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Review on Performance Improvement of AS/RS by Implementing Various Techniques for Industries

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ABSTRACT

Automated storage and retrieval system has been invented for easy storage and retrieval of products from inventory location with the use of computer. It is the task of an engineer to develop an Automated storage and retrieval in such a way that it can cop up with daily industrial challenges. Automated storage and retrieval is part of flexible manufacturing system. It is a manufacturing system in which is offers flexibility that permits the system to react for changes, whether predicted or unpredicted. In this paper we will explore use of automated storage and retrieval system and review the methods used for performance improvement of storage and retrieval system. To review this research area, we will discuss the following topics: storage methods, new technologies, logical and analytical methods.

KEY WORDS: Automated storage and retrieval system, computer vision, robot control technology, expert system, Storage allocation, wire robot.

1. INTRODUCTION

The function of storage system is to store and retrieve inventory whenever it is required. Inventory contains raw material, semi-finished, finished products. Their physical properties, frequency of their usage and quantity may differ, so that it is required to sort them. Performance of storage system is recognized by parameter such as, Storage capacity which is measured by volumetric space available or no of compartments for unit load, Storage density is the ratio of available volume for storage to total volume in warehouse, Accessibility is easiness to access. Throughput is rate of storing and/or retrievals per hour. Utilization and reliability are related to ASRS. There are two storage location strategies. First is randomized storage which involves “first in first out”. Second one is dedicated storage which tells about each stock keeping unit which is allotted to the specific location. Material handling and storage is auxiliary system which supports production but it does not add any value to product.

Conventional Storage Methods are of four types. First is Bulk storage, which stores materials in open floor area. Second one is Rack systems, in which loads are stored vertically without the support of unit loads below them. And Shelving or bins are the cantilever structures which support the unit loads on horizontal platform or boxes/buckets for loose items respectively. Last one is Drawer storage, which is a box like structure, used for storage of parts which are frequently used.

In the conventional system, manual labor is more focused and it takes more time for storing and retrieving the items. Since, it is ambiguous to find the location of the load for human. If the quantity of storage is more, then it is inconvenient and laborious in manual labor system. Human physical limitation is one of the important drawbacks of conventional system which also includes their safety. Hence, most of the industries recognized the need of Automated Storage and Retrieval System.

An automated storage and retrieval system contains variety of computer-controlled systems which is used for automatically storing and retrieving loads from specified storage locations. In ASRS system large number of loads are transferred from one location to other and retrieved from specified location. Since Accuracy has importance to avoid damages during load handling for that ASRS plays important role The system is controlled and monitored by computer and also maintains an inventory of stored items. In ASRS, very few and specific input information is required for Retrieval of items. The computer recognizes location of stored items and schedules the retrieval. It gives input of location to the automated storage and retrieval machine (SRM) and also gives the signal to the machine to deposit the item at a location where it is to be picked up. For material handling AS/RS uses a system of conveyors and or automated guided vehicles.

Figure.1. ASRS Process line diagram

Automated Storage/Retrieval System (As/Rs): Mainly rack structure is used for automatic storage and retrieval system. Load units are maintained vertically and horizontally. The motion of SRM for storing and retrieval is along X, Y, Z coordinates only. There are various types of AS/RS available in industry, some of them are explained below. Unit load AS/RS- It means handling of various loads at a time by converting them into single unit using material handling equipment. Horizontal carousel system-It can be operated manually or with the aid computer controls which

allows to perform various activities regarding material handling and storage. It takes less time for delivery of product to the operator, also occupies low-floor for storing and retrieving .Vertical carousel system- It is similar to horizontal carousel system but it moves in vertical loop. Mini load AS/RS -It typically handle loads, cartons or other small containers, by saving space and delivering product to order operator, assembly operations, and various other work in progress groups. Mini-load systems save space and also increase efficiency. Man on board AS/RS- Human operator rides on the carriage to pick individual items from storage. It provides floor space savings over manual or fork lift operations but it is not fully automated SRM. It is mostly useful for less consuming items where space is moderately extortionate. Vertical lift storage modules are mainly used to utilize overhead space. In a facility VLMs occupy less floor space, also increases labor productivity and improve worker ergonomics.

The advantage of ASRS are improvement in storage capacity, storage density also for recovering factory floor space currently used for work in process security and to reduce continuous theft of small items in company, reduce labor cost and/or increase productivity, to improve safety, to improve inventory control, stock rotation, customer service. From the above, because of advantages of ASRS over manual system, ASRS has widely used in different fields such as manufacturing industries, foods, libraries, hospitals, retail distribution sectors, etc.

This review paper is divided into three sections. It focuses on Technologies that have been already implemented for efficient working of AS/RS in industrial environment. This Paper further deal with various types of problems rose during the working of AS/RS & different methods for solving them. It also involves various ways to implement AS/RS for industry.

There are many technologies which are associated with ASRS .But this paper emphasizes on flexible AGV, Computer vision & Robot controlled technologies, Barcode & RFID (Radio Frequency Identification) and Bluetooth technology. Various problems faced by the industry during working of AS/RS have been solved. Problems regarding design, rusting of components, sequencing and scheduling of loads, routing of cranes & AGV and inventory control are discussed. Solutions for these problems had been found out by using various methods some of them are Genetic algorithm & Expert system. Further low cost implementation of ASRS for small scale industries has been discussed in detail with the use of ERP (enterprise resource planning). Also applications of ASRS for Manufacturing assembly lines have been studied.

This review paper explores and concludes the existed considerations of AS/RS. It is very beneficial for further research and understandings of the system.

Problem definition and techniques to solve it:

Design problems in automated warehousing: Edward (1986), discussed the problems aroused in the design of automated warehousing. In this paper author tried to find solution for ubiquitous problems get ups during designing of an automated warehouse and to discover analysis techniques for dealing these problems. Miniload ASRS is selected because problems related to it are most common. Also this paper summarizes that design problems in automated warehousing comes under two categories. First is physical configuration and another one is operations strategy in design. Physical configuration design problems consist of shape and size of the system, number of input/output points and interface of material handling .Operational strategy design problems consist of hybrid storage, Distribution of activity in automated warehousing system and balancing of man-machine system.

Operating an Automated Storage Retrieval System: Paolo Serafini and Walter Ukovich (1988), explored the knowledge of operation ASRS. This paper mainly focuses on optimal operation of ASRS in real industrial environment. Also explains the system and problems associated with it. Routing problem of carrier is discussed in detail. This paper was impelled by experience of author in automated warehouse in industrial environment. There are various standards that can be adopted to estimate the performance of ASRS. In this author has considered standard of time required to perform a complete storage and retrieval operation. Also he has classified the factors affecting the performance of ASRS in broad category such as static and dynamic .Assignment problem and routing problem is explained in detail. Further solution for the delay in retrieval is found out by using simple mathematical formulae and SET theory then by using algorithm considerations.

New S/R mechanism for high loads in ASRS & its Travel time analysis: Hu Yahong (2003), presented new Storage and retrieval (S/R) mechanism for handling heavy loads. Also travel time model is mentioned for reducing travel time. Finally, it is validated by computer simulations. In this mechanism, storage and retrieval mechanism has one vertical and 'N' horizontal platform for serving N rows of AS/RS rack. After separation of vertical platform from horizontal platform, vertical platform can have higher velocity. By this way, travel time will decrease. Also, high lifting capacity can be achieved and more flexible AS/RS rack configuration design is possible. Hence, downtime of machine got reduced.

Scheduling rules for ASRS on the basis of Genetic algorithm: Wen Wang (2007), proposed a solving method to obtained scheduling rules for ASRS on the basis of Genetic algorithm. There are various methods available for solving optimization and scheduling problems of AS/RS such as Petri net, Expert system, temporal logic, Neutral Network and Genetic Algorithm. This paper also solves loading-unloading laneway AS/RS problems. These

problems are very tough to solve because of their uncertainty, Complexity and characteristic of multi object & multi constraint. By using decision optimization method integrating analytic hierarchy process (AHP), Adaptive function value is obtained. In this paper, for calculating the fitness value of Genetic algorithm scheduling problems, Integer coding and analytic hierarchy process are used. Also the practicability of genetic algorithm in selection of AS/RS scheduling rules is anatomized by explaining an example. By seeing final results it can be conclude that discussed methods are very much appropriate for these problems.

The scheduling problem for square rack on the basis of set theory for ASRS: Felix Lee (2006), studied the scheduling problem for square rack on the basis of set theory for ASRS. In this paper author has taken a generalized problem of sequencing which determines the location of specific bin for retrieval and sequencing with chosen location of bin. For solving this problem, heuristic methods with their present computational results have been introduced. Author has also obtained the cycle time distribution with mean values for single command applicable squared racks. Experimental results obtained, clearly specify that retrieval set consideration, reduces the time of travel of storage and retrieval machine .Thus increasing the efficiency of ASRS.

Improvement for job scheduling and storage management on Expert System: Zeng Mingru (2009), presented method to improve the efficiency of ASRS by optimizing storage management and job scheduling based on expert system. He has considered the experience of experts of various fields based on their knowledge.

Interference engine of ASRS search knowledge to achieve purpose of solving the problem. In this, experts have made one program based on their experience. For the testing of expert system, two programs are taken into consideration. One of them is random and another is the program based on expert system. After results it is concluded that the expert system optimizes the storage management and job scheduling. Also it takes less time for ASRS.

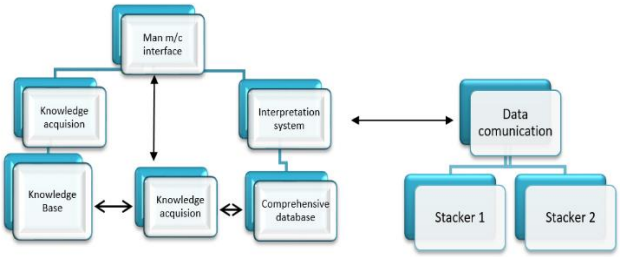

Figure.2. Structure Diagram of ASRS based on Expert

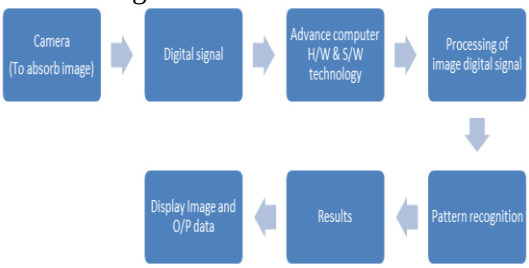

Figure.3. Process of Robot vision technology

Technologies associated with ASRS:

Study of computer eye (vision) and robot control technology incorporated with ASRS: Chengxin Yu (2007), explored robot technology applications and computer vision in ASRS. Because of that automatic positioning and recognition of goods is possible. In this, technology is compared with some human body parts. Computer vision is substitute for human eye, also Computer's processor is used in the place of human brain. Computer vision involves picture obtaining, processing, analysis, output and demonstration. There are three methods to control Robot. a) Word recognition, b) Demonstration reappearance, c) High level programming language. By implementing computer vision and robot control technology, operating efficiency of logistics ASRS has been increased considerably.

ASRS with Wireless Communication: Rashid, proposed wireless communication in ASRS. This can improve existing warehouse management system which costs more, also takes more time. Paper has presented that the communication between computer and PIC is done by wireless technology. For the motion in X, Y, Z axis respectively. Three DC motors are installed. Experiment with prototype is done to check results. This system is mostly demanded in large scale factories such as Automobile and mass production industries as it reduces cost and time consumed by handling.

The strategies of dead lock detection and avoidance for ASRS: Mariagrazia Dotoli and Maria Pia Fanti (2007), explored the strategies of dead lock detection and avoidance for ASRS. This paper focuses on control of AS/RSs serviced by rail guided vehicles for avoiding deadlocks and collisions. The formal analysis of deadlock states gives two deadlock resolution strategies for AS/RSs. The first strategy is a DA strategy for avoiding deadlocks governing the system events so that the necessary conditions for deadlock cannot be verified in any reachable system state. The second strategy is a DDR strategy, which follows the digraph theory to detect deadlock states and restores the system operations by means of a recovery procedure. The comparison indicates that the DA strategy always provides better values of throughput and vehicle utilizations with respect to the detection/recovery strategy. Moreover, the avoidance approach does not require the additional buffer space near each retrieval system. The obtained results and the simulation study can be very useful in the field of deadlock resolution strategy applications.

Growth of ASRS in Dynamic Industrial Environment: Farah (2015), has improved efficiency of ASRS in Dynamic Industrial Environment with the use of microcontroller, Bluetooth technology and servomotor. Also they

improved Productivity and quality hence better performance of this system. In this system, it communicates with each other as shown in Figure.4. Computer supervisory control is used to store and retrieval of items.

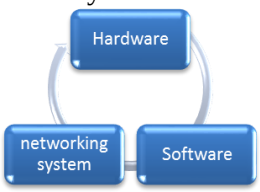

Figure.4. Communication with different parts of system

Task of identifying Product can be investigated by using RFID (Radio frequency Identification) or barcode system. By using Microcontroller Arduino UNO, Bluetooth technology and Servomotor, system gives high performance. Also it takes less time. Just in time production is followed for development of ASRS.

Application barcode technology in AS/RS: Vishwanatha Rao (1996), explored the application barcode technology in AS/RS by explaining barcode labels, Sybologies and reader. There are different technologies, available for controlling the management of goods in industry such as Radio frequency Identification System (RFID), Optical Character recognition (OCR), Magnetic stripe, Data code technology and barcode technology. Barcode technology provides computer vision to get control of management of logistic cargo and industrial goods. Bar coding can be defined as method of labeling with bars and spaces printed side by side on the good .In this author has first given the idea about barcode labels generating methods and contact & non-contact type barcode readers then explains about the application of barcode in ASRS. Since the author and his colleagues are working in BHEL, implementation of barcode technology at BHEL is discussed with example.

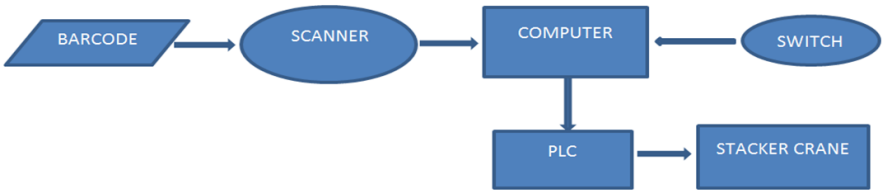

Figure.5. System Layout

Problem of bearing rusting due to long time storage: Shu-an Liu (2011), find solution to avoid rusting of bearing during storage by optimizing model. For this multi-objective optimization model is used for reducing the rusting of bearing in storage and also reduce energy consumption during stock in. There are several methods are used to archive this objective like “shortest storage time”, “shortest distance”, “least gravity center”, “first in first out”. Different industry follows different methods. In this paper Author first define “Satisfaction level” of rusting which considers different atmospheric conditions, storage location conditions. Which give rusting time and storage conditions. In this paper for simulate the study storage allocation for “stock in” and “stock out” model are formed. There are two ways are used one is “special chromosome representation” and other one is “one-point mapping based crossover”. By successfully implementing Genetic Algorithm for the automated storage and retrieval system the problem of rusting of bearing in storage before utilization is minimized. Further the author proposes the study of flexibility of storage equipment for different storage system arrangement.

Problem of scheduling of 2 crane on one aisle: Henri and Esko (2015), presented study to solve the problem arise due to the use of 2 cranes in storage, which have common rail. Due to the common rail they have restricted motion. This paper present the scheduling study for retrieval items to output station. By considering 5 type of scheduling restriction the best way of IP/OP locations are analyzed. These restrictions are as “fixed sequence”, “free sequence” and “no interaction”, “own area”, “free scheduling. These areas of restriction are analyzed by local search algorithm. Result of study found that no interaction strategy perform better than free scheduling, and free scheduling is perform better than own area scheduling. Considering the input/output location the own area gives worst result if input/output station locations are away from actual storage. The own area and free scheduling give same result if input/output station location is at middle. In comparison between free scheduling and no interaction scheduling both don’t affected by location of input/output station location.

Wire based storage system: Christian Sturm (2013), implement wire based storage system to reduce energy consumption during the travel of robot/crane in automated storage and retrieval system. This project is lead by 8 industrial partners also “Chair of Mechatronics” and “chair of technical logistics”. As in many storage system there is aisle used to moment of crane. In which the motion of crane is can be possible along the rail and in vertical direction. Also due to heavy weight and rigid structure of crane there is restriction to vertical distance travel. But in wire system different size of pulley and wires are used. The advantages of this system are: Weight of designed system is less, No restriction for moment in any direction as conventional crane has, Mechanical component used are simple.

This paper provides information about what type of component should be used and position of different pulleys i.e. modeling. Compare to system which contain rigid linkages the system with the flexible linkages (wire) is more energy efficient. And this proved by simulation by considering parameter for different systems like "conventional", "wire robot without counter weight", "wire robot with counter weights", " counterweight and spring".

Implementation of ASRS for industry:

Scalable less cost automated Storage & retrieval system: Dimitrios Bargiotas (2009), designed low cost ASRS and developed it for small and medium scale industry. For this purpose, market survey is carried out. Also old existing system is analyzed for determining the specification of new ASRS. Process involves motion based on 3AC motors, one for each X, Y, Z (Controlled by programmable logic controller).Invertor and incremental encoder controls the X & Y motor along length and height of rows of shelves. According to the existing ERP, control software and human m/c interface are designed. Also prototype is made for shelf system and construction of demo version which is proposed, is made for scalable low cost ASRS.

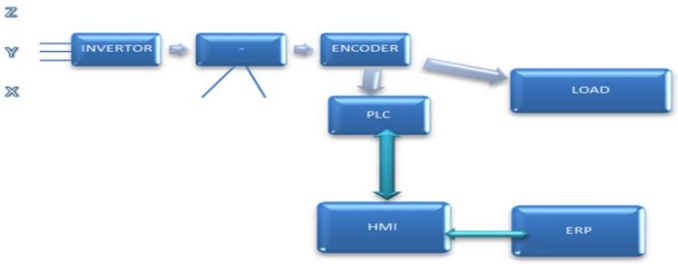

Figure.6. Proposed System

By using this, Scalable low cost ASRS can be implemented in medium and small scale industries.

Optimize sequence of operations: Rolf Dornberger (2014), implemented this study to optimize the sequence of operation, paper considers multi-aisle system of ware house with single ASRS system. Purpose of study is to check ability of system to pick the items in different location efficiently. The paper objective is accomplished by application of genetic algorithm. "Open-Opal" software is used for simulate and optimization study. The results of this paper are divided into 3 parts "Analysis", "Implementation", and "Evaluation of implementation". As many papers also suggest optimal picking sequence but this paper is focus on more than a few storage locations in same storage facility.

Scheduling of pallet shuttle: Xiaofeng Fu (2015), implemented the study to improve scheduling of pallet shuttle in high-density-storage system. Also increase efficiency and utilization rate. Automated storage and retrieval vehicles (ASRV) are very important due to high density storage in ASRS. In ASRS pallet based handling of material is used. In order to manage the multiple vehicles in system it is required to schedule them. In this paper the "offline vehicle routing" and "online vehicle routings" are studied. In offline routing the A algorithm is used since it is efficient. This algorithm provides the shortest path for travel. In online scheduling there is some buffer is provided. Vehicle can parked at that location and it will be released on authentication. By applying this method ASRV's are utilized efficiently. Also author claim that the utilization rate archived is more than 98% for appropriate number of ASRVs.

System to find optimum travel time of platform: Bashir (2011), developed the system to find the dimensions and size of warehouse for given load size. First the sample modeling of "stewart-gough platform" is done. Travel time of platform is considered for the optimization parameter. By creating design of ASRS the individual storage space is calculated and throughput is found out. Single and Duel command cycles time is measured by considering assumptions and following some step-by-step procedure. The 3 case studies are performed by author. There results show that the use of the suggested optimization system give specific cycle time which is minimum, for the given unit load and input parameter. Other than these cycle time design of ASRS will not give the optimal result.

Improvement of ASRS for Manufacturing Assembly lines: We-min Chow (1986), described the work-in-process management policy with AS/RS. Also line design concept is added with AS/RS. Description of development considerations for AS/RS and logic for that is mentioned in the paper. For identification of key performance parameters, evaluation of design alternatives and for comparison of various dispatching rules, queuing and simulation models are prepared. By using these concepts, life of material handling equipment has been increased considerably.

2. CONCLUSION

This paper deal the recent trends of AS/RS in industry. It helps the researchers to understand different views stated by the researches on AS/RS and its trends in industrial environment .This review paper also gives solution to the various problems that arise during implementing the AS/RS in CIM environment. For the improvement of efficiency of production, industries need the knowledge of AS/RS. This study is quite helpful. We have discussed the problems regarding AS/RS and solutions for it. Further we reviewed the technologies and its implementation techniques.

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