Materials handling technology and significance of expert systems to select appropriate handling equipments in engineering industries: A review

Thoguluva Raghavan Vijayaram*
Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, UPM 43400 Serdang, Selangor Darul Ehsan, West Malaysia, Poskod: 43400, Malaysia

Received 22 August 2005; revised 13 April 2006; accepted 12 May 2006

This review discusses various handling equipments and the role of material handling systems in engineering industries. Flow of material through ecosystem of an industrial society is the physical manifestation of its substance, productivity and wealth. A brief explanation on the material handling interests and activities are also highlighted. Simulation models are precisely given to generate the expert system software for handling systems.

Keywords: Automated flexible manufacturing system, Automated guided vehicle, Integrated manufacturing system, Inventory control, Material handling equipment, Prototype expert system, Simulation model, Transit movement

Introduction

Material handling (MH) system is applied for both manufacturing and distribution operations. It does not add value to product but it usually adds a significant element of cost. The three basic characteristics of MH are picking up the load, transporting the load and setting the load down. Production effectiveness can be increased by having the right quality of material at right places at the right time. One of the most logical developments to evolve from the science of MH is the unit load concept. The handling of a quantity is treated as a single mass, which is a simple outcome of mechanically assisted handling. The traditional approach for handling selection has been to entrust this task to process engineers. MH design problem requires combining the total logical and physical aspects of material flow and then justify the design from performance and economic perspectives. Generally, handling control systems can be fully integrated into the business to gain the maximum benefits from the investment. Testing the design of a conventional or automated MH system is essential to ensure that system will provide the expected benefits after implementation.

History

MH technology is becoming increasingly important to all types of business operations in today’s competitive society. It can change the way in which a business competes in the market place and early identification of opportunities will become increasingly important for the survival in the future. A prototype expert system has been developed to identify a suitable conveyor solution from 76 conveyor types. SEMH (selection of equipment for MH) knowledge base system consists of 39 rules and the knowledge base is divided into level of mechanization and the equipment selection knowledge base. A prototype expert system for industrial truck type selection have been developed using a combination of forward and backward chaining for inferencing. MATHES (material handling equipment selection expert system) has been developed. A prototype knowledge based system has been developed for robot selection using an expert system shell (Kappa-pc). An integrated approach has been developed to operation allocation (OA) and material handling system selection (MHSS) in the cellular manufacturing system. The model formulations can be used as a planning tool to generate some of the design features of manufacturing system. An algorithm is presented to solve the models in three steps. Each iteration consists of solving the model P (OA), followed by solving the model P (MHSS), and then modifying the available choices of MH equipment for part process combinations and returning to P (OA). A hybrid knowledge based / optimization system for automated selection of MH selection have been developed. Kerni & Tsur has developed six paradigms for knowledge-based system

*E-mail: vijayaram1@gmail.com
A knowledge base is proposed for determining the most appropriate architecture suitable for the given application. A decision model and methodology have been developed for the selection of bulk MH equipment. The model accounts for economics, characteristics of the equipment, environmental characteristics, and compatibility between equipment types. A multi-attribute MH equipment selection called MHAD introduces fuzzy information and axioms approach and uses it in the selection of MH equipment. MHAD consists of a database, a rule-based system, having multi-attribute decision-making models. The most important factor influencing the selection is effective use of labour, providing system flexibility, increasing productivity, decreasing lead-time, and cost. MH equipment selection has been developed by fuzzy multi-criteria decision-making methods. Fuzzy multi-criteria decision-making methodology is used to aggregate the rating attitudes of decision makers (DMs) and trade-off various selection criteria to find ranking values of fuzzy suitability indices. A hypothetical problem is designed and coded into TURBO C Programming language to obtain the final ranking of the alternatives automatically.

MHESA (material handling equipment selection advisor) is a knowledge-based expert system for assessing material handling equipment selection and analytical hierarchy process (AHP) model to choose the most favourable equipment type. MHESA can automate the design of a MH equipment selection system, and provides artificial intelligence in the decision-making process.

### Table 1—Material handling interests and activities

<table>
<thead>
<tr>
<th>Areas of interest</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Packing at the suppliers plants</td>
<td>i) Handling and storage methods</td>
</tr>
<tr>
<td>ii) Loading at suppliers docks</td>
<td>ii) Loading and unloading techniques; methods</td>
</tr>
<tr>
<td>iii) Transportation from suppliers</td>
<td>iii) Packing (consumer and protective)</td>
</tr>
<tr>
<td>iv) Unloading activities at our plant</td>
<td>iv) Testing packaging, loading, and handling methods</td>
</tr>
<tr>
<td>v) Receiving operations</td>
<td>v) Setting specifications and standards for handling, packing, and storage</td>
</tr>
<tr>
<td>vi) Storage of both material and supplies</td>
<td>vi) Equipment feasibility studies</td>
</tr>
<tr>
<td>vii) Issuing material to production</td>
<td>vii) Handling and storage equipment selection</td>
</tr>
<tr>
<td>viii) In-process storage and handling</td>
<td>viii) Auxiliary equipment evaluation and selection</td>
</tr>
<tr>
<td>ix) Work place, Intra-departmental handling and Inter-departmental handling</td>
<td>ix) Selection of containers (shop, packing, shipping)</td>
</tr>
<tr>
<td>x) Intra-plant handling</td>
<td>x) Handling equipment repair and maintenance policy and procedure</td>
</tr>
<tr>
<td>xi) Handling related to auxiliary functions</td>
<td>xi) Damage prevention (material and product)</td>
</tr>
<tr>
<td>xii) Packaging (consumer)</td>
<td>xii) Safety</td>
</tr>
<tr>
<td>xiii) Warehousing of finished goods</td>
<td>xiii) Training</td>
</tr>
<tr>
<td>xiv) Packing (protective)</td>
<td>xiv) Surveys to uncover saving opportunities</td>
</tr>
<tr>
<td>xv) Loading and shipping</td>
<td>xv) Handling costs and cost control methods</td>
</tr>
<tr>
<td>xvi) Transportation to customer</td>
<td>xvi) Keeping up to date on equipment, methods, procedures, etc</td>
</tr>
<tr>
<td>xvii) Inter-plant transportation</td>
<td>xvii) Related paperwork, control and communication systems</td>
</tr>
<tr>
<td>xviii) Related record keeping</td>
<td></td>
</tr>
</tbody>
</table>

### Material Handling

MH maintains product quality by reducing damage and providing protection of materials. It promotes safety and improves working conditions. MH promotes productivity, increases use of facilities, reduces weight and controls inventory (Table 1).

### Benefits and Advantages

There is an upward trend in most industry segments that reflects the growing labour force required to service and maintain increasingly complex equipment. In-transit movements, either from supplier to plant, from plant to plant, or in-plant, have a tendency to increase the level of the damage that occurs to the product being handled. Since scrap and rework can be costly, one should make every attempt to prevent such losses by the proper training of material handlers and by getting good data on the costs of the damage due to materials handling. Factory and warehouse space becomes more costly each year. It is even more costly when reviewed from the standpoint of the dislocations and lost time that occur when a move is made or when plant expansion takes place. MH is a vital part of layout planning, but of equal importance is MH interdependency that is found in both production scheduling and inventory control. The most important of MH project is the safety of the worker. Expert materials handling...
practice requires each job involving the movement of materials to become safe every time it is performed. Efficient MH has following factors: 1) Improves production operations and indirect to direct labour handling ratios; 2) Reduces damage due to MH and maximum space utilization; 3) Reduces accident rate and severity of injury; 4) Minimizes unit cost and hence minimizes project cost and optimizes quality; 5) Promotes the effective use of people, equipment, space and energy and provides for employee’s convenience, safety and comfort; 6) Controls project costs, archives the production standard, builds flexibility in the plan and reduces or eliminates excessive inventory; 7) Achieves miscellaneous goals to use work cells which will reduce inventory and material handling and to build visual management system into the design to improve factory management; and 8) To design for first-in-first-out inventory for inventory control.

**Role of Material Handling Systems in Industry**

MH engineering automates materials movement at all stages of the economy. In hard goods manufacturing industries, the complexity of MH operations has been approached in a list of statement handling oriented productivity improvements. This pattern has matured into automated flexible manufacturing system (FMS) and the integrated manufacturing system (IMS) or automated factory. Conveyors and automated vehicles move warp beams, quills bales and cloth rolls in the basic mills. Robots pick spinning frames and tie yarn. Automated system operates the dying and printing of cloth. Computers control looms and direct weaving patterns. It has also control on sewing machines. Automated monorails are being used to move, work stations in garment factories. The flexibility of computer control has again permitted application of MH automation in a very random scheduling environment. Manufacturing material handling automation has been the result of the programming control technology.

**Classification of Available Material Handling Equipment**

MH equipment is broadly classified into 5 major categories (Table 2) as follows: i) Transport; ii) Positioning; iii) Unit load formation; iv) Storage; and v) Identification and control.

**Application of Material Handling System**

MH systems are having greater applications in the manufacturing engineering industries like mechanical, metallurgical, chemical, automotive and in aerospace industries, and used to handle heavy weight components in the assembly workshops. Some of the important engineering operations requiring MH systems are arc welding, metal coating, metal bending, metal sealing, plasma cutting operation, assembling operation, palletizing, packaging, measuring and inspection, spot welding, pressure joining and riveting, laser welding and cutting, water jet cutting, deburring, polishing and grinding, paper manufacturing industries, metal casting industries, heat treatment industries and rolling mills.

**Classification of Material Handling Equipment Selection System**

Recent advances in the development of MH equipment selection system have affected most of manufacturing industries. Handling equipment is used for movement and storage of materials within a facility or at a site. MH is classified into categories such as transport, storage and identification and control equipments. Each class of this handling equipment is used for a particular application, which...
mainly depends on the mass and size of the handling material. Transport equipment is used to move the items from one location to another. Some examples of transport equipment are conveyors, cranes, and industrial trucks\(^48\).

**Software Package and Expert Systems for Selecting Appropriate Material Handling Equipment Systems**

Various researchers have developed different MH system selection software packages (Table 3)\(^15, 18, 48\). Principles involved in MH equipment selection expert systems are as follows\(^49\): 1) Planning; 2) System; 3) Material flow; 4) Simplification; 5) Gravity; 6) Space utilization; 7) Unit size; 8) Mechanization; 9) Automation; 10) Equipment selection; 11) Standardization; 12) Adaptability; 13) Dead weight; 14) Utilization; 15) Maintenance; 16) Control; 17) Performance; and 18) Safety.

**General Methods Available for Material Handling Equipment Selection Programme Development**\(^16, 50-54\)

The following methods are available for developing the handling equipment selection software program: i) Mixed integer programming; ii) Hybrid knowledge-based optimization system; iii) Weighted evaluation method; iv) Expected value creation; v) If-then rules; vi) Analytical hierarchy process and dividing weight; vii) Rationalization procedure; viii) Fuzzy multi-criteria decision-making methods; ix) Fuzzy information axiom approach; and x) 0-1 integer programming formulation.

**Simulation Models and Industrial Engineering Aspects on Material Handling Equipment Selection**

Stochastic simulation, systems simulation or just plain simulation has come to mean the technique of preparing a model of a real-life situation and then performing a series of sampling experiments upon the model\(^55, 57\). Observing the behaviour of the model then forms the basis for predicting the behaviour of the real-life situation- and subsequently it is useful in controlling the real situation\(^58\). Simulation models may be classified in several different ways according to how closely they appear to typify the real situation\(^59\). Models that include all the characteristics of the real situation are called as isomorphic. Simulation models are further classified as:

**Iconic Models**

Iconic models appear similar to the subject of inquiry, and are characterized by the use of some metric transformation or scaling. Such models (globe, still photos etc.) describe static or dynamic things at a point in time.

**Analog Models**

Analog models are characterized by the use of a convenient transformation of one set of properties for another set of properties in accordance with certain specified rules\(^60, 61\). Such models are flow charts, schedule boards, plant layouts, etc.

**Symbolic Models**

Symbolic models are characterized by the fact that the components of the subject of inquiry, and the interrelationship among them, are represented by symbols, mathematics and logic\(^62, 65\). In order to identify the particular homorphic, symbolic model used in systems simulation, one more stratification is required. This is done by the solution mode numerical methods and Monte Carlo methods.

**Conclusions**

Appropriate selection of material handling system reduces rework, time and increases the production effectiveness by increasing the profit and application of expert systems in the manufacturing engineering industries. Material handling system helps to choose

---

**Table 3**—Existing software package and expert system

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Software package of expert system</th>
<th>Year</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SEMH (Selection of equipment for material handling)</td>
<td>1984</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Prototype expert system for industrial truck type selection</td>
<td>1987</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>MATHES (Material handling equipment selection expert system)</td>
<td>1988</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>MAHDE</td>
<td>1988</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>MHES (Material handling equipment selection)</td>
<td>1989</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>MATHES II (Material handling equipment selection expert system)</td>
<td>1990</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>EXCITE (Expert consultant for in plant transportation equipment)</td>
<td>1990</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>EMHES (Expert system for material handling equipment selection)</td>
<td>1992</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>ICMESE (Intelligent consultant system for material handling equipment)</td>
<td>1996</td>
<td>48</td>
</tr>
<tr>
<td>10</td>
<td>MASHES (Material handling selection expert system)</td>
<td>1997</td>
<td>48</td>
</tr>
</tbody>
</table>
exact handling equipment based on the variables like weight and size. Expert systems software can be developed and they vary on the principles, models and the solution methods.

Acknowledgements
Author thanks the Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, Malaysia for encouragement to publish this paper.

References
35. Lambert W, Integrated transport systems for high-tech component cleaning and drying, in Conf Automated


38 Allegri T H, Material Handling (Van Nostrand Reinhold company, New York, USA) 1984, 21-22.


47 Cox B, A technique for identifying the logistical importance of material handling technology within an organization, in Conf Automated Materials Handling, edited by R H Hollier (University of Birmingham, UK) 15-17 May 1985, 24-28.


