

# Ergonomic Design of Material Handling Tasks with Buffer Stock in Production System for Effective Operations

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**Abstract-** The use of ergonomics study is to improve the workers safety and health, increase job satisfaction and enhances performance. Lack of ergonomics criteria in workspace and workstation design can cause physical and biological hazards to the workers. Ergonomics evaluations in industrial setting have recently received increased attention due to the cost incurred as a result of repetitive motion injuries. In Flexible Manufacturing System, the human capabilities and limitations must be respected to ensure safe effective operations. The material handling tasks, workplace and the equipment must be designed so they are easy to operate which eliminates strenuous labor. Supplies of unfinished workpieces called buffer stock put in front and behind each workstation eliminate time pressure for the worker. This arrangement gives much flexibility and better organized at work. This can lead to improved productivity in the Flexible Manufacturing System. The ergonomic design and equipment selection with buffer stock must be safe for the human operators and Flexible Manufacturing System.

**Keywords-** Ergonomics, manufacturing, safety, industry, workplace

## I. INTRODUCTION

A production system which includes Flexible Manufacturing System (FMS) typically possesses multiple automated stations and is capable of variable routings among stations. Its flexibility allows it to operate as a mixed model system. The FMS integrates into one highly automated manufacturing system many of the concepts and technologies, including: flexible automation, CNC machines, distributed computer control, robotics, automated material handling and storage.

*A flexible manufacturing system (FMS) is an arrangement of machines.... interconnected by a transport system. The transporter carries work to the machines on pallets or other interface units so that work-machine registration is accurate, rapid and automatic. A central computer controls both machines and transport system... [1]*

## II. MANPOWER REQUIREMENTS

Human resource development, equipment operator skills, manufacture of processing tools, products, processes & machinery, research and development are some of the issues resulting from higher level of technology implementation. In

this situation, a contingency strategy for training engineers and other specialists with FMS should be considered in university learning with engineering education. These evolving trends in industry must be applied back into the engineering curriculum. Industry needs universities to respond with increase emphasis on design and manufacturing skills.

## III. TRAINING COMPETENT ENGINEERS

Production system training in the university laboratories, increases the capability of engineers provides a distinct advantage for manufacturing industries. The proposed approach should be developed and implemented economically with the desired experience exists inside the university and the experience level of the teaching staff with the technological approach is high, its use should be considered, Fig.1.



Fig. 1 Training manufacturing engineering students with material handling tasks in the laboratory.

### A. Reasons why storage buffers are used on automated production lines

There are a number of reasons why storage buffers are used on automated production lines. Fig.2. The reasons include:

- *To reduce the effect of station breakdowns.*  
Storage buffers between stages on a production line permit one stage to continue operation while the other stage is down for repairs.
- *To provide a bank of parts to supply the line.*  
Parts can be collected into a storage unit and automatically fed to a downstream manufacturing system.

- This permits untended operation of the system between refills.
- *To provide a place to put the output of the line.*  
This is the opposite of the preceding case.
  - *To allow for curing time or other required delay.*  
A curing or setting time is required for some processes such as painting or adhesive application. The storage buffer is designed to provide sufficient time for the curing to occur before supplying the parts to the downstream station.
  - *To smooth cycle time variations.*  
Although this is generally not an issue in an automated line, it is relevant in manual production lines, where cycle time variations are an inherent feature of human performance.



Fig.2. Storage buffers and robots used on automated production line.

**B. Function of material storage systems**

Main function is to store different types of material and to permit access to those materials when required.

*The types of materials stored:*

- Raw materials
- Purchased parts
- WIP
- Finished products
- Rework / scrap
- Refuse
- Tooling
- Spare parts
- Office supplies
- Plant records

*Measures to assess performance of storage system:*

- Storage capacity
- Density
- Accessibility
- Throughput
- Utilisation (for automated storage systems)
- Reliability/availability (for automated storage systems)

*How to organise storage location:*

- Randomised storage – incoming items are stored in the nearest available location
- Dedicated storage – SKUs are assigned to specific locations ---by part number or product numberby level of activity (more active – closer to input/output stationby activity-to-space ratio (higher ratio - nearer to input/output station)

- Class-based dedicated storage system – a combination of the above 2 – the storage space is divided into classes based on activity level, and randomised storage strategy is used within each class.

*Automated storage systems*

- Automation reduces or eliminates human intervention
- In less automated systems – need human operator
- In highly automated systems – loads are S/R'ed under computer control
- Two types of automated storage systems –
- (1) automated S/R systems,
- (2) carousel storage systems

*WIP application for automated storage technology*

Automated storage systems can help improve control over work in process WIP by providing...*buffer* storage in production

- support of *JIT* delivery
- more *space* for parts (in totes, pans, etc) for assembly
- *computer control* and tracking of materials
- support of *factory-wide automation*

**IV. STORAGE BUFFERS**

Automated production lines can be designed with storage buffers. A *storage buffer* in a production line is a location where parts can be collected and temporarily stored before proceeding to subsequent (downstream) workstations[3]. The storage buffers can be manually operated or automated. When automated, a storage buffer consists of a mechanism to accept parts from the upstream workstation, a place to store the parts, and a mechanism to supply parts to the downstream station. A key parameter of a storage buffer is its storage capacity, that is, the number of workparts it is capable of holding. Storage buffers may be located between every pair of adjacent stations or between line stages containing multiple stations. Refer Fig. 3 to 6. [3]

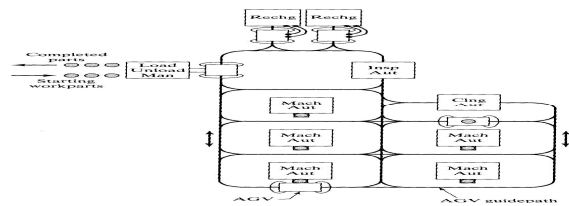


Fig.3.Open Field FMS layout –Parts loading and Unloading

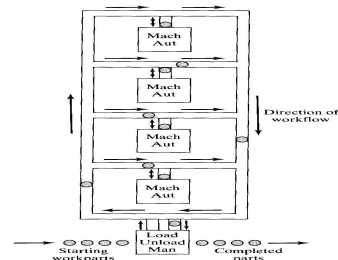


Fig.4. FMS Ladder Layout

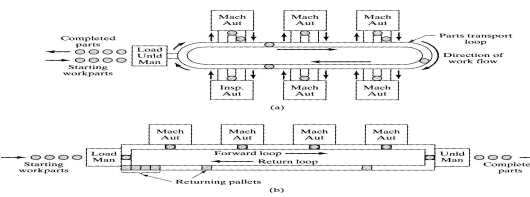


Fig.5. a) Loop layout b) Rectangular layout

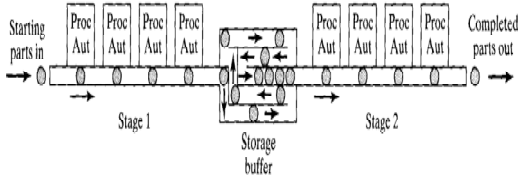


Fig.6. Storage buffer between two stages of production

V. AN AS/RS THROUGHPUT ANALYSIS CASE STUDY

An automated storage/retrieval system has many aisles[5]. A unit load AS/RS for work-in-process storage in a factory must be designed to store pallet loads, with an allowance of no less than xx% additional storage compartments for peak periods and flexibility. The unit load pallet dimensions are: depth (x) and width (y) . Maximum height of a unit load .It has to be determined that the AS/RS will consist of how many aisles with one S/R machine per aisle. The maximum ceiling height (interior) of the building permitted by local ordinance, so the AS/RS must fit within this height limitation. The rack structure will be built above floor level, and the clearance between the rack structure and the ceiling must be fixed. Determine the dimensions (height, length, and width) of the rack structure, the length of the storage aisle in an AS/RS and its height. Horizontal and vertical speeds of the S/R machine, respectively. The S/R machine requires accomplishing a pick and depositing operation.

Find: the single command and dual command cycle times per aisle, and throughput for the aisle under the assumptions that storage system utilization = xx% and the number of single command and dual command cycles are equal [4].

Using the general approach of the method for computing cycle time but adding considerations of acceleration and deceleration, determine the single command and dual command cycle times. Rates of acceleration and deceleration are constant in both directions. Pick and deposit time = T s. Utilization of the AS/RS is assumed to be xx%, and the number of dual command cycles = the number of single command cycles. Calculate the single command and dual command cycle times, including considerations for acceleration and deceleration. Determine the throughput rate for the system [5].

VI. ERGONOMIC DESIGN of MATERIAL HANDLING TASKS

Many companies are seeking proposals for an automated storage/retrieval system that will have a throughput rate of X number storage/retrieval transactions/hour during the one 8-hour shift per day [6]. The request for proposal indicates that the number of single command cycles is expected to be four times the number of dual command cycles .Your recommendation is to reduce the number of aisles from x1 to x2 and to select a S/R machine with horizontal and vertical speeds of xm/min and xm/min, respectively. Determine the length and height of a six-aisle AS/RS whose storage capacity would be the same as the proposed X-aisle system. Determine the throughput rate of the x1-aisle AS/RS and calculate its utilization relative to the specified number of transactions/hour. Given the dilemma now confronting you, what other alternatives would you analyze and recommendations would you make to improve the design of the system? As the responsible engineer for the project, you must analyze the proposal and make recommendations accordingly. The FMS AS/RS shown in the Fig.7.



Fig.7.FMS with an AS/RS arrangement

VII. CONCLUSION

Ergonomic design of material handling tasks with buffer stock in production system for effective operations is technologically more sophisticated for the industries and the human resources who must make it work. Production systems are a great focus of attention in industry and in academic research for a number of years. The advantages of a well-run ergonomic design were clear: short lead-times, low inventory, reduced cost and a step towards the factory of the future.

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