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APPLICATION OF THE MODERN SIMULATION METHODS AT THE FLEXIBLE SYSTEMS OF ELECTROMOTORS' ASSEMBLING

Mirlind Bruqi
Mechanical Engineering Faculty
10000, Prishtina
Kosova

Avdyl Bunjaku
Mechanical Engineering Faculty
10000, Prishtina
Kosova

Ramë Likaj
Mechanical Engineering Faculty
10000, Prishtina
Kosova

ABSTRACT
The flexible assembling systems belong to the group of the most sophisticated modern systems. As such, they are able to be transferred from one to another assembling program for a very short period of time. Through these systems the assembling of different types of products is realized. Even known as very effective systems they have they're negative side – system managing. Therefore, to avoid it the in depth preparations for production must be carried on. Preparations include optimal or suboptimal scenario for the flow of material, energy, information and manpower set up. The selection of the scenario means that from a very big number of different scenarios as a result of the miscellaneous types of products that take part in an assembling program, the optimal one is chosen.
The choice of such scenario is done through the different optimization algorithms, which are integrated in software, therefore a module must be selected and programmed.
In this paper a module for a concrete system of electromotor production is built and analyzed.
Keywords: Flexible assembling system, electromotor, simulation.

1. INTRODUCTION

Simulation is a modern and attractive way of imitating a real thing, system or process. Nowadays, it is an irreplaceable tool on solving the engineering problems comparing to the traditional analytical methods, which sometimes can fail to bring desired results even for the simple systems. It includes planning, design, analysis and optimalisation of complex manufacturing process, architecture of computers, bio systems, military systems etc.

The modern concept of simulation for analysis of the systems in general, and for manufacturing systems in particular was led by quick computers development and informatics technology. Different experts have compiled many algorithms and archived in them into different programming languages.

Engineer's duty today is to learn simulation ideology and to be released of complex mathematical apparatus creating more space for individual creativity and engineering.

But, of course for the simulation process other knowledge is needed depending on field or level of research. If needed to be a Decision Maker, high level concerning manufacturing decisions etc., then individual must have knowledge on statistics, theory of probability, and a number of other theories connected to buffering and services. Fortunately, the last days simulating programs are very advanced with integrated program packages for statistical preparation of production data and automatic optimization of entire process. In many cases such simulation process of manufacturing system allows very fast and efficient analysis of the stability for its chosen parameters.

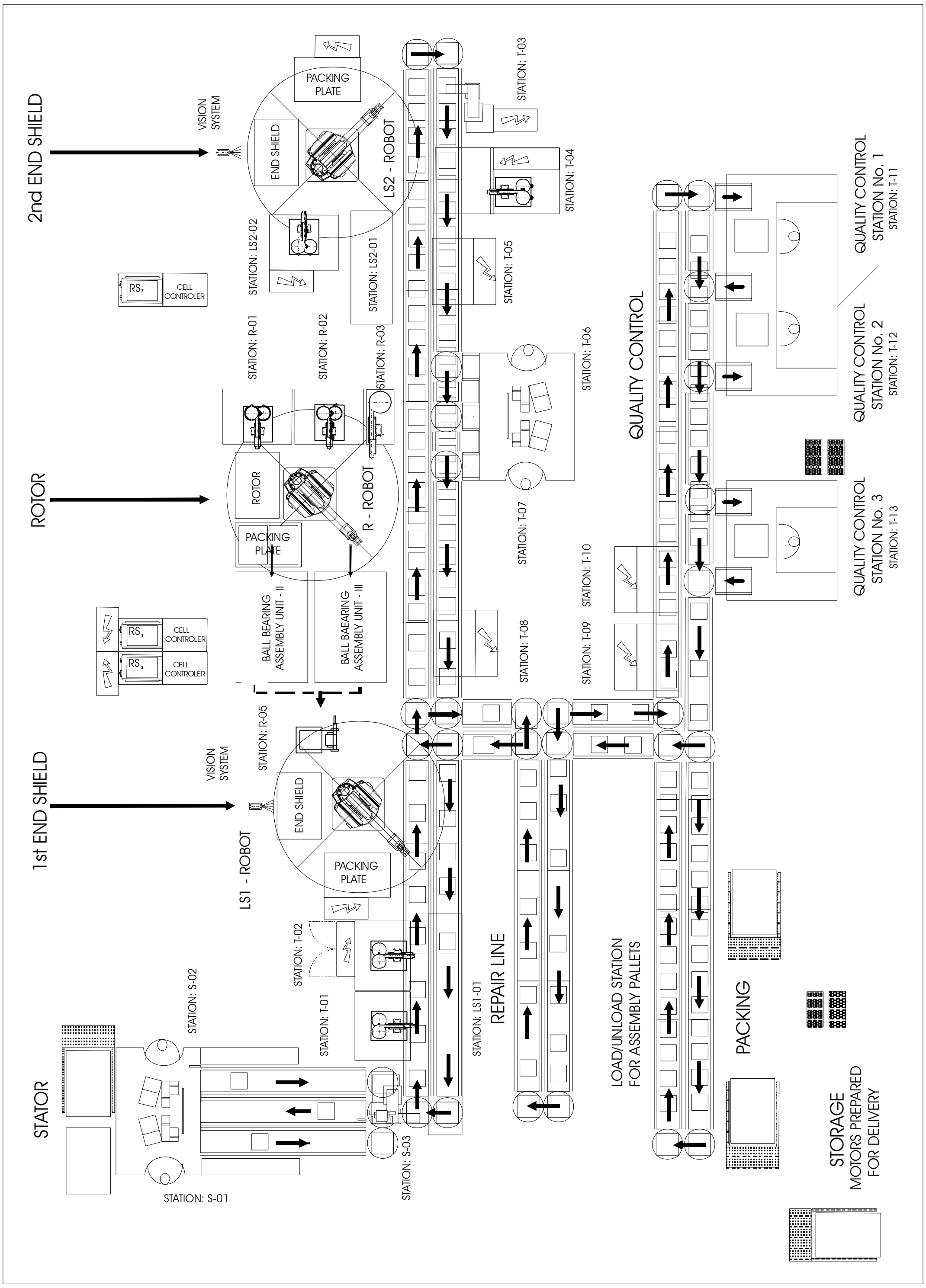

Figure 1. Flexible system of electromotor's assembling ATB-Austria

2. MODEL OF THE ASSEMBLING FLEXIBLE SYSTEM

Activities at the flexible system of the electromotors assembling are very complex, Figure 1. For purpose of modeling, only main points of them will be subject of analysis.

The system considered for analysis from start at the first conveyor as source point to the exit from conveyor as a point for absorbing the parts, is built by following resources:

- Human resources,
- Industrial robots,
- Pallets with ID chips,
- Rolling conveyors.

In Figure 2 is shown graphically the path of entities that circulates in the assembling flexible system.

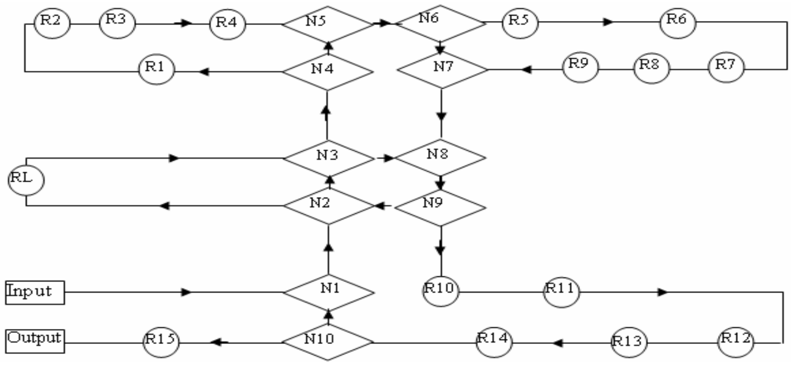

Figure 2. Scheme of material flow through the assembling flexible system

The path of material flux through working stations contains following elements:

- Input/Output points of the system given by rectangle;
- Stations given by small circle with letter R (Resource);
- Logic points or system nodes given as parallelepiped (N-Node);
- Straight lines presents conveyors;
- Arrows show direction of the material flux.

System input presents entity resources, indicating the input limit of the system, while output or so-called disappearance point of entities is output limit of the system. But, the subject of study is analysis of the system inside considering that all external activities are reduced in to points, input and output. Such approximation brings to definition the system limits.

System allows change of resources number at working station and also change of material flux depending on overfeed of the system with pallets. Therefore, the system input and number of the engaged resources are considered as variables. In the other side, the system is influenced by different demands of consumers coming at different times and in different quantity presenting stochastic effect that interfere and condition the system itself.

3. SIMULATION OF THE ADOPTED MODEL

Mathematical model of a hydrostatic system in matrix form is given by:

The aim of simulation is to achieve the highest level of efficiency with above mentioned demands, conditions, timeframe and available resources. It is adopted that:

C_{Ri} - is cost for *i* resource for the simulation period, $i=1,..,n$,

C_{Mi}- is material cost of specified product *i*, for *i=1 to n (Euro)*

C_{Ti} - is cost for waiting time of product-Entity Flow Time *i* of the system, for *i*=1 *to n (Euro)*

Ψ - is objective function.

The simulation process tries to minimise the objective function. It means that if decrease of the costs is achieved the objective of optimisation is met, meaning that “with minimum utilisation of resources the maximum production volume is obtained, satisfying technical and organization conditions of the system”.

Mathematical model is expresed by:

$$min(\Psi) = min\left[\sum_{i=1}^{n} C_{Ri} + \sum_{i=1}^{n} C_{Mi} + \sum_{i=1}^{n} C_{Ti}\right] \qquad \ldots(1)$$

If *k*- simulations are executed then function (1) has form as in (2):

$$min\left(\sum_{j=1}^{k} \Psi_j\right) = min\left\{\sum_{j=1}^{k} \left[\sum_{i=1}^{n} C_{Rij} + \sum_{i=1}^{n} C_{Mij} + \sum_{i=1}^{n} C_{Tij}\right]\right\} \qquad \ldots(2)$$

So, the simulation that in the best way fulfils criteria is adopted. This operation is realized with **OptQuest** package later to be described.

At **OptQuest** it was chosen the option:

$$min\left(\sum_{j=1}^{k} \Psi_j\right) \approx = \text{minimize}\{\text{Entity.Flow.Time}\} \qquad \ldots(3)$$

In this case, the only goal was to definition of objective of our experiments in the assembling flexible system - ATB.
In Table 1 is presented the resources exploitation at respective assembling stations for the flexible system. Simulation was carried within time of 5760 seconds with material flux of one part per second. The **Arena** program in its **Reports** windows shows: **Replica 1,** Start Time=250,00 [sec], Stop Time= 5760,00 [sec], Time Unit=sec, Resources Utilization.

Table 1. Resources utilisation in the simulation process

	System Resources	Instantaneously Utilisation	Number Busy	Number Scheduled	Number Seized	Schedule Utilisation
1	Resource 01	1	1	1	1.102,00	1
2	Resource 02	1	1	1	552	1
3	Resource 03	1	1	1	394	1
4	Resource 04	1	1	1	365	1
5	Resource 05	0,93	0,93	1	366	0,93
6	Resource 06	0,79	0,79	1	364	0,79
7	Resource 07	0,98	0,98	1	362	0,98
8	Resource 08	0,92	0,92	1	361	0,92
9	Resource 09	0,78	0,78	1	359	0,78
10	Resource 10	0,9	0,9	1	356	0,9
11	Resource 11	0,98	0,98	1	337	0,98
12	Resource 12	0,85	0,85	1	336	0,85
13	Resource 13	0,73	0,73	1	334	0,73
14	Resource 14	0,66	0,66	1	333	0,66
15	Resource 15	0,6	0,6	1	331	0,6
16	Resource 16	0,79	0,79	1	215	0,79

4. CONCLUSIONS

Based on the simulation process for the adopted model, can be concluded that:

- For large and very complicated models there is a possibility of simplification through the elimination of the model elements during the simulation process;
- The chose of simulation method with or without animation - “batching” is desired especially when a big number of simulations are needed and such animation can make slower the process and result achievement. Therefore, with “batching” method the program would be executed very fast related to animation methods;
- Use of “full screen” method through which can be monitored only the programming field enables operator to have better view in a small screen.

Advantages that can be obtained by this simulation method are:

- Optimal scheduling of messages according to time they start to be manufactured and their number in a group;
- Optimal number of human resources for such a planning period;
- Elimination of the bottle-necks during the planning period.

All this can be done Off-Line in advance, by the same time when system is assembling with old production program, meaning before transferring to the new one.

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