

The Application of Process Simulation Software FlexSim in Textile Study Program

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Abstract. Nowadays simulation is becoming a common tool for various processes analysis, whether it is a video game, local weather forecast, or any other area of daily life. FlexSim software provides virtual environment with the ability to simulate any process with as much information as the user needs. FlexSim simulations are commonly applied in areas such as manufacturing, warehousing, distribution of goods and products, materials processing etc. The aim of this presentation is to show how FlexSim software can be integrated into textile orientated study programs and to illustrate its application possibilities in the analysis of garment production process. Also, to take measures to increase the efficiency of production flow by eliminating its bottlenecks.

Keywords: simulation software, garment manufacturing, bottlenecks, efficiency, production flows

I. INTRODUCTION

Nowadays simulation is becoming a common tool for various processes analysis, whether it's a video game, local weather forecast, or any other area of daily life. Animated scripts are usually simulated in virtual environments that correspond to a real situations, processes or data flows. FlexSim program provides virtual environment with the ability to simulate any process with as much information as the user needs FlexSim simulations are commonly applied in areas such as manufacturing [1], warehousing [2] distribution of goods and products, materials processing [3], etc. They can also be easily adapted to simulate human resource logistics, e. g. in healthcare [4] or other service areas, due to their flexible and virtual design. Often, simulation models are quite abstract, because they are projected to answer a specific question or solve a specific problem.

The aim of this presentation is to show how FlexSim software can be integrated into textile orientated study programs. Parallely to illustrate its application possibilities performing the analysis of garment

manufacturing process by taking certain measures to eliminate bottlenecks and to increase the efficiency of production flow. The presentation shows how FlexSim software can be used by educators, students, and researchers as a learning resource in the classroom, or as a research tool.

II. METHODS

Layout of manufacturing workplaces can be modelled using traditional or digital methods. Traditional methods are static, time consuming and usually lead manufacturing industries to real time problems, e.g. like unpredicted presence of bottlenecks. Meantime, FlexSim is a simulation software used to model, to visualize, and to analyze the production flow with real-time situations.

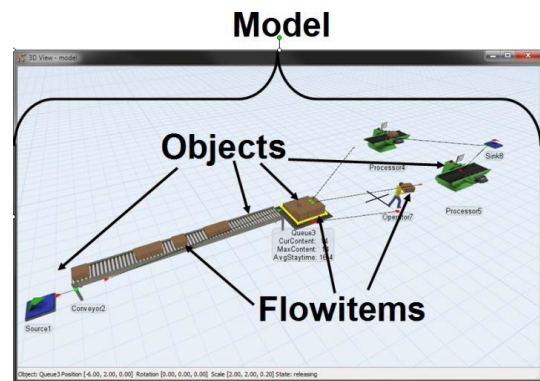


Fig. 1. The sample of FlexSim model, composed of objects, flowittems and input-output port connections [5]

FlexSim simulation model consists of objects and flowittems [5]. Objects: *Queue*, *Processor*, *Conveyor* are the basis of simulated model. They are stationary blocks with predefined attributes, variables, e.g. processing time, and visual properties. Meantime flowittems are semi-finished products that travel from one workplace to another, e.g. from one processor to the other. Objects are

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also considered as fixed resources, which send and receive flowitems. For example, the *Source* introduces flowitems into the simulation model, the *Queue* stores them; the *Processor* processes and at the end flowitems leave the model through the *Sink* (Fig. 1).

Specific parameters must set for each fixed resource. In this case of garment manufacturing process for the *Source* ‘arrival schedule’ style was selected and it was indicated that semi-products of all 800 garments were provided at the start of production (Fig. 2a). For *Queue*, which in real garment manufacturing production represents trolley, maximum capacity was limited up to 800 garments (Fig. 2b) and for each *Processor* individual processing times were set, e.g. 138 seconds (Fig. 2c).

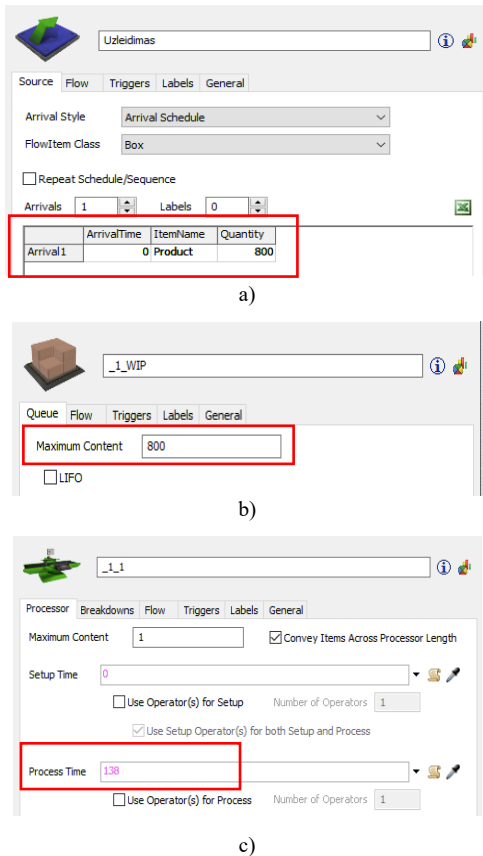


Fig. 2. Configuration of fixed resources: a) *Source*; b) *Queue* and c) *Processor*

At the start for training and aiming to provide initial skills to work with FlexSim software simple tasks with little number of objects and flowitems are provided for students. For example, it may be the task related to the efficiency of customer service in the store, e.g. buyers arrive every 120 s and only 25 buyers can wait in line at the store at the same time. There are two cash registers with a service time of 45 s each, the store's working hours are 8 h (28800 s). Unserved customers are directed away (Fig. 3). At the second step of training the task becomes more complex in such a way that it is necessary to find means and to model new situation so that there would be no unserved buyers.

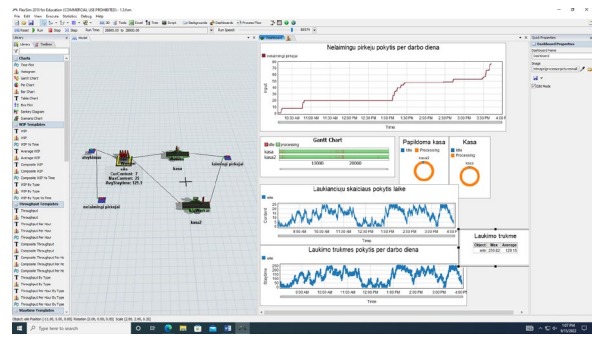


Fig. 3. The sample of FlexSim model, composed of objects, flowitems and input-output port connections

By modelling and simulating the above-mentioned situations, students simultaneously learn to use the analysis tools integrated in the software, i.e. various forms of graphs and charts that illustrate system changes in real time (Fig. 3). After acquiring initial knowledge and skills in Flexim, the students are moving towards more complex tasks. In this case - the analysis of the garment manufacturing process, which is described in the next section.

III. RESULTS AND DISUSSIONS

Garment production management starts with product specification - the document, in which the information about particular garment is collected, i.e. its type, collection, season, size range, etc. Usually it includes technical sketch, brief description and specific manufacturing instructions.

The sample of a textile student work, which is presented below, started with the specification of women’s shirt-style dress: a) Technical sketch (Fig. 4), b) Description and c) Making plan (Table 1), i.e. technological sequence of shirt dress making (sewing) operations.

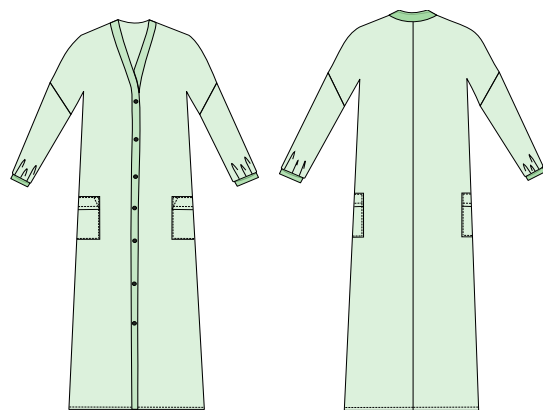


Fig. 4. Technical sketch of women’s shirt-style dress

The Description of the product is as follows: oversized shirt-style dress the length of which is below the knees. The shoulder line of the garment is lowered and soft. The dress is fastened with seven buttons. Sleeves are single-stitched, with ruffles and cuffs. On the sides of the dress there are deep pockets with decorative flaps.

TABLE 1 THE SAMPLE OF WOMEN'S SHIRT MAKING PLAN

Op. No.	Making operation description	Work type	Time t , s	Equipment
1.	to fuse cuffs, stand and collar	P*	35	ironing bar
2.	to sew cuff details together; seam width 1,0 cm	M**	364	universal sewing machine
35.
Total making time:			2365 s	

NOTE: P* - hot pressing work; M** - machine work.

In traditional textile studies garment manufacturing efficiency and production flow planning are performed on the basis of theoretical calculations the data for which is: process capacity (PC); process tact (τ); total making time of a garment ($T_{garment}$); number of employees (D). In this task process capacity PC was 800 shirt dresses per shift. Total making time of a shirt dress $T_{garment}$ was 2365 s. Duration of a work shift T_{shift} 8 hours (28800 s). Process tact τ (the average time of organizational operation) is calculated using equation (1) and the number of required employees D - using equation (2):

$$\tau = T_{shift}/PC = 28800/800 = 36s \quad (1)$$

$$D = T_{garment}/\tau = 2365/36 = 65,6, \text{ i.e. } D = 66 \quad (2)$$

During the next step 35 making operations from Making plan (Table 1) must be grouped into organizational operations so that their duration is equal to or a multiple of the tact τ , which is 36 seconds. However, to group making operations by following this rule is practically impossible. Therefore, 15% deviations from the tact are allowed for non-conveyor processes. Thus, the duration of organizational operations is calculated by considering these limits:

$$\tau_{min} = 0,85 * 36s = 31s \quad (3)$$

$$\tau_{max} = 1,15 * 36s = 41s \quad (4)$$

The sample of making plan division for 66 employees by grouping 35 making operations into 18 organisational operations is presented in Table 2.

Using synchronization chart of women's shirt production flow, it is possible to analyse theoretically the employee efficiency by comparing the compatibility of the durations of organizational operations with the tact τ of the process. The time of each organizational operation must be equal to or a multiple of τ , which is 36 s. However, due to the allowable 15% deviations, the limits of the correct time are between 31 and 41 seconds (Fig. 5). Columns marked in yellow represent workplaces with occupancy below the permitted limits, while red columns represent workplaces with occupancy above the tact τ and the permitted deviation (Fig. 5).

From this synchronization chart theoretical prediction can be made that the most problematic workplace will be no.12 as the biggest bottleneck will appear here and certain organization measures must be considered before starting the manufacturing process. Still this is theoretical assumption that by solving the problem of workplace no. 12, 800 garments will be successfully produced in one shift of 8 hours.

TABLE 2 THE SAMPLE OF ORGANISATIONAL OPERATIONS PLAN

Op. No.	Description	Time t , s	Number of employees		Employee efficiency, %
			Theoretical	Actual	
1.	1. to fuse cuffs, stand and collar	35			
	3. to iron the seam to the inside	20			
	4. to fold the top edge of the pocket by 1 cm	10			
	5. to iron the sides and bottom of the pocket by 4 cm	40			
	6. to fold the cuffs in half, to flatten another 1 cm from one edge	90			
			195	5,4	5
2.	7. Sew the sleeve piece to the base	60			
		60	1,67	2	83,3
18.
In total:		2365 s		66	

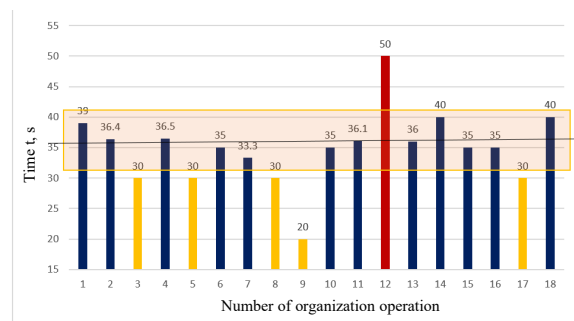


Fig. 5. Synchronization chart of women's shirt production flow

Actual situation, which was simulated by student with the help of FlexSim software, appeared to be different. The model of the process is presented in Figure 5 and it shows that after 8 hours (28800 s) only 525 shirt dresses were finished and it will take much more time to finalize the whole order of 800 garments.

Also, work efficiency graphs were generated with FlexSim simulation software, which indicate workplaces loaded at maximum during the entire shift: no.1 (100%), no.2 (92.15%), no.4 (91.56%) and no.12 (93.94%) (Fig. 6). It corresponds to theoretical data presented in synchronization graph (Fig. 5), as the time of these organizational operations exceeds process tact of 36 s. It can be also noticed that operational time at workplace no.14 and no.18 are also higher than 36 s (40 s), but their efficiency is very low due to the bottleneck at workplace no.12, because of which they were not receiving garments.

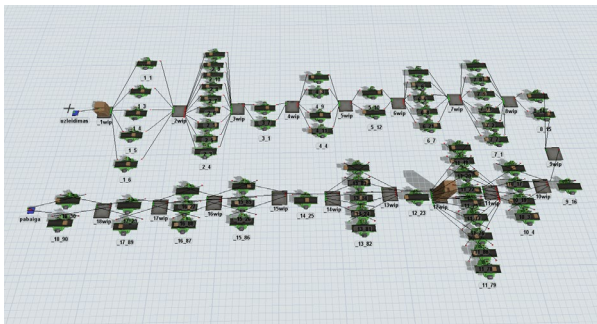


Fig. 6. FlexSim simulation model of women's shirt production flow with bottlenecks

Analysis of simulation results allowed to make the conclusion that making operations must be grouped into operational seeking to get their duration equal or a bit less than process takt τ at the very start of the production flow in order not to form bottlenecks and not to stop the work at the following workplaces. In the analysed case 60 garments were stuck at the workplace no.1 and were not started to be processed even at the end of the shift, i.e. after 8 hours. The difference between process takt τ (36 s) and operational time at workplace no.1 (39 s) is only 3 seconds, but it was enough for the bottleneck to form at the start of manufacturing process.

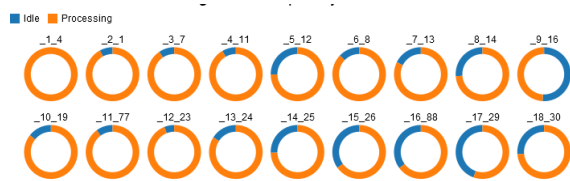


Fig. 7. Efficiency of work stations in women's shirt production line simulated by FlexSim software

The second bottleneck of 152 garments was formed at the workplace no.12 - in the ironing zone. A rational way of solving this problem is to plan a return operation, i.e. transfer part of the products to the workplace no.9, e.g. by trolleys, because this workplace is also equipped with an iron. In this way, the occupations of both workplaces would be balanced and the problem of workplace no.9 - too low work efficiency, which was only 49%, will be solved.

Thus, it is evident that virtual modelling of garment manufacturing processes and the ability to simulate them

in real time provides significant added value to the study process by developing a wider skill of students, as the knowledge of production process planning is not limited only with theoretical calculations.

IV. CONCLUSIONS

Nowadays textile and clothing companies are different in terms of innovations, knowledge generation, experience and competences. In order to accelerate the transformation of fashion industry into intelligent and digital, it is necessary to educate specialists by providing knowledge and practical skills to analyse, research and solve the problems of product development and production processes based on their digital simulation and virtualization. FlexSim software provides a powerful real-time simulation tool which makes it possible not only to check different solutions for the elimination of bottlenecks, which may appear in production flows due to the deviations in the synchronization of production operations, but also to check them through the whole virtual production period. Virtual modelling of garment manufacturing processes and the ability to simulate them in real time provides added value to the study process by developing a wider skill of students, as the knowledge of production process planning is not limited with theoretical calculations, but deepened by real time simulations.

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