16th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2012, Dubai, UAE, 10-12 September 2012

MODELING AND SIMULATION OF FLEXIBLE SYSTEM FOR ELECTRICAL MACHINE ASSEMBLING

Mirlind Bruqi
Mechanical Engineering Faculty
10000, Prishtina
Kosovo

Ramë Likaj
Mechanical Engineering Faculty
10000, Prishtina
Kosovo

Jorgaq Kaçani
Polytechnic University of Tirana
1001,Tirana
Albania

Arben Gjukaj
Electric Corporation of Kosovo
10000, Prishtina
Kosova

ABSTRACT
Simulations are new and very attractive area. Nowadays they have become indispensable engineering tools for solving engineering tasks, leaving behind the traditional analytical methods. They include design, analytical and optimisation tasks of complex production systems, computer architecture, biological and military systems etc. This is made possible, because of failure to gain good results by the analytical methods, which is the case also for simple systems too. In the group of traditional methods are distinguished: arrays method (querying theory), different heuristic mathematical methods etc.
This paper deals with modelling and simulation of flexible system for electrical machine assembling by ARENA software.
Keywords: modelling, simulation, assembly, flexible.

1. INTRODUCTION
Simulation as a modern concept for system analysis, in particular for production systems are driven by rapid technological development of IT. Various experts have developed a numerous algorithms, archiving them in various programming languages. Nowadays engineer task is to teach the simulation philosophy in order to be released from very complex mathematical expressions, 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 is 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 linked to buffering and services. Fortunately, the modern simulation programs are very advanced, and integrated program packages for statistical preparation of production data and automatic optimization of entire process are included on them. In many cases such simulation process for production system allows very fast and efficient analysis of the stability for the selection of its parameters.
Arena is a simulator, which enables fast and efficient modelling of wide natural and artificial systems. It is a language which is designed for analysis and simulation of a large number of production and logistic systems, warehouses and all service systems. Service systems include: restaurants, post offices, banks, hospitals etc.
Systems which can be analysed by Arena are listed in the following:

- Detailed analysis of each type of production systems, transportation devices and industrial robots,

- Analysis of complex service systems and customer relationship management systems,
- Global analysis of a Supply Chain which include, warehousing, transportation and logistic,
- Prediction of system performance based on key parameters such are; cost, quantity, cycle timing, and system efficiency,
- Identification of bottleneck of the Queuing systems and over exploitation of system resources,
- Resource planning of staff, equipments and facilities, materials etc.

So, by using Arena and its template can be achieved:

- **Modelling** of relevant processes within imaginary system boundaries,
- **Simulation** of the system in order to understand and interpret complex relationship between its elements, the identification of strategic points of production segments,
- **Visualisation** of system operations by graphic animation in order to facilitate both simulation steps, verification and validation,
- **Analysis** of the current state of the system "as it is" or "how it might be", in order to make better planning for the future.

2. SYSTEM ANALYSIS AND GOAL DEFINING, THE AIM OF SIMULATION

Activities at the flexible system of the electrical machines assembling are very complex, and needs to be described in detail. For purpose of modelling, only main points of them will be subject of analysis. The system which is considered for analysis from the entry at the first conveyor as a resource point up to the exit from conveyor as an absorbing point for the parts, and is built by following resources:

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

In Figure 1 is shown graphically the path of all entities that circulate in the flexible assembling 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 denoted by R (Resource),
- Logic points or system nodes given as parallelepiped (N-Node),
- Straight lines represent the conveyors,
- Arrows show the direction of the material flux.

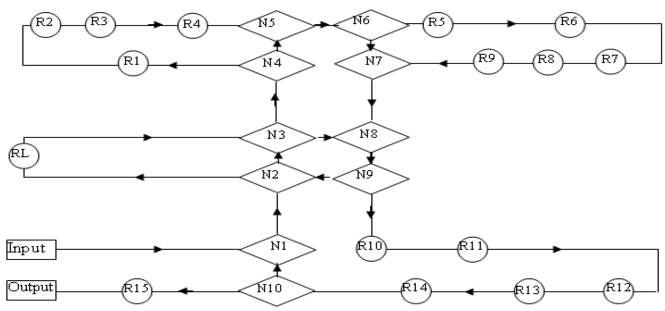

Figure 1. Scheme of material flow through the assembling flexible system

System input represents the source of entities, indicating the input boundary of the system, while output or so-called disappearance point of entities is output boundary of the system. But, the subject of study is analysis of the inner part of the system by considering that all external activities are reduced in two points, input and output. Such approximation brings to the definition the system boundaries.

System allows change the number of resources at working station and also change of material flux depending on overfeed of the system with pallets and to change the frequency of material flux. 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 the consumers which are made in different

timing and in various quantities. These are representing stochastic effects that interfere and put condition to the system itself. The aim of the simulation is to achieve a maximum level of rent ability based on these demands, conditions, schedule and resources.
It is adopted that:
C_{Ri} - are the costs for *i* resources for the simulation period, *i=1,..,n,*
C_{Mi}- are the material costs of specified product *i*, for *i=1 to n (Euro)*
C_{Ti} - are the costs for waiting time of product-Entity Flow Time *i* of the system, for *i*=1 *to n (Euro)*
Ψ - is the objective function.
By the simulation process we are trying to minimise the objective function. This means that if decrease of the costs is achieved the main goal 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 expressed by:

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

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

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

So, the simulation that in the best way fulfils the criteria is adopted. This operation is realized with **OptQuest** package which will be described later.
At **OptQuest** is chosen the option:

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

In this case, the only goal was the definition of the objective for our experiments in the assembling flexible system.

3. ENTERING SAMPLES FOR FLEXIBLE SYSTEM FOR ASSEMBLING

Another important point of the simulation is to generate data for the working stations known as samples, which is made in manual and automatic way. Once the system is equipped by a device for identification of pallets and because the system has the possibility of communication with central computer, in this way there is possibility for automatic tracking of data. The data that must be entered in this case are listed in the following:

- Time of arrival of piece at the x station and type,
- Time of piece processing at the station,
- The time between the fall of assembling system and the duration of the fall,
- Schedule of the system, short and long breaks, changes and other organisational restrictions.

4. SYSTEM SIMULATION

System simulation and the animation ascheme is shown in the Figure 2.

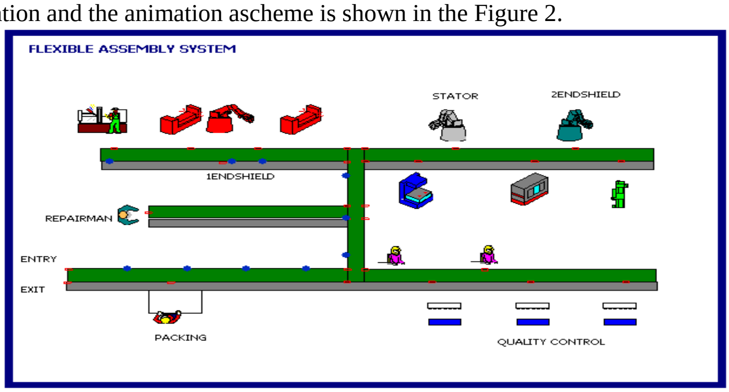

Figure 2. Animation scheme of system simulation

In Table 1 is presented the exploitation of the resources at respective assembling stations for the flexible system. Simulation was carried out during 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

5. CONCLUSIONS

Flexible systems for assembling are part of the most sotisficated systems of the time. As such they have the possibility to pas from an assembly programme to another in a very short period of time. The flexibility of such systems is the main property. In this way the pas from one assembling system to another is made in automatic or semi-automatic way or manually, by the replacement of the auxiliary devices of robots and machines.

But besides the positive side these systems also have their negative side. Very often in such systems are mounted also different products, and the managerial point of view this is heavy duty because of prior planning and preparations. These preparations include tasks of choosing an optimal or suboptimal scenario of material, energy and information flow, including human resource organisation. The selection of such scenarios is made through different optimisation algorithms such are: finite, limited and random enumeration.

Module varies from one system to another, thus this module must be built for each and specific system.

6. REFERENCES

[1] Bruçi M., Stopper M., Bunjaku A., Stuja K., Kubat A.: Optimisation of Flexible Assembly System for Electrical Motors using Optquest for Arena, DAAAM International pp. 071-072, Vienna, Austria 2003.,

[2] Bruçi M., Bunjaku A., Stuja K., Buza Sh.: Optimizing of Flexible Palletizing Lines Usning Simulation Tools".TMT 2005, pp. 693-696. Antalya, Turkey, 2005.,

[3] Stuja K., Stopper M., Bunjaku A., Bruçi A.: A concept for scheduling of flexible assembly for electrical motors. DAAAM International Scientific Book 2003, pp. 591-598, ISBN 3-901509-36-4, ISSN 1726-9687, Vienna, Austria, 2003.