

## **Improvement in Production Processes in a Company in the Electronics Sector using Simulation**

### ***Verbesserung der Fertigungsabläufe in einem Unternehmen der Elektronikbranche mit Hilfe der Simulation***

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**Abstract:** This paper deals with improvements in production runs in the manufacture of electronic components for application in automatic control engineering. The comprehensive utilization of all existing manufacturing data as well as their correct representation play a key role here as does the critical assessment of the actual situation. Various scenarios were considered, based on the representation of the manufacturing processes in the simulation runs. The objective was to identify bottlenecks and problems in production with the help of simulation. During the simulation runs that were conducted, three different scenarios were considered, each having different time-slot patterns and order situations.

## **1 Introduction**

This paper deals with improvements in the production processes in the manufacture of electronic components for the field of automation. A key role here is played by the comprehensive recording and presentation of all existing production data as well as a critical assessment of the actual situation.

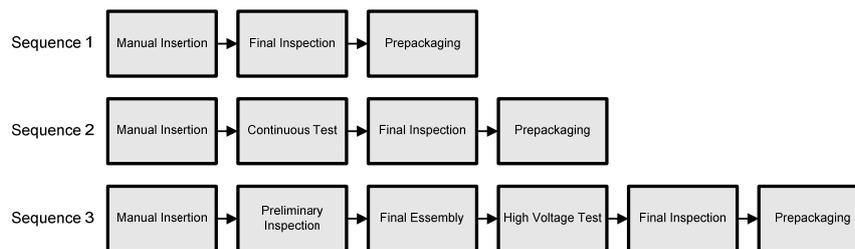
Simulation here is taken to mean the "Replication of a dynamic process in a system with the aid of an experimental model to obtain knowledge which can be applied to real systems" (VDI 2000). The ensuing replication of the procedures and processes in production was realized with the simulation tool Arena Version 11.0. (cf. also Kelton et al. 2006; Altiok and Melamed 2007). Using this simulation tool it is possible, as reported by Fuchs et al. (2004) and Treadwell and Herrmann (2005), to examine chained assembly and production systems along with their decoupling buffers and to assess them regarding their performance.

In order to support the efforts in the generation of models for the simulation of production processes the simulation tool Arena offers, as described and applied by Herpers and Schulz (2006), Rogers (2002) and Ali and de Souza (2007), the possi-

bility of hierarchically building up models from standardized objects. Successive, comprehensive and complex simulation models can be produced through insertion, linking and parameterizing these objects. With event-oriented simulations the simulated time normally runs substantially faster than the physical time describing the real time referred to the modeled system. Through this type of control it is possible to simulate long time spans in a temporally significantly shortened form and to obtain conclusions about the behavior of chained production systems having different time-slot patterns and order situations.

## 2 Production

The manufacture of automation components takes place in a single-shift production facility. The production equipment is arranged oriented to the material flow so that the organizational form is that of series production. Since the devices are always regularly produced and are mostly technically similar, the type of production can be regarded as large-scale variant production. There are a total of 81 different product groups, distributed over four product sub-groups with 61.7 %, 21.0 %, 13.6 % and 3.7 % of the production volume. Taking the individual product groups together, the variant range covers 432 different production components. The simulation begins from the time the customer orders are released. This implies that the assemblies for the components are already produced and all other parts needed are available.

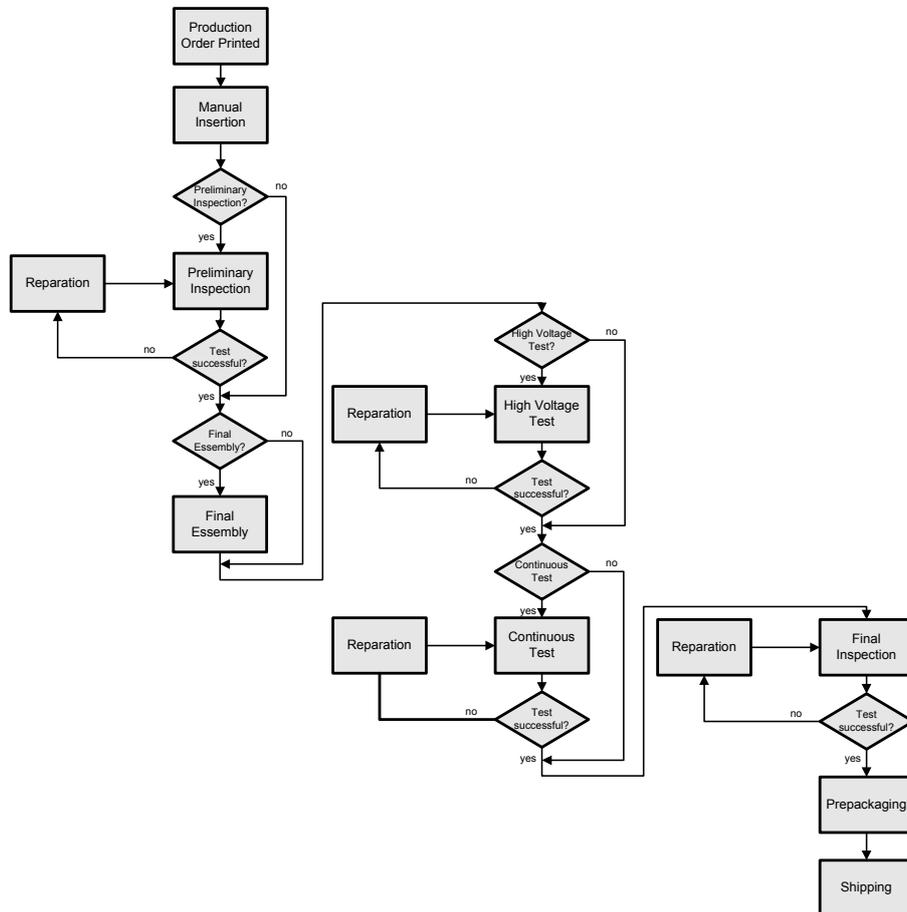


*Figure 1: Possible Working Sequences*

Depending on the type of device, the production of the individual components can take place in a minimum of three and a maximum of six working steps with a total of seven different working sequences. Consequently, none of the products passes through all the working steps which can be subdivided into manual insertion, preliminary inspection, final assembly, high voltage test, continuous test, final inspection and prepackaging.

As the examples in Figure 1 clearly show, all products pass through manual insertion, final inspection and prepackaging. There are only differences in the sequence of the various tests. The total processing sequences which are possible can be taken from the flow chart in Figure 2. However, it is worth noting here that the flow chart includes repairs after the tests, whereas Figure 1 represents the working sequences for the optimum case in production, i.e. without repairs. Whether after the test the simulation must go through a repair or not, is represented by a probability given from empirical values. During the preliminary inspection a 10% probability and

during the high voltage test a 5% probability was accepted. For the repair after the continuous test and the final inspection due to the negligibly small material repair frequency a probability of 0% was accepted.



**Figure 2:** Flow Chart

The simulation assumes that the working points are occupied normally so that the distribution of the employees for the processing steps of manual insertion, final assembly, preliminary inspection, high-voltage test, continuous test, final inspection, repair and prepackaging can be taken as a fixed quantity.

### 3 Simulation

The simulation tool Arena Version 11.0 is based on mechanisms of event-oriented simulation. In contrast to continuous simulation, with this type of simulation the individual events play an important role. The characteristic feature of event-controlled simulation is that each planned event has a time of occurrence and its

occurrence causes a certain transition of status. The simulation time can be increased to the time of occurrence of the next event and the relevant event can be simulated if nothing significant occurs between these events. Through time incrementation to the time of occurrence of the next event longer waiting periods are bridged.

After the implementation of all initial data, the model sequence begins. The data required for the progression of the simulation are read in from an Excel table after the start of the simulation and then pass through the model as attributes of entities. The basis for the data forms the actual quantity of orders of selected weeks of the regarded enterprise. For this the creation time, order number, order quantity and the sequence number are essential. Appropriately specified probabilities define whether the relevant product has to be repaired after a test or not. Before the entities leave the model, the respective process time is acquired with the associated order number. For improved evaluation of the scenarios, statistics with mean, minimum and maximum loading on the applied resources and queues were also included in the model definition. The maximum duration for all simulation runs is restricted to two weeks to ensure better comparability of the characterizing figures to be evaluated. The respective operating time of the work procedures, which are differentiated according to the products, corresponds to the adapted calculated operating time.

The distribution of resources represents a further constituent of the basic data. Here, differentiation is made between the actually existing working points and the usual manning of the working points, particularly as more working points are available than employees. This differentiation is important for the subsequent consideration of the scenarios between pure employee distribution and the full exploitation of all capacities.

### **3.1 Simulation of Scenario 1**

Scenario 1 represents one week with a relatively low order volume. To improve the simulation results two analytical approaches are to be considered. Firstly, the manning of the machines or working points can be varied with the existing number of employees. The second approach checks in what relationship the manning of all working points influences the result of the sum of the process times in comparison to the result with a distribution of employees.

At the best solution found with distribution of the employees to other stations, the final inspection is reduced by two employees and the manual insertion is increased by two employees. At all other stations the original manning is retained. Although the maximum queue length at manual insertion and that of prepackaging remain constant, they in turn increase at the final inspection. The increased loading on final inspection is compensated by the improvement at the other stations.

If all working points are manned, the percentage loading on all stations reduces or remains partially constant and is reflected in the decisive characterizing figures. As a result, it can be said of Scenario 1 that with a redistribution of the employees the mean process time of the orders can be reduced by 5%. Increasing the personnel by four employees causes a reduction in the sum of the process times of 17%.

### 3.2 Simulation of Scenario 2

The simulation of Scenario 2 involves one week with an average order volume. With a pure redistribution of the employees the simulation result can be improved, although production completion takes up almost as much time as in the initial situation. In total at the best case found, the maximum queue length reduces, but the mean loading falls. The queue length in prepackaging is clearly reduced, whereas final inspection shows a marked increase. This increase however appears to have no serious effect on the result. All other values do not display any significant changes and for this reason are not mentioned at this point.

If all capacities are exploited, the production of the orders finishes only ten minutes earlier than in the initial situation. However, the sum of the process times falls substantially. Similarly, there is a noticeable reduction of the values in prepackaging and in final inspection, whereas the positive changes for manual insertion are relatively slight. With Scenario 2 the redistribution of the employees can lead to a reduction in the mean process time of up to 18%. If all resources are fully exploited and the personnel is increased by four employees, the potential reduction in the sum of the process times is 33%.

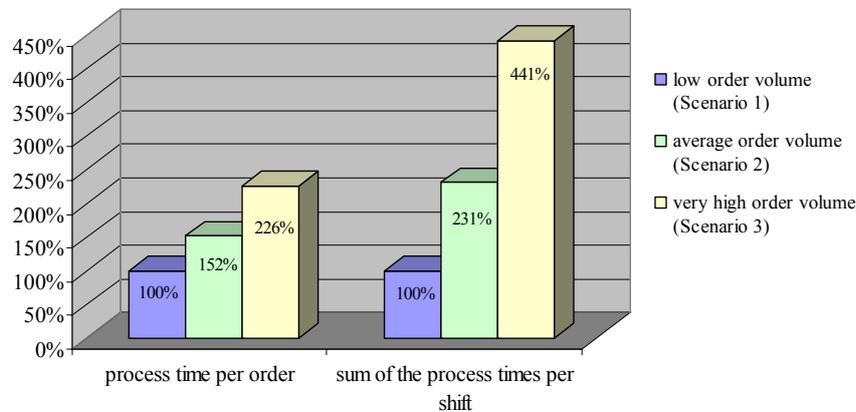
### 3.3 Simulation of Scenario 3

Scenario 3 represents one week with a very high order volume. When an employee redistribution is carried out, the process time is of similar length as in the initial situation, but the sum of the process times is substantially reduced. With the exploitation of all capacities even more time is saved. Consideration of the results of Scenario 3 for the case of the redistribution of employees shows that the loading and the maximum queue length of manual insertion are only reduced slightly. A significant improvement is seen with the preliminary inspection, but the values for the high voltage test and final inspection have increased. Due to the improved loading values of almost all stations, these increases do not impair the final result of the simulation run.

If all capacities for Scenario 3 are fully exploited, the most noticeable change is with the manual insertion. Furthermore, the prepackaging displays a clearly positive change with regard to queue lengths and the mean order quantity. With all other stations there were no far-reaching changes so that they are not mentioned at this point. Comparison of the two methods of improvement demonstrate that in the case of the redistribution of employees a time saving of up to 24% is possible. When the capacity is fully loaded, the saving increases to 33%.

### 3.4 Comparison of the Scenarios

In all three scenarios the orders were finished in the specified time. Overall, with the three scenarios an increase in the sum of the process times was found, but it must be taken into account that both the mean process time per order and the mean quantity per order have increased.



**Figure 3:** Relationship between the process times and order situation

A percentage comparison of the respective increases in Figure 3 shows that the process times increase disproportionately to the mean quantity per order. As an example this is shown based on the data "Optimum with redistribution" for the three scenarios.

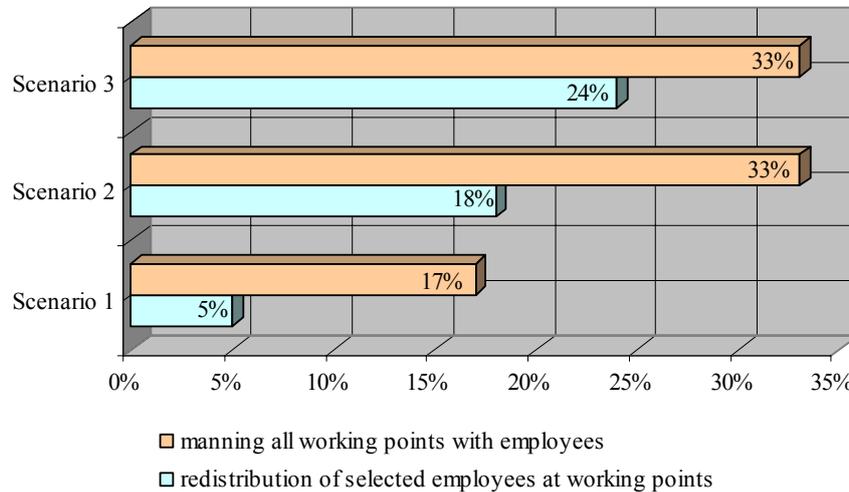
From Scenario 1 to Scenario 2 the mean quantity per order increases by 17.02%. The process time per order increases by 52.68%, whereas the sum of the process times increases by 131.87%. Comparison between Scenario 1 and Scenario 3 shows a rise in the mean quantities per order of 42.17%. In this case the process time per order increases by 126.34% and the sum of the process times increases to even 341.15%.

If the respective potential improvements in the sum of the process times with redistribution of the employees and exploitation of all capacities is compared in Figure 4, an increase with higher order quantities is found. In Scenario 1, which represents a low order situation, time savings of 5% with a redistribution of employees and 17% with full exploitation of capacity are possible. Scenario 2, which represents an average order situation, includes a potential improvement of 18% due to employee redistribution and 33% due to manning all working points. With the highest order situation in Scenario 3 a reduction in the sum of the process times of 24% can be obtained with redistribution of the employees and 33% with full exploitation of all capacities.

## 4 Summary

The findings published by Hernandez-Matias et al. (2008), which shows that as a simulation tool Arena presents a solid basis for a continuous improvement in production processes can be confirmed with this paper. Through the comparison of different simulation runs with in each case different allocation of resources, the best distribution of personnel has been found for the individual scenarios. Despite a very

detailed implementation of the production processes in the model, there are some facts to be taken into account during the assessment of the results, so that the results and evaluations of the scenarios should only be considered as a guideline for the allocation of resources.



**Figure 4:** Potential Improvements in Time Saved

The scenarios represent in each case one order week and have been simulated through to completion of production. The simulation starts at time zero and, in contrast to the real case, there is no production already running. Similarly, following orders from the second week of simulation onwards are not taken into account. Furthermore, in rare cases in the production of automation components rush orders are possible which demand a change to the order processing or short term changes in resource allocation. Situations of this nature have also not been taken into account in the various scenarios.

All the processing times used for the devices produced are based on calculated times which have been spread over the respective resources according to a specified distribution schema. The decisive quantity here is manual insertion, which normally takes up 70% of the total processing time. The comparison of all existing actual processing times with the calculated target processing times has shown that with 61% of the orders time deviations of more than 20% are obtained. An appropriate adaptation of the calculated processing times for the respective products is recommended.

It is always preferable with a high order situation to place the focus on more intense manning of manual insertion in order to facilitate a reduction of the queue lengths there and quicker progress in production. However, it should be borne in mind that increased use of personnel is linked to additional costs. This means that it is practicable to consider the economic efficiency between the increased personnel costs and the time advantage obtained.

In conclusion it can be said that based on the simulation results and the above mentioned critical points, adaptation of the calculated processing times is to be

recommended. With these corrected values a subsequent regularly implemented simulation of the current order situation represents one way of checking the existing allocation of resources and, where necessary, their adaptation.

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