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FABRICATION CELL DESIGN THROUGH SIMULATION MODELING AND ANALYSIS AT THYSSEN-KRUPP ELEVATORS

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ABSTRACT

One of ThyssenKrupp Elevator's (TKE) manufacturing plants recently underwent a major facility redesign in order to improve throughput. Part of that effort involved converting a fabrication area from a by-equipment departmental arrangement to a work cell. This case study describes the use of simulation to effectively analyze and design the cell. The simulation model provided TKE with a means to not only assess the feasibility of an initial proposed design, but to consider and evaluate a number of alternative designs. Decision variables included equipment and labor resources, work hours, product mix, level of variability, work release strategies, work sequencing, etc. Simulation demonstrated infeasibility of the initial proposed design and led to a feasible, and much improved, production system.

1 INTRODUCTION

In order to improve operations and overall throughput, one of ThyssenKrupp Elevator's (TKE) manufacturing plants recently underwent a major rearrangement. One proposal was to change the fabrication area from a by-equipment departmental arrangement to a work cell layout with much smaller batch sizes. Plant management had doubts as to whether the proposed system design could meet the anticipated demand. They did not doubt the concept that a cell arrangement with small batch sizes is good, but their concern was with what resources – labor and equipment – and operating policies were needed to meet demand given their production constraints. It was suggested that simulation be used to test the feasibility of the proposed design before it was approved.

The simulation model soon became the key design tool for the cell. It provided the means to determine resource requirements, flow, and layout. The modeling effort forced the cell proposers (external consultants) to consider operations in much more detail. The simulation model was used as a "what-if" tool to consider and assess system alternatives. In order to effectively test scenarios, data from various TKE production data sources had to be accessed and used by the simulation model. While the basic flow through the cell is quite simple, the information flow, process logic, and operational considerations added considerable complexity to the model. Mississippi State University (MSU) performed the simulation modeling and analysis using *FlexSim* simulation software.

2 SYSTEM DESCRIPTION (CELL CHARACTERISTICS)

The fabrication area produces multiple product families that have similar routings and resources. Information on how many of each product to produce are pulled from current customer demand data. TKE has many types of finished products and the demand for each product is highly variable. Goods produced by the cell are sub-assemblies for elevators and are composed of components - a fixed number of components are produced from each sheet of material (that number varies by component). Components can be unique to a product or can be used in multiple products. Setup time is only incurred when the previous component processed at a fabrication step differs from the component to be processed.

Components are pushed through the cell in order to meet product demand. Components are typically sheared, punched, and pressed. Some products are kitted based on product BOMs and then welded. Each component has its own route, as well as setup and process times for each fabrication step.

Since the proposed cell was within the current facility, space and work-in-process (WIP) were limited. Component work needed to be released based on the current WIP level and those levels are specified in terms of hours of work content at each fabrication step. If the awaiting work content at a fabrication step exceeds a threshold, work ceases to enter the cell until inventory is below a limit.

One thing became obvious as the project evolved, sequencing of work through the cell significantly impacts performance. Sequencing was not considered at all in the initial proposed cell design. While sequencing algorithms are a topic for further research, the one developed for this project is based on the common notion that ordering by shortest expected processing time results in better throughput. This algorithm results in significantly better performance than an arbitrary sequence.

Process time variability is known to exist in the process, but was not considered in the initial proposed cell design. Data were not available to assess the probability distributions for the simulation model; however, process times were assumed to follow a triangular distribution.

3 SIMULATION MODEL

The basic input to the simulation model is the quantity of each product needed in a planning horizon, each product's BOM, and the sequence of components to be produced. For each component, setup times, process times, quantity to produce, and number of components per sheet are inputs. To support what-if analyses the following are input in easy-to-use table format: number of fabrication and welding operators on regular time and during overtime, operating hours (regular and overtime hours per day), information on WIP control on the queues to dynamically stop input to the cell, two types of setup times (current and proposed), level of variability by process step, and the number of resources (equipment and labor).

The simulation model became a key means to evaluate alternative designs. Therefore, model output provided such performance measures as: mean and maximum WIP, mean cycle time (time to complete a week's planned production), and mean time for products to be processed in fabrication.

4 RESULTS AND CONCLUSIONS

In general, a major outcome of the project was the demonstration of how effective simulation modeling and analysis can be, when used as a design tool. It went well beyond the basic need of testing the feasibility of a proposed approach; it provided a valuable means to trade-off and assess alternative designs in the search for the "best" option. It also forced the cell designers to consider many other production aspects not addressed in the initial proposal. Some of the key specific findings of the project were:

- Setup reduction, ranging between 50% and 85%, was a part of the initial plan to change to a cellular approach. Simulation showed this would result in about a 35% improvement in overall cycle time and time in production.
- Simulation showed that a change in the way products are sequenced through the cell would result in approximately a 10% improvement in cycle time and time in production.
- Simulation showed that the initial cellular plan, in terms of the number of operators and equipment, was infeasible. This confirmed production management's initial suspicion.
- The "best" option found required one additional welder and 2 hours of overtime per day for half of the cell workforce. This resulted in a 15% improvement in cycle time and time in production over the base case. Adding additional workers on the regular shift or overtime did not result in further improvements. WIP profiles over time helped assess the feasibility of each option and design storage areas in the cell. The simulation was also used to set operation WIP controls.