Facility Layout Improvement Model using Ergonomics and Layout Simulation

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***Abstract*— Facility layout enhancements that focus on ensuring smooth flow of operation without taking into consideration the needs of workers are deemed useless whenever operational inefficiencies occur due to worker's health and safety. Therefore, the integration of process analysis, ergonomics and plant layout simulation into a facility layout model ensure both improvement on efficiency and productivity of the operation and the workers. This paper proposes a model that takes into account process variables such as productive and unproductive time and distance travelled, ergonomic variables such as body posture and awkward position, weight handled or muscular load, workstation dimension and appropriateness to workers, physical and environmental hazards and variables such as productivity (units produced per hour), in-process percentage (process efficiency), resource utilization and units produced for plant layout simulation to create a comprehensive analysis and measure the improvement and the performance of the integrated framework. To test the effectiveness of the integrated model, the proponent incorporated an actual industrial case to compare and evaluate existing and proposed layout results and also utilized simulation software to validate the procedure and support methodology applicability.**

Keywords— facility layout design, ergonomics, simulation, model, process analysis

I. Introduction

In an intense market competition, companies opt to find ways to streamline processes to achieve overall operational effectiveness. Facility Layout and Design (FLD) is said to be an integral component to optimize effectiveness of the process while considering the needs of the employees (Baykasoglu et al., 2006). Facility layout, on the other hand, aims to realize the smooth flow of work, inputs, as well as the information, whether in a single or multifaceted system (Lasser, 1994). The combination of layout and design of facilities affects how work is performed and accomplished. Hence, the integration of worker's needs (including health and safety), input (material), machinery and method are determining factors to develop an optimal and effective system (Weiss et al., 1989).

There is a strong association between ergonomics and layout design both in theory and application. Issues like repetitive tasks, awkward postures, fatigue, stress and work-related musculoskeletal disorders (WRMSDs) as well as plant layout efficiency and productivity are interrelated to one another and thus, both can improve worker's output and performance as well as quality and overall productivity of the system (Battini et al., 2011). A methodology that integrates ergonomics of workstation and layout simulation is deemed to give better results since it provides the lowest material handling costs and shortest cycle time. While the methodology that optimizes material handling and distances, without considering the need of workers, is considered useless when time losses due to worker's disability arise (Battini et al., 2011).

The primary goal of this research is to develop a method of obtaining improved facility layout design using ergonomic analysis to resolve inefficiencies and risks in workstations; and plant layout simulation to eliminate delays and bottlenecks in production process and improve material handling system. To ensure effectiveness of the proposed method, a case study in the production area of a garment manufacturing plant is presented and examined. The effectiveness of the method is evaluated through efficiency and productivity ratio, cycle time, utilization and ergonomic indicators as metrics.

II. Methodology

Figure 2.1 illustrates the framework that integrates ergonomics and plant layout simulation in designing an effective facility layout on which the present study is anchored. Variables are identified in every phase of the model. These variables are related to process, ergonomics and plant layout. Since the testing of the effectiveness of methodology is through a case study, gathered data vary from production to production, from worker to worker and from workstation to workstation, hence variables should be highly considered. Moreover, this methodology is divided considering variables related to process analysis, ergonomics and layout simulation

A. Process Variables

The process variables are related to process cycle time or simply the total elapsed time to move a unit of work from the beginning to the end of a physical process, and includes the productive and non-productive time, distance travelled of the workers from one station to another, process efficiency, productivity (units/hour), resource utilization and units produced. These have direct effect with the production floor size or dimension of the tested company and are dependent on the production and the process itself.

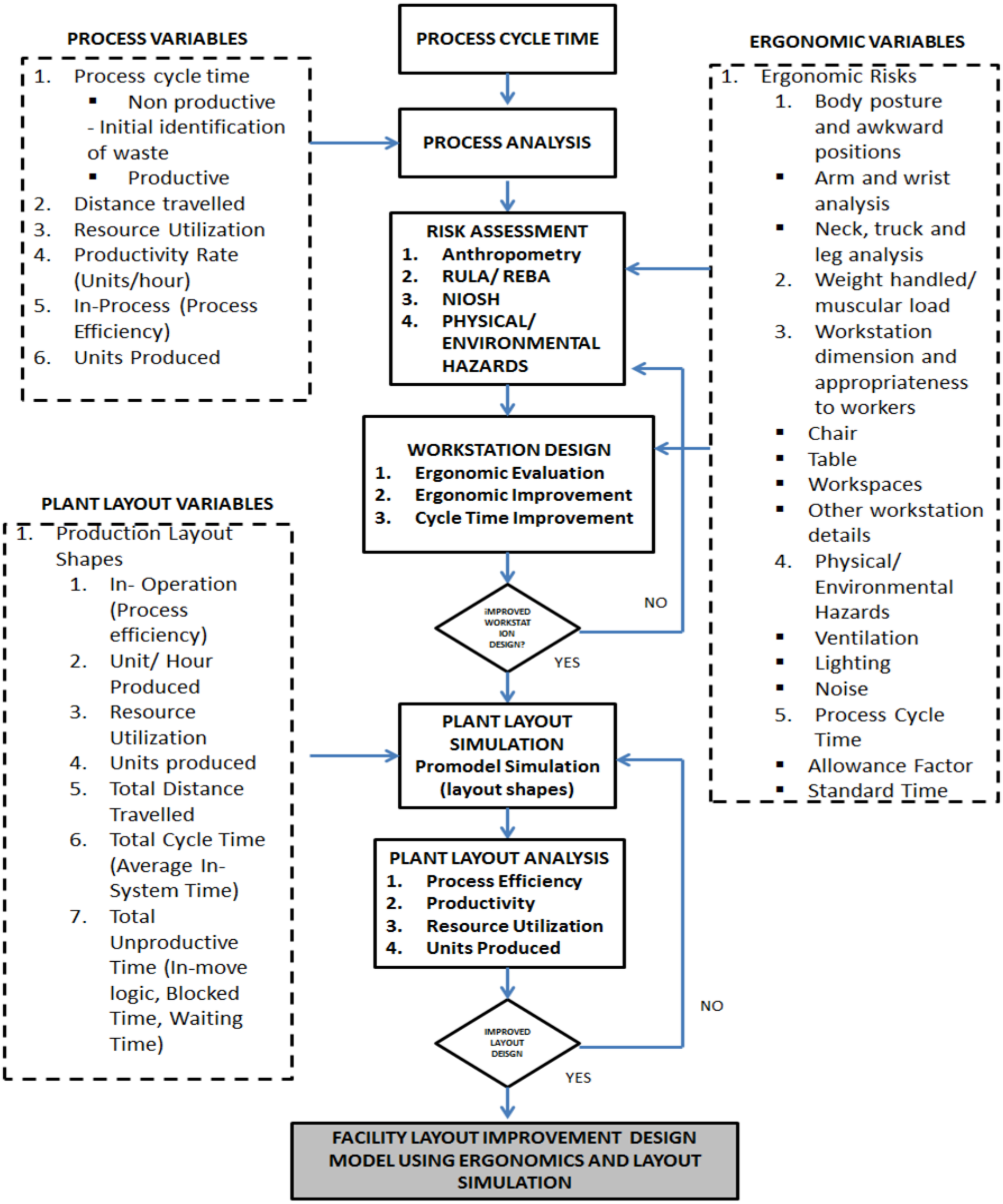

Fig. 2.1 Facility Layout Improvement Model Framework

B. Ergonomics Variable

Ergonomic variables are related to body posture and awkward positions with great emphasis on neck, arm and wrist, legs and truck, weight handled and the coupling, workstation dimension and spaces, anthropometry of the workers and its workstation and physical environmental factors that affect productivity such as lighting, air/ ventilation and temperature and noise. In short, these are variables that are related to the workers and the effect of these variables to their health and safety and to their performance in work. These variables are assessed to determine what activity and factors contribute to ergonomic risks among workers. Since these are highly dependent on the workers and their activities, process and workstations and physical environment, these may vary from one production or process to another.

C.Plant Layout Variables

The last set of variables in the model are related to plant layout, which include process cycle time (productive and unproductive), resource utilization, productivity rate in terms of units per hour, total units produced, total distance travelled and process efficiency. These variables are all measured through Promodel software. Depending on the production floor area, the revised workstation dimensions, the layout shapes vary.

III. RESULTS AND DISCUSSIONS

The process analysis phase of the case study revealed that the existing process and layout produced huge unproductive time and reduces the total units produced. Meanwhile, the ergonomic phase showed several factors that contribute to higher ergonomic risks among workers, which resulted to process inefficiencies.

To reduce the level of ergonomic risks, improvements are made in the workstation, chair, tables including the physical and environmental factors such as lighting, ventilation and noise level of the plant. The plant layout phase translates the improvements made on ergonomic phase as basis on the layout simulation such as the appropriate dimensions of each workstations. Using Analytical Hierarchy Process (AHP), the proposed layouts are evaluated using the following criteria, % In-operation Time (10%), % Unit Produced (20%), Resource Utilization (10%), Total Distance Travelled (10%), In-system Time (15%), Total Unproductive Time (15%) and Unit per Hour Rate (20%), for a total of 100%. From the set criteria and rating, it was found that the best layout among all proposed layouts is the P-shape. Figure 3.1 presents the matrix and graphs generated from AHP software that summarizes the comparison of proposed plant layouts.

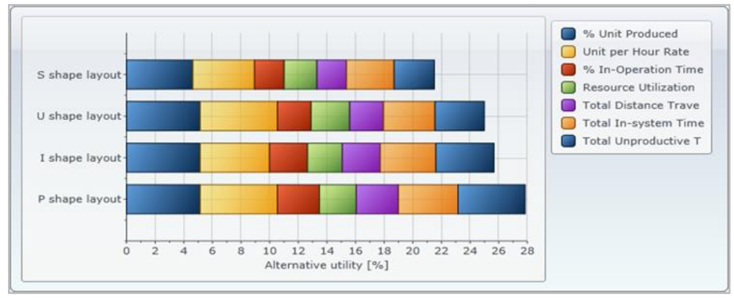

Fig. 3.1 AHP proposed plant layout simulation improvement result matrix

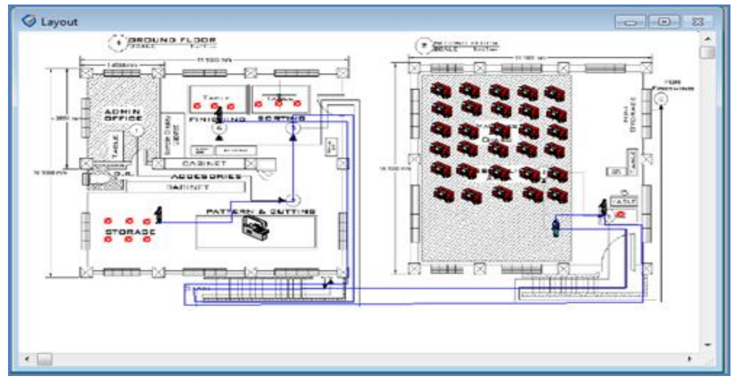

Fig. 3.2 Simulation of Existing Layout

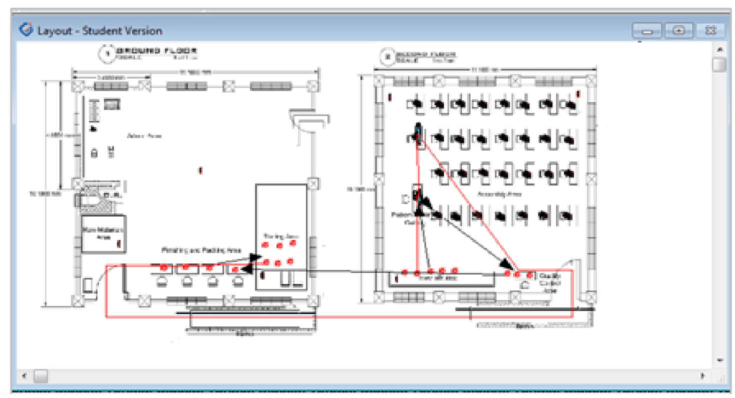

Fig. 3.3 Simulation of Existing Layout

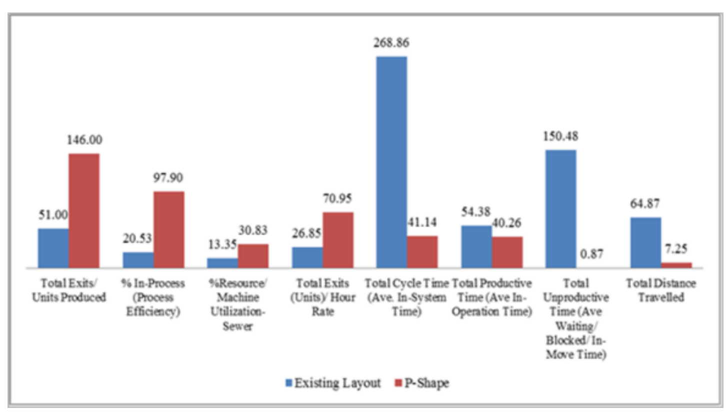

Fig. 3.4 Comparison of Existing and Proposed Layout Simulation

Upon comparison, its shows that the proposed layout improved the total units produced from 51 units to 146 units, increased the % In-Operation from 20.53 to 97.90 and decreased the total cycle time from 268.86 minutes to 41.14 minutes.

IV. CONCLUSION AND RECOMMENDATION

The proposed model for facility layout using ergonomics and layout simulation improved the production operation of the company based on the performance measures such as increasing In-operation Percentage or Process Efficiency, Units per Hour Produced and Resource/ Machine Utilization. It also reduced the Unproductive Time, which includes in-move logic time, blocked time and waiting time, Total Distance Travelled, Total Cycle Time and ergonomic risks.

The proposed integrated model improved the entire facility layout including workstations and ensured appropriateness both on layout and workstation since it considers the actual dimensions.

The proposed model could further include a design on the incentive, wage system of the company. A cost-benefit analysis could also be included to see the potential return on investment (ROI) from the improvements made. This approach could make use of the Sim Runner option of Promodel, which has the capability to compute the possible maximization of profit and minimization of costs relating to process and resources. It could also determine the number of resource needed to reach the highest utilization and process efficiency. Moreover, the model could also be used in other manufacturing industries other than garments to test robustness of the method.

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