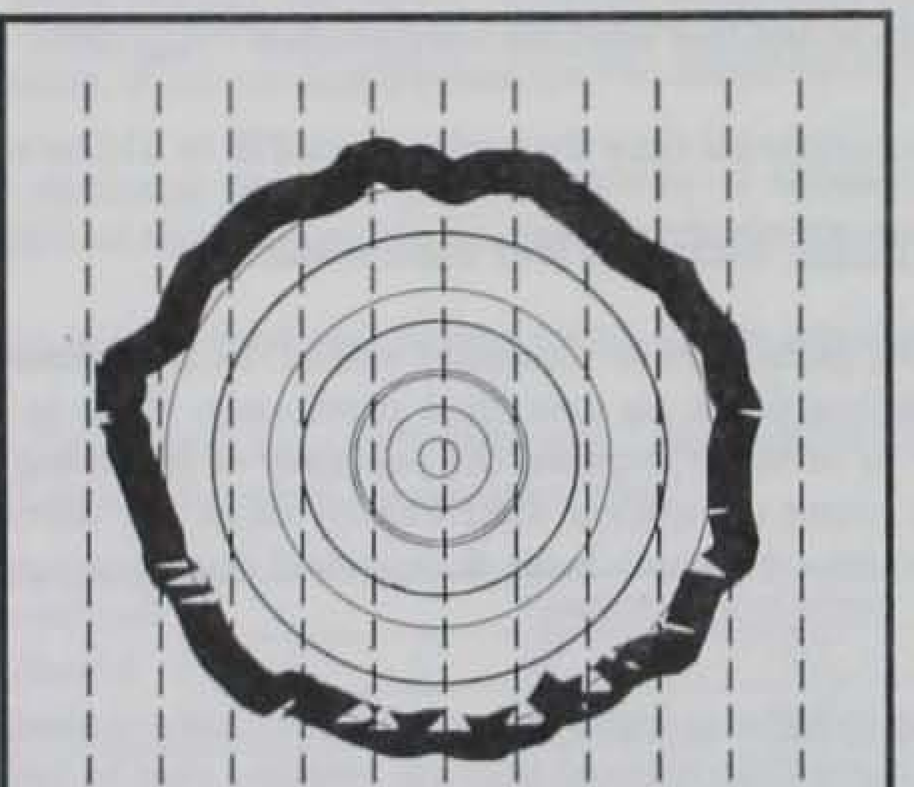

Figure 1: Graphical image of rough processing

4. CONSTRUCTION OF THE SIMULATION MODEL

The inner structure and construction of a simulation model of log processing by a power saw depend directly on the previously mentioned research goal purpose. To this end, mainly analytical methods have been used to date. They calculate the observed value of incoming parameters. The simulation approach to this problem involves a somewhat different methodology [3], including the following stages:

1. Setting the necessary parameters in the field.
2. Calculation of a projected balance of working time.
3. Creation of the model.
4. Experimental stage.
5. Analysis of the results and reaching profitable decisions.

1. Setting the necessary parameters involves setting the machine speed (1.27 m/min), setting the diametrical and longitudinal classes of logs that are being processed, and observing the operating time in a working day. Four diametrical classes are observed, i.e.: from 20 to 29 cm, from 30 to 39 cm, from 40 to 49 cm and from 50 to 59 cm. The lengths of logs vary from 4 to 8 m. Observed exploitation of time (T_o) for 10 observations reached up to an average of 66,38%.

2. Calculation of the projected balance of working time is done according to the given involvement of individual elements of time. Given values of total working time are:

- preparation final time - T_{pf} (from 2 to 5%),
- time necessary for a job - T_j (from 1 to 3%),
- time losses due to organisation or technological reasons - T_{lot} (from 2 to 4%),
- time losses due to individual workers - justified - T_{lwj} (44 min),
- time losses due to individual workers - unjustified - T_{lwu} (0%).

Projected operational time To varies from 379 to 412 min.

3. The simulation model comprises four basic steps:

a) Simulation of log diameters as incoming values. In this phase four basic diameters are used as the starting point, as described previously. Each is then divided into ten classes (1 cm wide) in order to increase the accuracy of incoming data. Thus, incoming data are simulated using a uniform distribution since log diameters within a single class (1 cm) are the same. For each basic diametrical class one continual GPSS function is defined [6], [7].

b) Simulation of log lengths as incoming values. For this simulation a GPSS function is used to create a uniform distribution, bearing in mind that incoming values (according to available data) comprise values from an interval of 4 to 8 m, with classes 50 cm wide.

c) Simulation of log processing by a power saw. This process is observed as a discrete process where the passing speed is a key parameter (expressed in cm/min.) In the simulation model a facility device is used as just one log is processed by a machine [4].

d) Setting the total volume of processed logs. One of the key parameters for functioning of the observed process is the total volume of logs treated in different operating times. It can be determined as the cumulative volume of each processed log during the simulation.

4. The experimental stage involves four phases: the first phase has three basic experiments for the projected To_max of 412 min., To_min of 379 min. and observed To of 302 min. In the second phase 32 experiments were conducted with eight different operating times and the four diametrical classes already mentioned. In the observed company, within a single working day, mainly two by two identical diametrical classes were processed. The third phase includes combinations of different classes without repeats. In the fourth phase of the experimental stage the influence of changes to the machine's speed on the number and total volume of processed logs is discussed for different operating times (selected in the second phase of the experimental stage) applied to the first diametrical class. In due course the basic fact is that in a real system the machine speed adopted is frequently less than moderated by the equipment manufacturer, mainly because of the lifetime and exhauster of the equipment or as result of any other business or technological decision which is made. Starting from the initial machine speed (1.27 m/min) which is used in the three previous phases of the experimental stage here we consider speed reductions by 10% (1.14 m/min), 15% (1.08 m/min) and 20% (1.01 m/min).

5. SIMULATION RESULTS

The obtained results have a standard GPSS/FON form including the following sets of data: (1) instantaneous and cumulative condition of all model logs the moment simulation is over, (2) statistical parameters of basic permanent entities in a model (devices, lines etc.), (3) conditions of memory locations the moment simulation is over and (4) other parameters of minor significance for the observed real system.

Instead of complete outcome results, a recapitulation of chosen parameters that are important for valuation of the real system functioning is shown, as follows.

1) Summarised results for the first and second phase of the experimental stage:

Table 1: Processing standards by a shift (480 min.) for implied diametrical classes and different involvement of operating time

T_0 (min)	Number of processed logs	Diametrical classes I (m^3)	II (m^3)	III (m^3)	IV (m^3)
250	55	14.00	27.87	48.49	69.71
275	59	15.35	30.68	52.60	75.55
300	64	16.64	33.55	57.37	82.78
302		16.91			
325	70	18.29	37.02	62.99	91.66
350	74	19.44	39.28	66.79	97.68
375	80	20.78	42.27	71.75	105.62
379		20.97			
400	86	22.45	45.12	76.62	113.16
412		23.09			
425	92	23.94	48.00	81.23	120.31

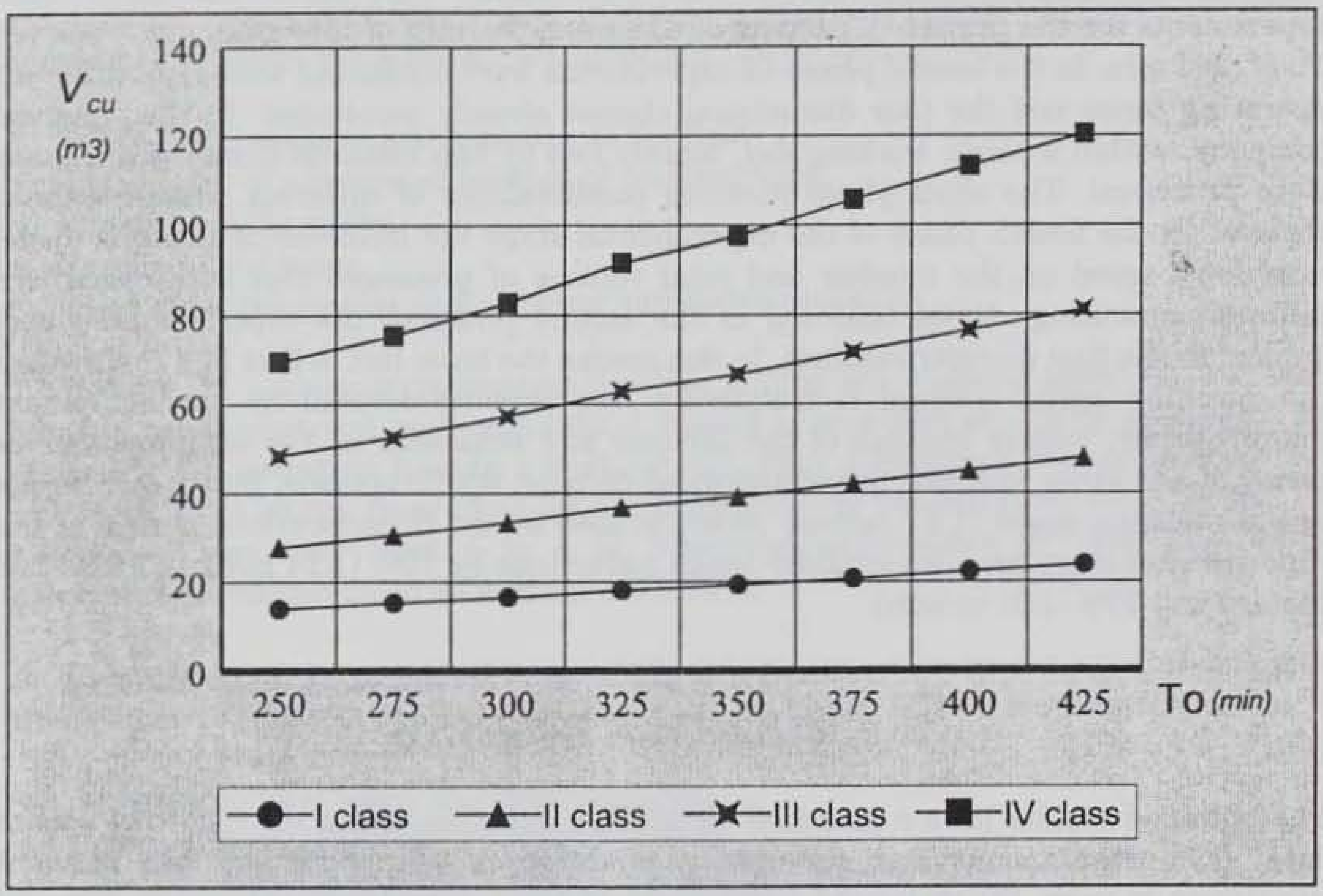

Figure 2: Table of results summarized in Table 1.

2) Summarised results for the third phase of the experimental stage:

Table 2: Standards set by a shift (480 min.) for combinations of diametrical classes and different involvement of operating time

	Diametrical classes					
T_o	I/II	I/III	I/IV	II/III	II/IV	III/IV
(min)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
250	20.94	31.25	41.85	38.19	48.79	59.10
275	23.02	33.98	45.46	41.64	53.12	64.08
300	25.10	37.01	49.71	45.47	58.17	70.08
325	27.66	40.65	54.98	50.01	64.34	77.33
350	29.36	43.12	58.56	53.04	68.48	82.24
375	31.53	46.24	63.20	57.02	73.65	88.69
400	33.79	49.54	67.81	60.87	79.14	94.89
425	35.97	52.59	72.13	64.62	84.16	100.78

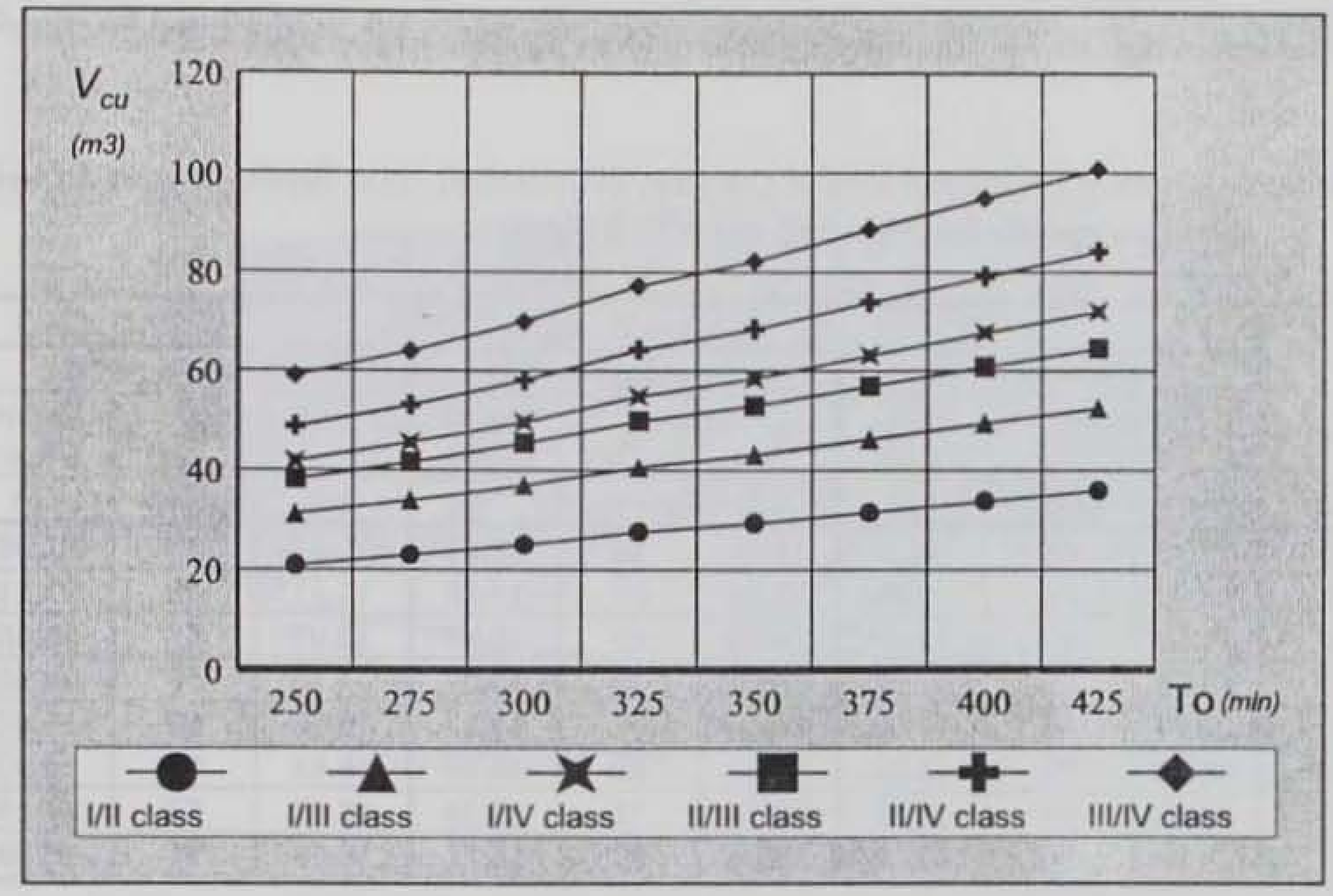

Figure 3: Graph showing results summarized in Table 2.

In order to observe the regularity of the simulation model the obtained results are compared with results from a real system and are analytically calculated. The partial deviation from results obtained by simulation (for the observed operational time T_0 = 302 min. - 1.5 cubic meters of treated logs, i.e. max. 7%) is within tolerable limits and is due to a different calculation approach (with analytical calculation average values are used).

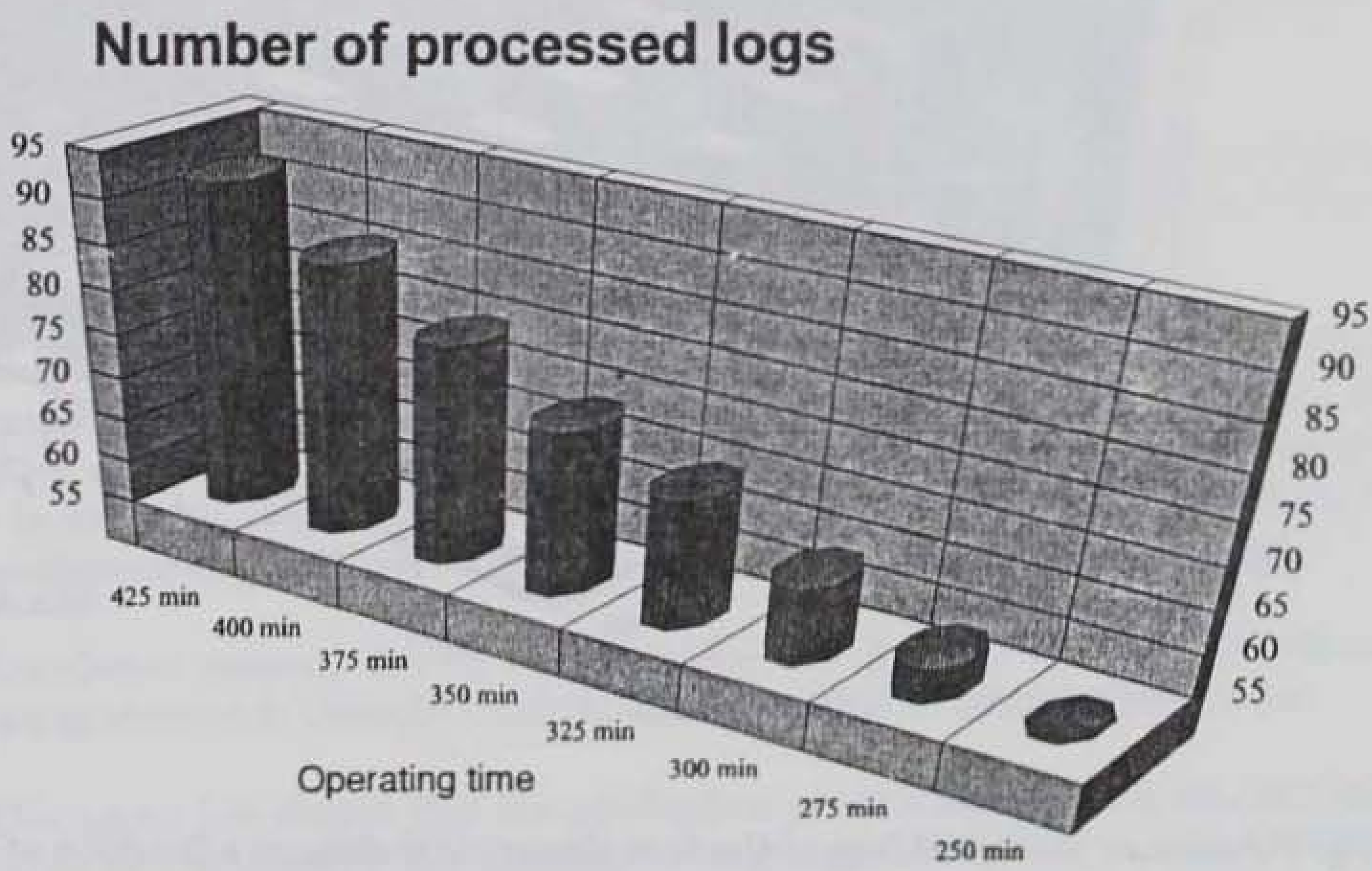

Figure 4: Number of processed logs (diametrical class I) by a shift and depending on the real or projected balance of the operating time usage

3) Summarised results for the fourth phase of the experimental stage:

Table 3: Volumes of processed logs of the first diametrical class depending on different machine speeds for different operating times

T_o	Machine speed								
	1.14 m/min (-10%)			1.08 m/min (-15%)			1.01 m/min (-20%)		
	Processed		Reduction	Processed		Reduction	Processed		Reduction
(min)	(m^3)	pieces	(%)	(m^3)	pieces	(%)	(m^3)	pieces	(%)
250	12.11	48	13.5	11.54	46	17.57	11.01	44	21.36
275	13.50	53	12.05	12.59	50	17.98	12.11	48	21.11
300	14.55	57	12.56	14.00	55	15.87	13.07	52	21.45
325	16.24	62	11.21	15.35	59	16.07	14.22	56	22.25
350	17.29	66	11.06	16.49	63	15.17	15.78	60	18.83
375	18.29	70	11.98	17.47	67	15.93	16.64	64	19.92
400	19.69	75	12.29	18.58	71	17.24	17.47	67	22.18
425	20.78	80	13.20	19.94	76	16.71	18.58	71	22.39

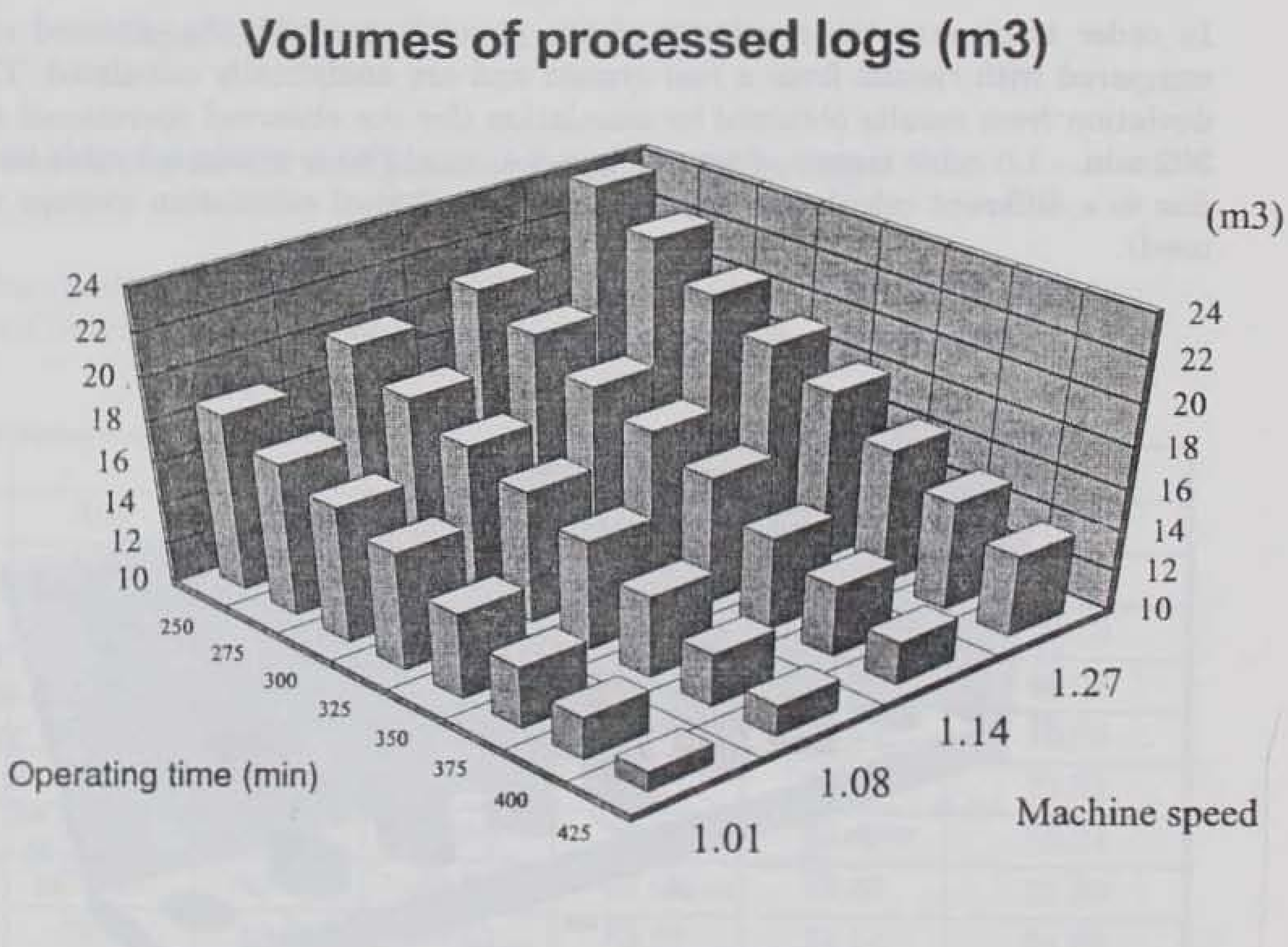

Figure 5: Volumes of processed logs of the first diametrical class as a function of machine speed for different operating times (from Table 3)

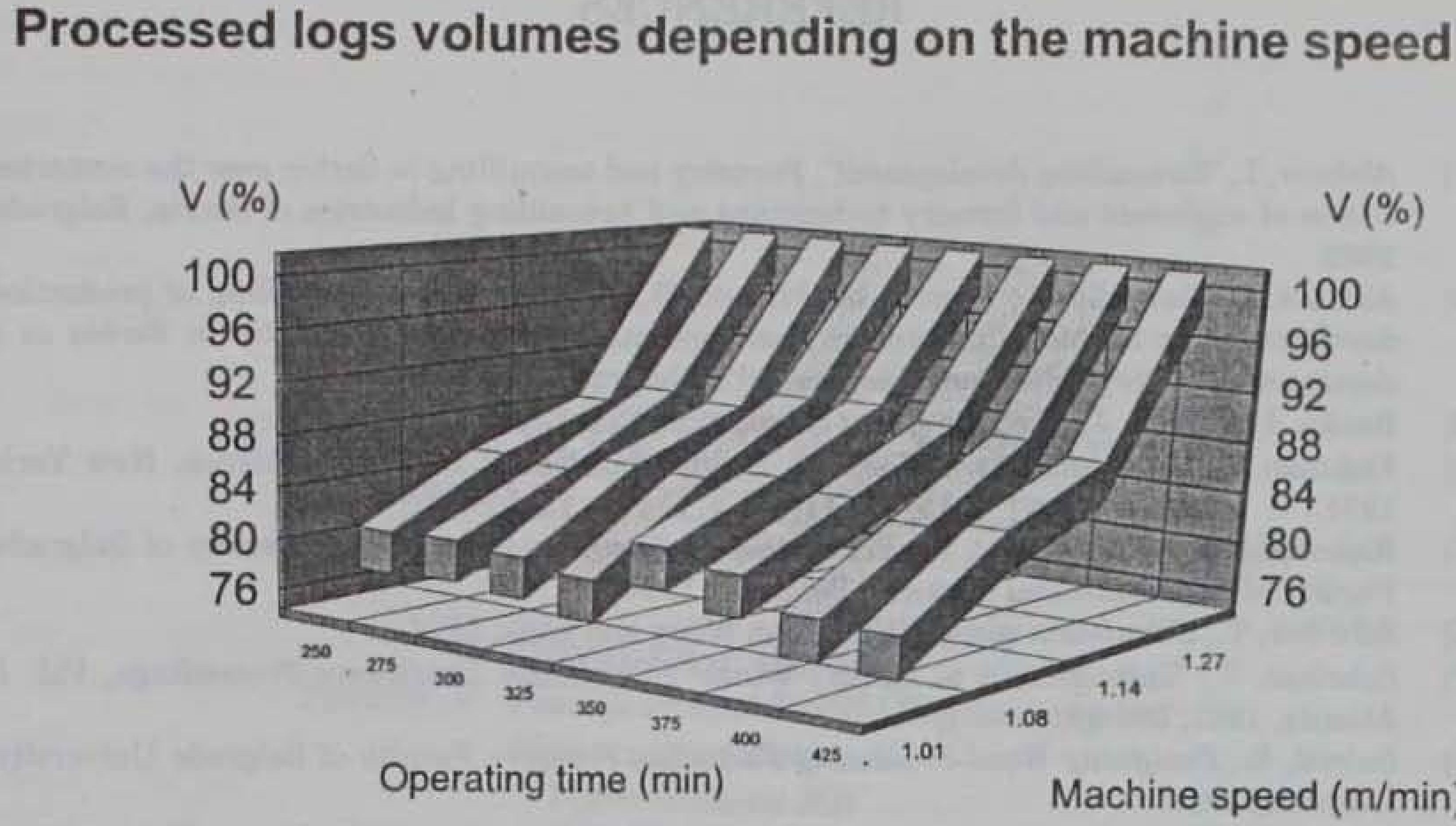

Figure 6: Processed log volume reduction as a result of a decrease in machine speed for different operating times

6. CONCLUSION

According to real system analyses, the constructed simulation model, conducted experiments and analysis results, several conclusions can be made including the most important:

- On the basis of simulation results it is possible to make eventual corrections to the projected technology (type and number of necessary machines in the phases of the technological process) before final equipment investment.

- Also it is possible, for an observed workplace, and on the basis of declared input and parameters (the amount of incoming raw material, operating time, the change of the speed of the machines), to determine the optimal passage power of the system, in order to avoid waiting or bottle-necks which result in overloading machines, and also tool malfunctioning and breakage.

- Simulation results, shown in the tables and graphs, can be used when setting processing standards through a simple approximation in concrete conditions.

- This paper has shown that the production process in sawmillis can be successfully simulated by the usage of the simulation language GPSS/FON and that the results of such a model can be used as additional arguments when making important technological and economic decisions.

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