Alternative System Design Based on Reliability Analysis and Simulation

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***Abstract*—The purpose of this study is the integration of reliability-availability analysis and simulation modeling to improve the productivity of the battery production system. The throughput of the system is increased by using integrated reliability-availability and simulation approach together and the proposed system design is more reliable than the current design. Moreover, system availability provides a valuable input for the company to realize the production plan for the future.**

Keywords-simulation modeling; reliability-availability analysis; battery production system.

I. INTRODUCTION

This paper presents a real case study of a multi-stage production line in battery production factory. In today's highly competitive industry, a company must be able to adapt to its customers' ever changing needs and improve the reliability of their system and products in order to survive. The battery production system of a company in Ankara, Turkey, is a complex system as is often the case in manufacturing environments, and so, to predict the throughput and to investigate the stochastic behavior of this system, simulation model could not be used alone. Although most operation units have stochastic operation times, curing unit has much longer constant operation time than the other operation units. Therefore, under its dominant effect, the simulation model works like a deterministic model not a stochastic. Although failure time, mean time to failure and down time are known for each machine working at all stations failures could not been considered in the simulation model. Because simulation run time of this very complex system already takes too long time such as 60 hrs even without considering failures. Therefore, simulation model of this system is built without failures. However, it is needed an additional method to imitate thestochastic nature of this system to be able to get true response from the system to improve system performance.

II. METHODOLOGY

In today's automated systems, to analyze production rates and system qualifications, reliability is one of the most important metrics of components and systems. Reliability could be analyzed in two main headings, product reliability and system reliability. Product reliability is the probability that a product will operate properly for a specified period of time. System reliability can be computed based on system configuration where all components are connected in series, in parallel or as networks. Some metrics related to reliability of components and systems are mean time to failure [1], the failure rates of components or system [2], the availability of components or system [3], and the repair rate of system [4]. Companies should present more reliable products in current competitive market; otherwise, customer satisfaction could not be provided and products are not preferred. Therefore, reliability and availability analysis in production fields have attracted interest recently, although in the literature, reliability analysis and availability analysis generally have been considered in electronic fields.

The battery is the main power component of the vehicles. Any failure of the battery (not working appropriately) could cause problems about vehicle or driver. It is desired that it has high reliability and availability. Therefore, reliability computation of production systems is important.

In this study, we propose to use the integration of reliability-availability analysis and simulation modeling to improve the productivity of the system because of system characteristics. In addition, overall system availability will provide a valuable input for realization of production planfor the future. Hence, in practice, production planning department can find valuable evaluation value to improve the system productivity. To the best of our knowledge the proposed method in this work is the first application in this area.

This study will proceed as follows: Firstly, a new system design is obtained based on reliability and availability analysis of the current system. The reliability block diagram method is used for the computation of reliability of existing and proposed complex battery production system. Secondly, we investigate the system behavior to find out bottlenecks and see the throughput rates under assumption of no failures with the simulation model.

III. CASE STUDY

In the eleven stations, only machines are taken into account for system reliability and availability analysis. In each operation units, all components are defined and their failure times and repair times are obtained from historical data. Failure distributions and their parameters are estimated and repair rate of the system are calculated [5]. The battery production system is analyzed and reliability block diagram is drawn considering their series or parallel configuration. The reliability block diagram of current battery production system is shown in Figure 1.

System reliability and system availability is computed [6]. The reliability equation of current system is obtained based on [7]. The system availability of current system is 0,890309 per month.

System reliability and availability is calculated again for new proposed system. System availability for alternative system is 0,899266 per month.

Using the reliability and availability analysis, new system

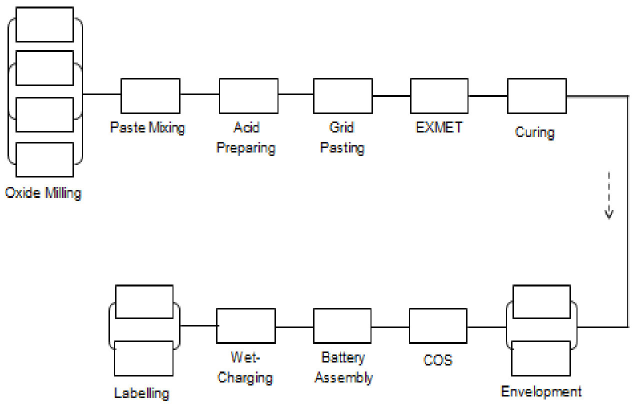

Figure1. Reliability Block Diagram of current battery production system.

is developed to improve the system productivity. To get a more reliable alternative system some stations (components) are added to the current system. Thus, a new series and parallel alternative system is designed.

Secondly, we investigate the system behavior to find out bottlenecks and see the throughput rates under assumption of no failures with the simulation model of existing and proposed alternative systems. In our approach, a simulation model is constructed using discrete event simulation. The ARENA simulation package [8] is preferred for its capability. Actual data from the production was utilized to determine the inputs for each process. Simulation model is modified and used to estimate the throughput of this alternative system. It is 7411 batteries per month.

Finally, using the simulation result and system availability value, expected production rates are obtained considering failures as follows. It is calculated that 6384 batteries can be produced each month by the current production system. The actual throughput considering failures is 6664,46 in the proposed new system. It can be said that using integrated reliability-availability and simulation approach together it can be obtained more reliable alternative system design with 6664 throughput (battery), which is more than the current system.

IV. CONCLUSION

This paper presented a new method to improve the productivity of the battery production systemof a company in Ankara, Turkey. Because of system characteristics, reliability-availability analysis and simulation approach are used together to analyze system and obtain throughput (battery). Finally, it is seen that the proposed new system design is more reliable than the existing system design and it is produced more battery than the existing system.

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