

EVALUATION OF THE TEXTILE INDUSTRY FABRICATION LINES PERFORMANCES USING PETRI NETWORKS MODELS

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Abstract — The paper presents an approach to the matters of the flux lines which are specific to the industry of textile clothes, from the point of view of their balance. Frequently, it happens that the time periods of the operations are much different, and this leads to jams and extended waiting times, with negative influence on the efficiency. This paper proposes the use of a modeling and simulation method based on timed Petri networks, which will allow the analysis of the flux lines operation, the highlighting of the bottlenecks and to yield information to the personnel that take managerial decisions. Three lines, which manufacture the following products: jacket, skirt and trousers, are analyzed. For each case, the modeling and simulation procedure yields solutions for jam solving.

Keywords — flux lines, bottleneck, Petri networks, modeling and simulation

I. INTRODUCTION

In textile clothes industry, a manufacturing line for a product consists of a set of distinct operations which are allocated to some work places which are connected by means of a transportation mechanism [1], [2]. The finite product is the result of the stitching of several sub-components by means of certain processes.

In the balance of the assembly lines, the task allocation for each work place aims to minimize the waiting times between operations, which increases productivity [3].

The matter of balancing the fabrication lines in textile clothes industry was approached in various papers [4], [5].

The paper presents the possibility to use timed Petri networks for the functional optimization of the flux lines [6]- [12].

The studied cases refer to fabrication lines of certain clothes articles, such as: jacket, skirt and trousers.

II. MODELING OF THE FABRICATION LINES BY MEANS OF PETRI NETWORKS

The specific products of the company SC TRICOUL

SRL belong to the category of (ready-made) clothes for children, women and men.

Fig. 1 shows specific products of this company of type “jacket”, “skirt” and “trousers”.



Fig. 1. Products of company SC TRICOUL SRL.

On the production lines of the company, very often it happens that each of the three lines yields other product. The schematic placement of the three lines is shown in Fig. 2.

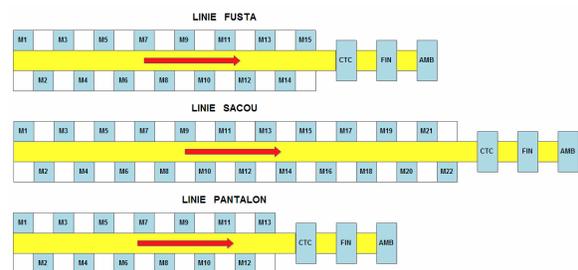


Fig. 2. The fabrication lines in the company.

Table I shows the operations corresponding to the realization of the product “skirt”, the work places where they are made and the time periods for each operation.

| Nr. | Operations | Work place (machine) | Time (min & sec) | Transition |
|-----|-----------------------------|----------------------|------------------|----------------|
| 1 | Close rear and lateral side | M1 | 2' | T ₁ |

| | | | | |
|----|-----------------------------------|-----|-------|-----------------|
| 2 | Close middle rear with slits | M2 | 1'30" | T ₂ |
| 3 | Prepare rear slits | M3 | 2 | T ₃ |
| 4 | Prepare rear pocket | M4 | 1 | T ₄ |
| 5 | Execute front pocket | M5 | 2 | T ₅ |
| 6 | Stitch zipper pocket | M6 | 2'30" | T ₆ |
| 7 | Close middle front + prepare slit | M7 | 2 | T ₇ |
| 8 | Execute slit | M8 | 2'30" | T ₈ |
| 9 | Lateral closure | M9 | 1'30" | T ₉ |
| 10 | Line slit lining + fix lining | M10 | 1'50" | T ₁₀ |
| 11 | Prepare lining | M11 | 2 | T ₁₁ |
| 12 | Prepare waistband | M12 | 2'30" | T ₁₂ |
| 13 | Mount waistband | M13 | 1'30" | T ₁₃ |
| 14 | Stitch waistband | M14 | 1 | T ₁₄ |
| 15 | Execute seam | M15 | 1'15" | T ₁₅ |
| 16 | Inspection | M16 | 5" | T ₁₆ |
| 17 | Final ironing | M17 | 10 | T ₁₇ |
| 18 | Pack | M18 | 5 | T ₁₈ |

Table II shows the operations for the realization of product "trousers", the work places where they are carried out and the time periods for each operation.

TABLE II
TECHNOLOGICAL FLUX FOR THE PRODUCT "TROUSERS"

| Nr. | Operations | Work place (machine) | Time (min & sec) | Transition |
|-----|----------------------|----------------------|------------------|------------|
| 1 | Rear clip | M1 | 1' | T1 |
| 2 | Execute front pocket | M2 | 2' | T2 |
| 3 | Seam front pocket | M3 | 1'30" | T3 |
| 4 | Close pouch + seam | M4 | 2'30" | T4 |
| 5 | Close | M5 | 2 | T5 |
| 6 | Execute front slit | M6 | 2'30" | T6 |
| 7 | Close side | M7 | 3' | T7 |
| 8 | Side reserves | M8 | 2'30" | T8 |
| 9 | Close interior | M9 | 2' | T9 |
| 10 | Close | M10 | 1' | T10 |
| 11 | Rear | M11 | 2'30" | T11 |
| 12 | Mount waistband | M12 | 2' | T12 |
| 13 | Seam waistband | M13 | 1'30" | T13 |
| 14 | Execute seam | M14 | 1'30" | T14 |
| 15 | Final ironing | M15 | 10' | T15 |
| 16 | Pack | M16 | 5' | T16 |

Table III shows the operations for the realization of product "jacket", the work places where they are carried out and the time periods for each operation.

TABLE III
TECHNOLOGICAL FLUX FOR THE PRODUCT "JACKET"

| Nr. | Operations | Work place (machine) | Time (min & sec) | Transition |
|-----|-------------------|----------------------|------------------|------------|
| 1 | Close facing | M1 | 2'15" | T1 |
| 2 | Seam facing | M2 | 2' | T2 |
| 3 | Execute pocket | M3 | 3' | T3 |
| 4 | Mount front band | M4 | 2' | T4 |
| 5 | Mount rear lapel | M5 | 2'15" | T5 |
| 6 | Close edge | M6 | 2'50" | T6 |
| 7 | Close middle side | M7 | 1' | T7 |

| Nr. | Operations | Work place (machine) | Time (min & sec) | Transition |
|-----|-------------------------|----------------------|------------------|------------|
| 8 | Close rear side | M8 | 1'50" | T8 |
| 9 | Seam side rear | M9 | 2' | T9 |
| 10 | Sew clips sleeve elbow | M10 | 1'50" | T10 |
| 11 | Seam clips sleeve elbow | M11 | 1'15" | T11 |
| 12 | Execute sleeve slit | M12 | 3' | T12 |
| 13 | Close sleeve slit | M13 | 2' | T13 |
| 14 | Close sleeve | M14 | 1'15" | T14 |
| 15 | Close collar | M15 | 2' | T15 |
| 16 | Close side + shoulder | M16 | 2'50" | T16 |
| 17 | Mount collar | M17 | 3'15" | T17 |
| 18 | Mount sleeve | M18 | 3' | T18 |
| 19 | Mount cushions | M19 | 3'50" | T11 |
| 20 | Line jacket | M20 | 4' | T12 |
| 21 | Line sleeve | M21 | 2'50" | T13 |
| 22 | Fix collar + lapel | M22 | 2'50" | T14 |
| 23 | Inspection | M23 | 5' | T15 |
| 24 | Finishing (ironing) | M24 | 20' | T16 |
| 25 | Pack | M25 | 10' | T17 |

In order to evaluate the production on the three fabrication lines, the time period is set to 8 hours (one shift), that is 28800 seconds.

Considering the simulation mode Max Speed, the volume of the production of each model is attained.

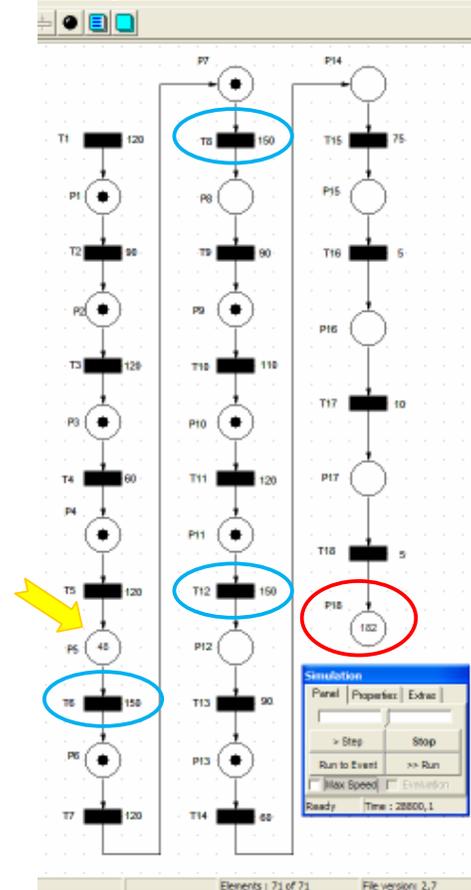


Fig. 3. Petri networks model for the skirts fabrication lines.

Fig. 3 shows the simulation results of the skirts

fabrication line operation.

The estimated number of produced skirts is 180 items during 8 hours.

The simulation highlights the bottlenecks of the fabrication line, which are: stitch zipper pocket (M6), execute slit (M8), prepare waistband (M12). Thus, in order to avoid jams, the multiplication of the work places for the critical places is proposed. Fig. 4 shows the resulted Petri networks model.

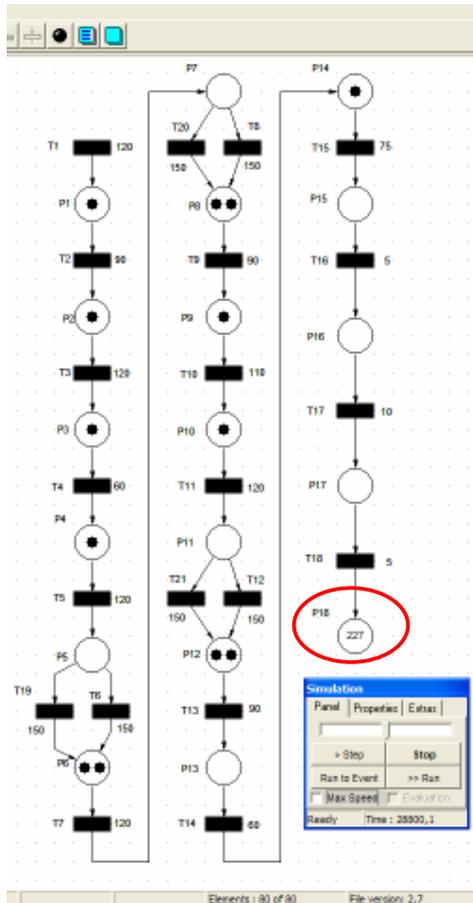


Fig. 4. Petri networks model for the skirts fabrication line after the multiplication of the work places.

Also, the productivity increased significantly: 124,7%.

Fig. 5 shows the simulation results of the trousers fabrication line operation. The estimated number of produced trousers is 151 items during 8 hours.

The bottlenecks of the trousers fabrication lines were identified by means of successive simulations. After the first simulation, they are Execute front pocket (M2 - T2), Close pouch + seam (M4 - T4) and Close side (M7 - T7). Afterwards, the bottlenecks shown in dotted lines appeared (Fig. 6). It can be seen that there are situations when the work places for one operation must be tripled in order to ensure jam-free functioning. After the removal of the bottlenecks, the productivity will increase: 454 items (300%).

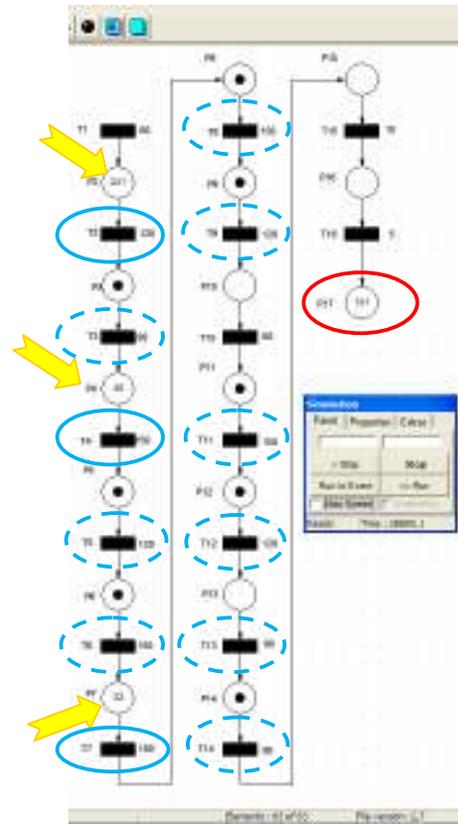


Fig. 5. Petri networks model for trousers fabrication lines.

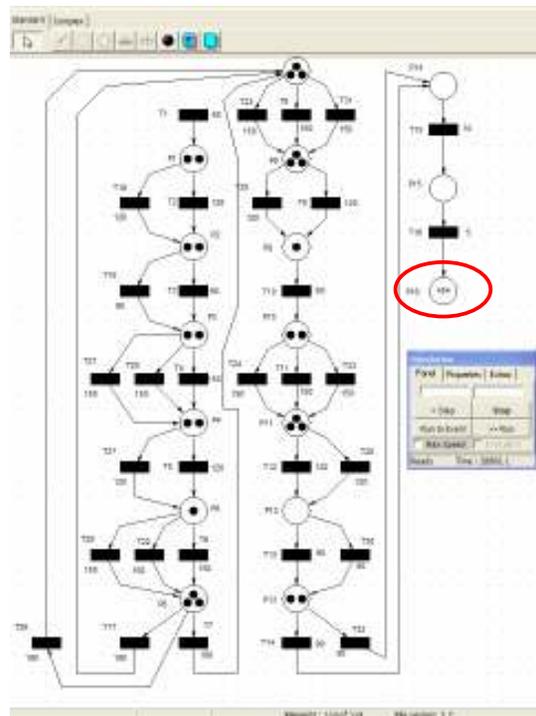


Fig. 6. Petri networks model for skirts fabrication lines after the multiplication of the work places.

Fig. 7 shows the simulation results of the jackets fabrication line operation.

The estimated number of produced jackets 85 items during 8 hours.

When the work places are multiplied, so that jams are avoided, the productivity may increase to 170 items.

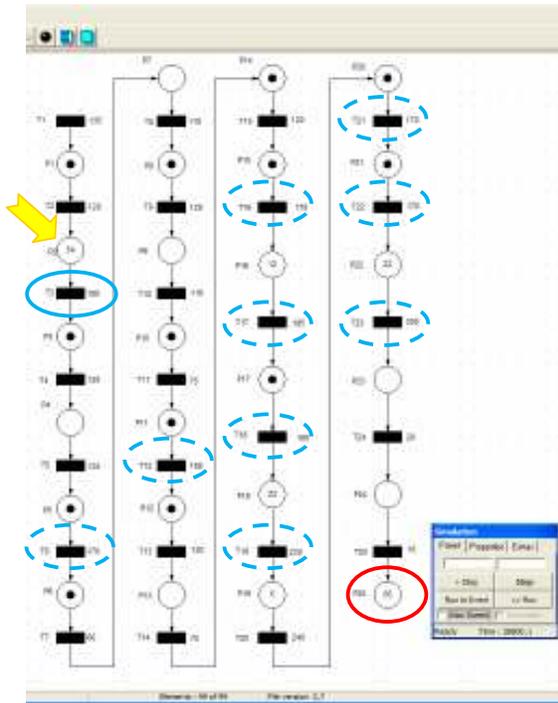


Fig. 7. Petri networks model for jacket fabrication line.

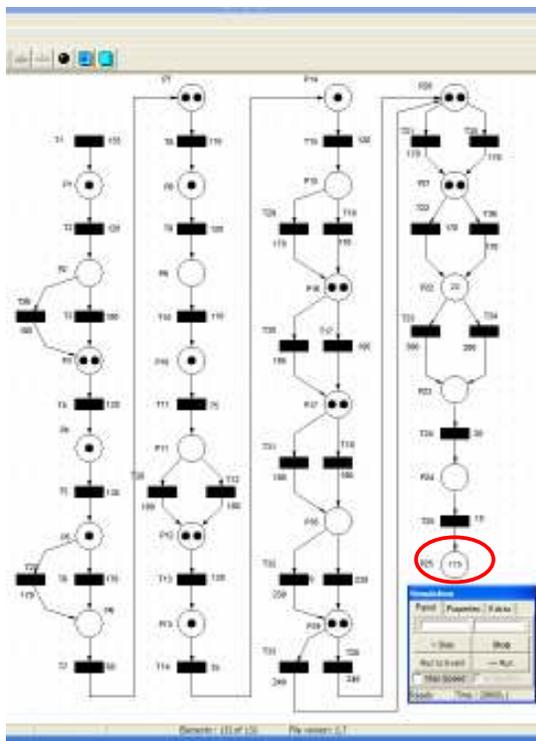


Fig. 8. Petri networks model for jacket fabrication line after the multiplication of the work places.

The successive simulations allowed the identification of the bottlenecks on the jacket fabrication line (Fig. 8).

III. CONCLUSION

Modeling and simulation give the possibility to analyze the operating mode of the fabrication systems for various production tasks (orders).

In the case of series production, which is a feature of the textile industry, imbalance situations may occur between the flux lines because of the different time periods of various operations. These situations yield jams and waiting times. Such disturbances can be highlighted by means of modeling and simulation.

The timed Petri networks are a very efficient modeling and simulation instrument, which allow the evaluation of the performances of fabrication systems in various operating conditions. Thus, in the cases that were studied by means of simulation, bottlenecks were identified and the number of necessary work places for jam-free operation was estimated. Finally, the simulation allowed the evaluation of the production volume during one shift, in the modeled operating conditions.

The management of these fabrication systems can rely in the decisional process on the information yielded by the simulations, in order to optimize their operation.

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