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Production flow synchronisation versus buffer capacities in assembly systems

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ABSTRACT

Purpose: The goal of the considerations carried-out in that paper is the determination of the system synchronisation conditions. Those conditions concern capacities of system buffers. The fulfilment of the developed conditions should guarantee the production flow synchronisation into the expected steady state determined by the system bottleneck. In analysed assembly system rhythmic concurrent production with wide assortment is realised.

Design/methodology/approach: The considerations presented in that paper are rooted in the authority method called Requirements and Possibilities Balance Method (RPBM). The experiments in the computer simulations programmes have been carried-out within the confines of the researches. The computer simulation models of the assembly systems using Taylor II for Windows and Enterprise Dynamics have been built.

Findings: There are two kinds of system buffers: the entrance buffers and the inter-resources buffers in the assembly systems. The interdependences informing about the required number of elements allocated into the system buffers in order to the production realisation during the first cycle of the system steady state has been formulated. Moreover, the minimal buffer capacities have been determined.

Research limitations/implications: The developed interdependences constitute the first step towards formulation of the automatic method designed for the automatic construction of rules controlling the system work during system transition state. That method should enable the automation of the system buffers filling-up.

Practical implications: The presented system synchronisation conditions can become an integrated part of existing authority computer system. It aids the decision-making process connected with production planning and control.

Originality/value: To develop the interdependences is the main achievement of the given paper. The presented approach permits to solve the problem concerning the production flow synchronisation into the expected steady state determined by the system bottleneck.

Keywords: Production and operations management; Assembly system; Buffer capacity; Rhythmic production

1. Introduction

New production planning and control techniques should be introduced in contemporary enterprises, because of high and changeable market conditions. The strategic results of the modern techniques application often achieve the company's main goals and substantial increase in competitiveness in the market. Computer aiding of the decision-making process connected with order acceptation into realisation is one of many areas requiring continuous development in the given firm [1, 2].

In the [3-7, 13] articles production planning and control problems in assembly systems have been considered. The environment of the analysed assembly systems is changeable. In those systems rhythmic concurrent production with wide assortment is realised. For that production short system cycles and small batches are characterised. The assembly resources (i.e. robots, manipulators) in the assembly systems are allocated. Tasks in the rendezvous-like mode in those systems are realised. For the rendezvous-like mode it is characteristic that minimum two pieces must meet at the same time and at the same place in order to be joined into a more complicated element.

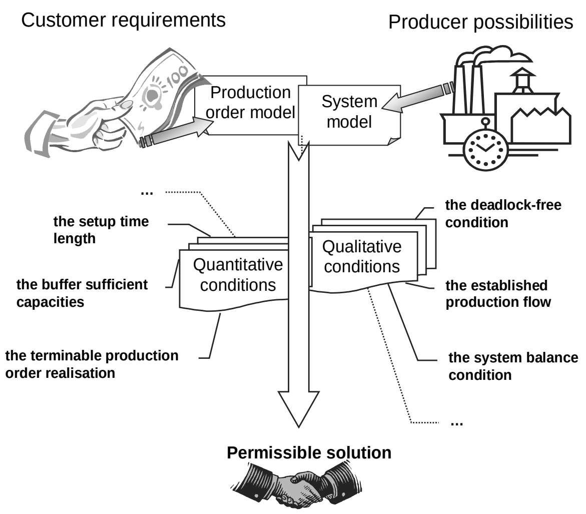

Fig. 1. The Requirements and Possibilities Balance Method

The considerations presented in that paper are rooted in the authority method called Requirements and Possibilities Balance Method (RPBM). The main assumptions of that method in Fig.1 are presented. Comparing with other approaches, the search of the optimal and quasi-optimal solutions consuming time and capital have been given up in favour of finding a solution that is included in the set of permissible solutions. The checking of the sequence of sufficient conditions enables the finding of the solution included in the set of permissible solutions. All sufficient conditions defining the links between the system constraints and the production order parameters can be divided into the qualitative and quantitative ones. At the beginning qualitative acceptable production flow characterised by the deadlock-free and starvation-free system behaviour has to be guaranteed. A deadlock happens when during the concurrent production at shared resources the cycle of the mutual expectations takes place. Starvation occurs when the process is infinitely long held in front of shared resource, because access to that resource is impossible as a result of other processes realisation [8]. It is certain that production flow in the system is possible when the qualitative sufficient conditions are fulfilled in the system. The next step boils down to the checking of the quantitative sufficient conditions. That activity heads towards determination whether a new production order can be timely realised in the system. There are the quantitative conditions concerning the number of the final products, the realisation term or the efficiency of resources utilisation. Each condition limits the set of permissible solutions. The first solution meeting the conjunction of all checked sufficient conditions is deemed as a permissible solution. That solution forms a basis of the production plans and the procedures controlling the work of the resources in the system. Thus, the stages of the production planning and control are integrated. It means that the planning decision about the order acceptation into realisation is made concurrent and the distributed control procedures guaranteeing the decision realisation are created.

2. Problem formulation

Production planning and control in assembly systems being in the steady state in the [9,10, 11] previous papers has been considered. The system transition state until very recently has been omitted. The Requirements and Possibilities Balance Method has been used for the preliminary specification whether the given production order can be accepted for the realisation in the system. That has also enabled the preliminary determination of the procedures controlling the production flow and the preparation of the request for quotation at the customer service facility.

Contemporary costumers have high requirements, thus they want to buy cheap and fast diversified high-quality products. For that reason production process rotation is substantial and processes eliminated from the system fast are replaced with new processes accepted into the system [12]. Because of that the determination of the rules controlling works during the system transition state is very important. The transition state of the system takes place, if the system does not work in the steady rhythm. There are three possible transition state phases: starting-up, cease and transient. The starting-up phase precedes the system steady state and is connected with production beginning. The cease phase follows the system steady state and is applied to the final production completion. The transient phase consists in the transition from one expected steady state of the system to another also realised in the certain rhythm. The transient phase includes elements of the starting-up phase as well as the cease phase.

The implementation of the Requirements and Possibilities Balance Method in real automatic assembly systems can be realised due to the application of the meta-rule conception. Each meta-rule includes three parts adequate to the starting-up, the dispatching and the cease phases. The first part of the meta-rule is the starting-up rule that is executed once at the production beginning and assures the production flow synchronisation into the expected system cycle. The second one is cyclically executed during production batch realisation and guarantees the steady state of the system. The third one is the procedure of the production cease and it is executed once at the production end after the cyclic realisation of the local dispatching rule [1]. Taking into account the previous considerations the following main question arises: Which conditions should be fulfilled in the assembly system in order to ensure production flow synchronisation into the expected steady state?

For the production flow synchronisation into the expected steady state it is necessary to guarantee the production realisation during the first cycle of the system steady state. It is because elements produced during a given system cycle in the real assembly systems working in the steady state are needed for the next system cycle realisation [14]. In accordance with the presented method, the production realisation during the first cycle of the system steady state has been guaranteed due to the preliminary filling-up of the system buffers [15]. The required number of elements is filled-up into the system buffers during the starting-up phase. That number of elements should ensure the deadlock-free production realisation during the first cycle of the system steady state. In automatic assembly filling-up of system buffers is realised using the staring-up rules generated on the basis of known dispatching rules. Those rules should guarantee deadlock-free system behaviour and synchronise the production flow into the expected steady state determined by the system bottleneck.

The solution of the main synchronisation conditions problem requires a solution to detailed problems included in the questions, as follows:

- In which places of the assembly system should system buffers be allocated?
- Which kind of elements in which quantity should be allocated in the system buffers for the production realisation during the first cycle of the system steady state?
- Which minimal capacities should the system buffers have?

3. Synchronisation problem in computer simulations

In order to find the solution of the main formulated problem as well as the detailed problems the computer simulation models of the assembly systems have been outworked. Those computer models have been created using computer simulation programme called Taylor II for Windows. The Taylor II system enables modelling, simulation and visualisation of discrete production systems. It is mainly used during simulation researches concerning the manufacturing processes and logistics. The modelling in the Taylor II system requires the application of predefined basic units, such as: machine, transporter, and buffer. The model construction consists in the choosing of the basic units and their parameterisation in order to adapt them into the system working conditions. The Taylor II system belongs to open systems. It means, that it allows to creatie the user's own subprogrammes realising functions meeting specific needs of the given system. The tool enabling that kind of activity is an internal computer language called Taylor Language Interface (TLI). Therefore, the TLI language allows for the realisation of all typical simulation functions as well as the creation of user's own functions. The assembly system with production controlled by local dispatching rules has been considered. At the beginning of the assembly system models development the model of the universal assembly cell has been outworked. That model of the universal assembly cell has been built thanks to advanced functions of the TLI language. It has become a new module, which can be used like a new basic unit in order to create more complicate assembly system models. The outworked assembly system models enable the visualisation of the considered problems concerning the synchronisation of the assembly system work into the steady state.

In order to carry out computer simulation the authority Requirements and Possibilities Balance Method has been used. According to presented method assumptions the tables set should be created. Those tables include the following data: production routes, links between production processes, realisation times, set-up times and local control rules. Data needed for computer simulations from those tables are taken. In order to synchronisation of the assembly system work into steady state has been applied in the technique of preliminary buffer filling-up in the starting-up phase. The number of filled-up elements should guarantee the production realisation in steady state at least once.

a)

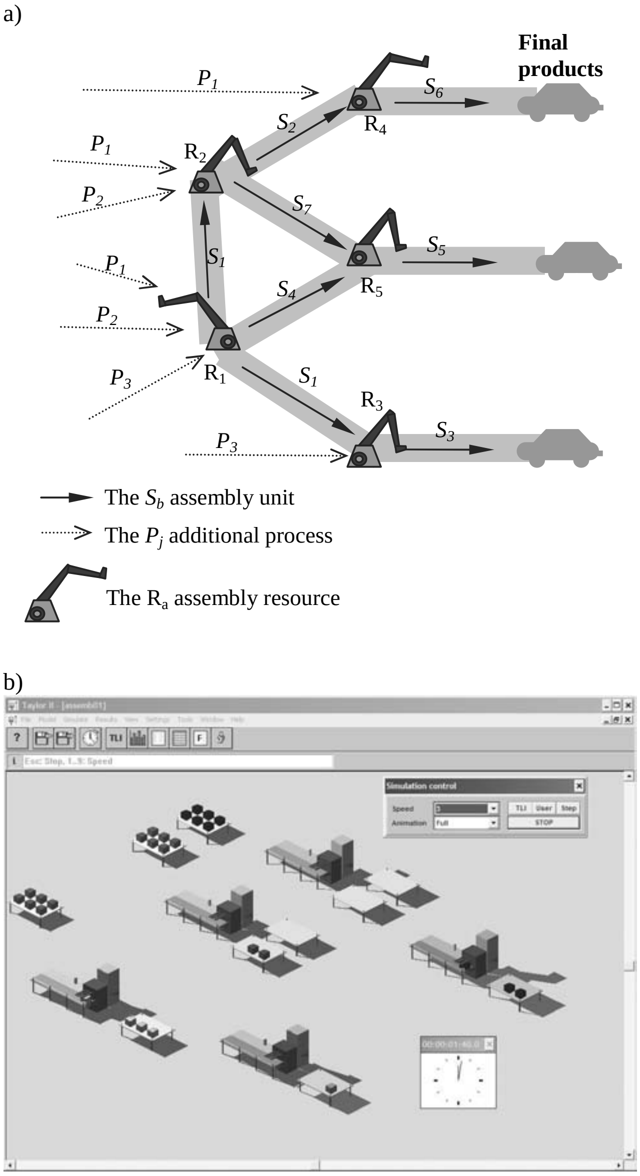

Fig. 2. The experimental assembly system: a) diagram, b) computer model

The proposed technique ensures deadlock-free system behaviour and synchronises the production flow into the expected steady state determined by the system bottleneck.

In the carried-out simulation experiments the model of the assembly system including five assembly resources has been considered. In the analysed system three additional processes and three assembly processes consisting of seven assembly units are taken into account. Each assembly process realisation is adequate to one kind of final product completed. The assembly system diagram used in the experiments realisation in Fig. 2a is presented. In Fig. 2b the window from the Taylor II system presenting the model of the assembly system is shown. The results of the carried-out simulation experiments in Fig. 3 are presented.

In the first simulation experiment (Fig. 3a) there is one buffer for every assembly units leaving the given assembly resource. It is regardless of the assembly resource at which the next step of production process according to production route should be realised. The system buffers are preliminary filled-up and the number of stored elements is enough for one system cycle realisation in the system being in the steady state. In those conditions during experiments in the system deadlock arises. It has been concluded that the reason of that is non-synchronous realisation of the local dispatching rules. It has been observed that the system balance condition is not fulfilled. It is because the same elements which should be realised at the different assembly resource during the next step of production process are stored in the same buffer. The system balance condition is fulfilled, if the number of elements introduced into each production route during one system cycle is equal to the number of the elements, which form the assembly unit leaving the system [10]. During computer simulations it has been noticed that one from the assembly resource uses elements needed for the assembly at another assembly resource. Because of that the local dispatching rules is unnecessarily again realised at the one from assembly resource. At the same time at another one local dispatching rules has been not realised any time. Those factors cause that in the system deadlock arises.

The goal of the second simulation experiment (Fig.3b) has been the elimination of the system deadlock which arisen as the result of non-fulfilment of the system balance condition. It has been assumed that the buffer capacities and the number of elements allocated to system buffers are the same as in the first experiment. Thus, into the system a mechanism enabling the synchronisation of the assembly resources work has been applied. According to the proposed mechanism each assembly resource could not realise the next system cycle if that cycle is not yet finished at other assembly resources. In that case during computer simulations it has been observed that the system deadlock has been not arisen any more. Anyway, an another important problem has appeared. It has been noticed that system work is rhythmic; the system balance condition is fulfilled; but the synchronisation is not determined by a system bottleneck and resources utilisation is poor. There is not a bottleneck in the system because the applied mechanism has been forced to the assembly resource into waiting for the system cycle finishing at every system resources.

Within the confines of the third simulation experiment (Fig.3c) has eliminated the mechanism enabling the synchronisation of the assembly resources work from the second experiment. However, into the considered production system another mechanism has been applied. That mechanism sorts elements into right system buffers depending on the assembly resource at which the next step of production route is realised. The result of the carried-out computer simulations is the production system synchronisation into the expected steady state according to bottleneck work. In the analysed case the separate buffer is assigned to the group of the same elements which are assembled at the given assembly resource.

On the basis of the outcarried simulation experiments it has been stated that in the considered production system the mechanism preventing the system from the deadlock arising should be applied. That mechanism sorts the elements and put them into the right system buffer allocated in front of the assembly resource at which the next step of production route is realised. However, that mechanism application causes problems during the realisation of the production control processes. Because of that the local control rules generated until recently according to the RPBM should be expanded. Former local control rules informed about the number and the sequence of the assembly units realisation at the given assembly resource. The modified rules include the same data, moreover they inform about the distribution way of the same elements which are assembled at other assembly resources.

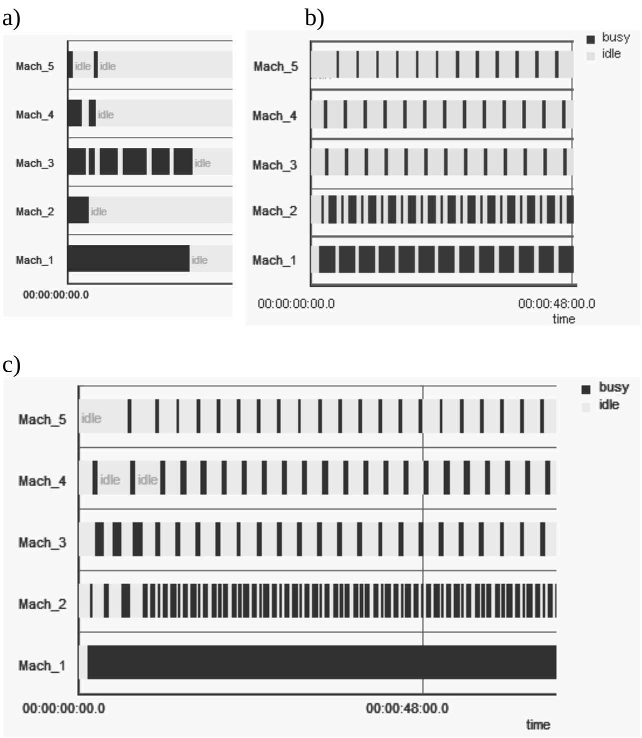

Fig. 3. Simulation experiments: a) system deadlock, b) system work without bottleneck, c) system work determined by the bottleneck

Conclusions from the results of the computer simulation experiments shown that at first the interdependences which automatically inform how many elements from the set leaving given assembly resource are assigned to given system buffers, should be formulated. It is the first step in the procedure of determination of the local control rules for the transition state phases in the assembly system.

4. Buffer capacities

The procedure of determination of the needed number of elements allocated to separate buffers requires introduction of input-data into the system. The input-data are included in system matrices and specify the number of elements forming the assembly units in question. Moreover, information about the realisation repetition of each assembly unit at individual resources within local control rules and information about realisation time is contained. The considered assembly system (Fig. 4) is described by the M_U^L processes links matrix, the M_U^M system structure matrix and the M^{N_u} assembly process matrices.

The M_U^L processes links matrix is $(n+s)\times s$, where U is the number of assembly processes realised in the system, n is the number of the Pj additional processes realised in the system; the realisation of those processes is equivalent to supply of the elements previously machined or purchased into the assembly system; s is the number of the S_b assembly units realised in the considered assembly system. That matrix specifies the links between the Pj additional processes and the S_b assembly units as well as the number of elements needed for the realisation of the consecutive assembly process steps. The M_U^L matrix also informs which additional processes and/or assembly units enter the given resource and which assembly units exit from that resource. The M_U^L matrix elements are signed in two different ways depending on the occupied matrix position. The z_{jb}^L matrix elements are allocated in the rows corresponding with the Pj additional processes, $j=1, 2, ...,n$, $b=1, 2, ...,s$. However, the $z_{(n+x)b}^L$ matrix elements are allocated in the rows corresponding with the S_b assembly units; $x\in(1,2,..., s)$, $x\neq b$.

The M_U^M system structure matrix is $s\times r$, where U is the number of assembly processes realised in the system, s is the number of assembly units realised in the system, r is the number of assembly resources existing in the system. The M_U^M matrix specifies at which R_a assembly resources given S_b assembly units are realised and how many times those assembly units have to be realised at the given assembly resources during one system cycle in order to realise production orders accepted into the system. The elements of the M_U^M system structure matrix are signed as the z_{ba}^M, $b=1, 2, ...,s$, $a=1, 2, ...,r$.

The M^{N_u} assembly process matrix is $3\times s_u$, where s_u is the number of assembly units belonging to the Nu assembly process, $s_u\leq s$. It has been assumed that $\Psi_b\in\{\Psi_1,\Psi_2,...,\Psi_{S_u}\}$ and $Nu\in\{N1, N2,..., NU\}$. The elements of the M^{N_u} assembly process matrix are signed in three different ways depending on the occupied matrix position. The elements of the M^{N_u} matrix are signed as $z_{1\Psi_b}^{N_u}$, if they are allocated in the first row of the matrix. Those elements are the figures of the S_b consecutive assembly units belonging to the Nu assembly process. The elements of the M^{N_u} matrix are signed as $z_{2\Psi_b}^{N_u}$, if they are allocated in the second row of the matrix and inform about most likely processing time. Finally, the elements of the M^{N_u} matrix are signed as $z_{3\Psi_b}^{N_u}$, if they are allocated in the third row of the matrix and they inform about most likely set-up time.

There are two kinds of buffers allocated in the considered assembly system: entrance buffers and inter-resources buffers. The entrance buffers are allocated at the beginning of the production route. There are the B_a^j entrance buffers in front of each R_a assembly resource, $j=1, 2, ...,n$, $a=1, 2, ...,r$. They collect elements machined during previous steps of the technological process or purchased from suppliers. The B'^{x}_{ak} inter-resources buffers are allocated between each (R_a, R_k) pair of neighbouring resources at which the S_X assembly unit is realised, $x\in(1,2,..., s)$, $a=1, 2, ...,r$, $k=1, 2, ...,r$, $a\neq k$. Note that for the same elements forming different assembly units at different resources the separate inter-resources buffers are indispensable.

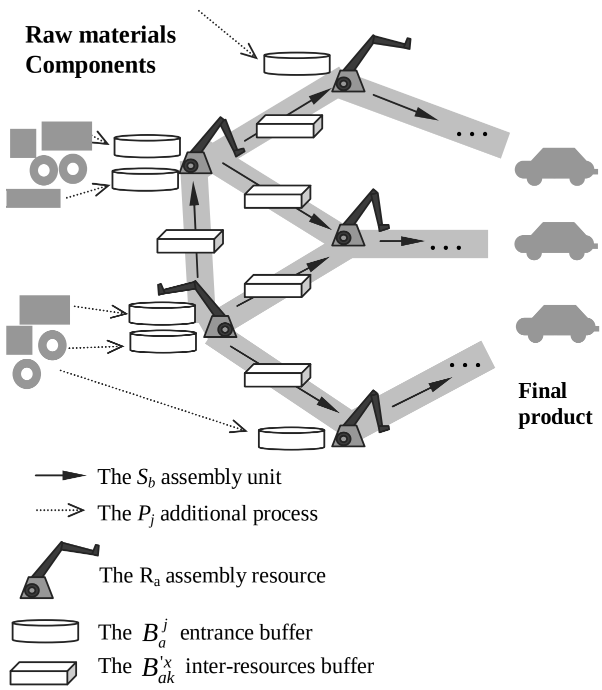

Fig. 4. An exemplary assembly system

The required number of elements allocated into the entrance buffers in order to realise the production during the first cycle of the system steady state is determined in accordance with the interdependence (1):

$$c_a^j = \begin{cases} \sum_{b=1}^{s} z_{ba}^M \cdot z_{jb}^L, & \text{if the } P_j \text{ is used in assembly at the } R_a \\ 0, & \text{in the opposite case} \end{cases} \quad (1)$$

where c_a^j is the required number of elements coming from the Pj additional process to the B_a^j entrance buffer which occurs in front of the R_a resource, $a=1, 2, ...,r$, $j=1, 2, ...,n$.

The required number of elements allocated into the inter-resources buffers for the production realisation during the first cycle of the system steady state is determined in accordance with the interdependence (2):

$$c'^{x}_{ak} = \begin{cases} \sum_{b=1}^{s} z^{M}_{bk} \cdot z^{L}_{(n+x)b}, & \text{if the } S_b \text{ is assembled at the } R_a \\ 0, & \text{in the opposite case} \end{cases} \qquad (2)$$

where C'^{x}_{ak} is the required number of elements coming from the S_x assembly units to the B'^{x}_{ak} inter-resources buffer which occurs between the (R_a, R_k) pair of neighbouring resources, $x \in (1,2,...,s)$, $a = 1, 2, ...,r$, $k = 1, 2, ...,r$, $a \neq k$.

The elements allocation into the entrance buffers according to the (1) interdependence and into the inter-resources buffers according to the (2) interdependence guarantees the system synchronisation into the expected steady state. Deadlock-free system behaviour during the starting-up phase is ensured if the minimal required capacities of the entrance buffers is equal c^{j}_{a} and the minimal required capacities of the inter-resources buffers is equal c'^{x}_{ak}. On the basis of that information the local rules controlling the assembly system work should be formulated.

5. Illustrative example

The calculation way of the required number of elements allocated into the system buffers has been explained by the use of an exemplary assembly system (Fig. 5). The assembly system consisting of the R_1, R_2, R_3 assembly resources is considered.

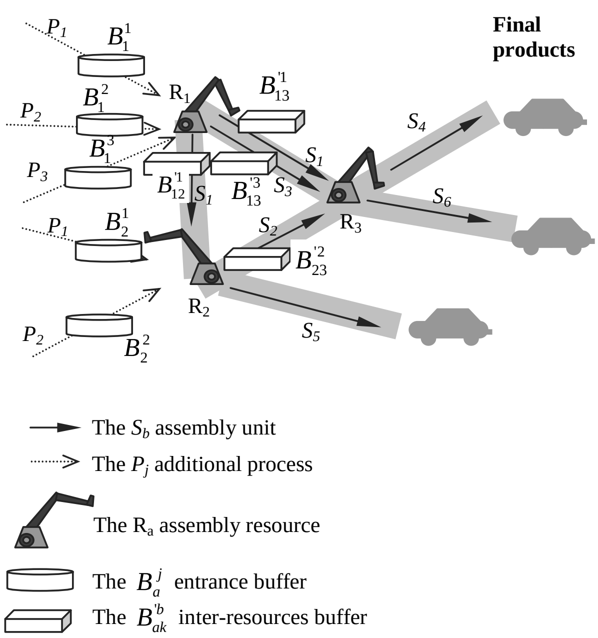

Fig. 5. The assembly system considered in the example

The elements being result of the P_1, P_2, P_3 additional process realisation into entrance buffers are accepted. In the system three assembly processes are realised and it is adequate to completion of three kinds of a final product. The S_1, S_2, S_3, S_4, S_5, S_6 assembly units are realised within the confines of three assembly processes. The S_4, S_5, S_6 assembly units are final units and their realisation means the final product completion. In the system the B^1_1, B^2_1, B^3_1, B^1_2, B^2_2 entrance buffers as well as the B'^1_{12}, B'^1_{13}, B'^2_{23}, B'^3_{13} inter-resources buffers are allocated. The input-data needed for calculations in the M^L_3 processes links matrix and the M^M_3 system structure matrix are included.

The M^L_3 processes links matrix for the considered assembly system is presented.

$$M^L_3 = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{array} \begin{array}{cccccc} S_1 & S_2 & S_3 & S_4 & S_5 & S_6 \\ 2 & 1 & 0 & 0 & 0 & 0 \\ 0 & 3 & 1 & 0 & 1 & 0 \\ 2 & 0 & 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 2 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{array}$$

The realisation times and set-up times concerning the assembly units forming the assembly processes in the M^{N1}, M^{N2}, M^{N3} assembly process matrices are presented.

$$M^{N1} = \begin{bmatrix} 1 & 2 & 4 \\ 15 & 19 & 23 \\ 0 & 0 & 0 \end{bmatrix}$$

$$M^{N2} = \begin{bmatrix} 1 & 2 & 3 & 6 \\ 15 & 19 & 21 & 20 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$M^{N3} = \begin{bmatrix} 1 & 5 \\ 15 & 17 \\ 0 & 0 \end{bmatrix}$$

According to RPBM and using data from the M^L_3 processes links matrix as well as times from the M^{N1}, M^{N2}, M^{N3} assembly process matrices the M^M_3 system structure matrix has been outworked.

According to the (1) interdependence the required number of elements allocated into the entrance buffers has been calculated. That number of elements ensures the production realisation during the first cycle of the system steady state.

$$M_3^M = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{array} \begin{array}{c} \begin{array}{ccc} R_1 & R_2 & R_3 \end{array} \\ \begin{bmatrix} 8 & 0 & 0 \\ 0 & 3 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \end{array}$$

The calculations for the entrance buffers allocated in front of the R_1 assembly resource calculations are following:

$$c_1^1 = (8 \cdot 2) + (0 \cdot 1) + (1 \cdot 0) + (0 \cdot 0) + (0 \cdot 0) + (0 \cdot 0) = 16,$$
$$c_1^2 = (8 \cdot 0) + (0 \cdot 3) + (1 \cdot 1) + (0 \cdot 0) + (0 \cdot 1) + (0 \cdot 0) = 1,$$
$$c_1^3 = (8 \cdot 2) + (0 \cdot 0) + (1 \cdot 2) + (0 \cdot 0) + (0 \cdot 0) + (0 \cdot 0) = 18.$$

The c_1^1 is the required number of elements coming from the P_1, additional process to the B_1^1 entrance buffer which occurs in front of the R_1 assembly resource. The c_1^2 is the required number of elements coming from the P_2, additional process to the B_1^2 entrance buffer which occurs in front of the R_1 assembly resource. The c_1^3 is the required number of elements coming from the P_3, additional process to the B_1^3 entrance buffer which occurs in front of the R_1 assembly resource. Analogically, the calculations for the entrance buffers allocated in front of the R_2 assembly resource are as follows:

$$c_2^1 = (0 \cdot 2) + (3 \cdot 1) + (0 \cdot 0) + (0 \cdot 0) + (1 \cdot 0) + (0 \cdot 0) = 3,$$
$$c_2^2 = (0 \cdot 0) + (3 \cdot 3) + (0 \cdot 1) + (0 \cdot 0) + (1 \cdot 1) + (0 \cdot 0) = 10.$$

The c_2^1 is the required number of elements coming from the P_1, additional process to the B_2^1 entrance buffer which occurs in front of the R_2 assembly resource. The c_2^2 is the required number of elements coming from the P_2, additional process to the B_2^2 entrance buffer which occurs in front of the R_2 assembly resource. Moreover, the c_1^1, c_1^2, c_1^3, c_2^1, c_2^2 are equal to the minimal capacity of the adequate entrance buffers.

The required number of elements allocated into the inter-resources buffers according to the interdependence (2) has been calculated.

$$c_{12}^{'1} = (0 \cdot 0) + (3 \cdot 2) + (0 \cdot 0) + (0 \cdot 1) + (1 \cdot 1) + (0 \cdot 0) = 7,$$
$$c_{13}^{'1} = (0 \cdot 0) + (0 \cdot 2) + (0 \cdot 0) + (1 \cdot 1) + (0 \cdot 1) + (1 \cdot 0) = 1,$$
$$c_{23}^{'2} = (0 \cdot 0) + (0 \cdot 0) + (0 \cdot 0) + (1 \cdot 2) + (0 \cdot 0) + (1 \cdot 1) = 3,$$
$$c_{13}^{'3} = (0 \cdot 0) + (0 \cdot 0) + (0 \cdot 0) + (1 \cdot 0) + (0 \cdot 0) + (1 \cdot 1) = 1,$$

The $c_{12}^{'1}$ is the required number of elements coming from the S_1 assembly units to the $B_{12}^{'1}$ inter-resources buffer which occurs between the (R_1, R_2) pair of neighbouring resources. The $c_{13}^{'1}$ is required number of elements coming from the S_1 to the $B_{13}^{'1}$. The $c_{23}^{'2}$ is required number of elements coming from the S_2 to the $B_{23}^{'2}$ and the $c_{13}^{'3}$ is required number of elements coming from the S_3 to the $B_{13}^{'3}$. Moreover, the $c_{12}^{'1}$, $c_{13}^{'1}$, $c_{23}^{'2}$, $c_{13}^{'3}$ are equal to the minimal capacity of the adequate inter-resources buffers.

The received calculations results in the *Taylor II* and the *Enterprise Dynamics* computer programmes have been verified. In Fig.6 the simulation model built in the *Enterprise Dynamics* and simulations results are presented. The carried-out computer simulations shown that the preliminary buffers filling-up in the starting-up phase enables the automatic system work synchronisation into the expected steady state determined by the system bottleneck. It can take place under condition that the (1) and (2) interdependences are accomplished.

a)

b)

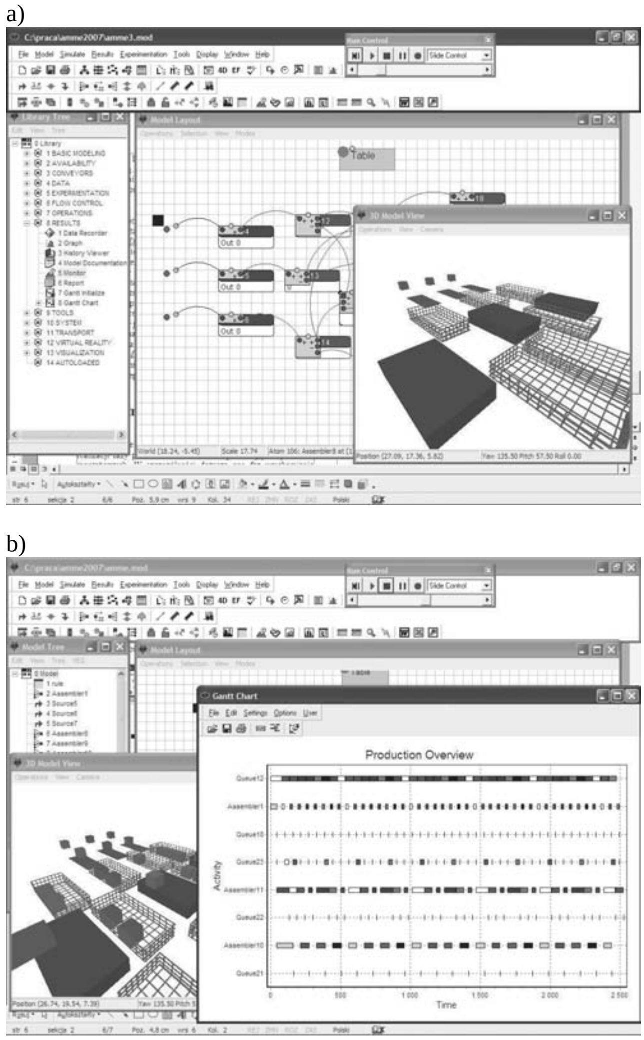

Fig. 6. Assembly system : a) model in Enterprise Dynamics, b) simulations results

6. Conclusions

In that paper the problems concerning the assembly system synchronisation into the expected steady state determined by the system bottleneck are presented. Particularly, it has been noticed that in the assembly systems the entrance and inter-resources buffers should be allocated. The entrance buffers are allocated at the beginning of the production route in front of each assembly resource. They collect elements machined during previous steps of the technological process or purchased from suppliers. The inter-resources buffers are allocated between each pair of neighbouring resources at which the given assembly unit is realised. The formulated interdependences inform about the required number of elements which should be allocated in the system buffers for the production realisation during the first cycle of the system steady state. Thus, the minimal capacities of every system buffers have been determined. The interdependences formulation is the first step in the procedure of determination of the local control rules for the transition state phases in the assembly system. In the future researches the presented approach will be spread and the transport processes will be also included. The presented system synchronisation conditions can become an integrated part of existing authority computer system.

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