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Development of Automatic Storage Retrieval System for Variable Loads

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ABSTRAK

Sistem Pengambilan dan Penataan Barang Otomatis (Automated Storage and Retrieval System /ASRS) telah banyak digunakan dalam sistem pergudangan untuk mempercepat dan menghemat ruang penyimpanan serta menurunkan biaya. ASRS merupakan sistem yang terintegrasi yang dilengkapi dengan controler dan mesin pengambil untuk pengambilan dan penyimpanan barang serta database. Tulisan ini membahas tentang hasil pengembangan sistim pengambilan dan penyimpanan barang untuk beban yang bervariasi. Elemen pengambil terdiri atas mekanisme untuk mengambil, meletakkan serta aplikasi untuk mendatakan kedalam database. Dalam penelitian ini dilakukan perancangan dan pengembangan ASRS untuk diterapkan dalam penyimpanan produk dengan berbagai ukuran. Proses pengembangan mencakup akan investigasi dari fitur-fitur yang sudah ada dalam ASRS, prosedur pengoperasian, pemilihan hardware serta pengembangan software yang sesuai dengan mekanisme yang dirancang. Pengontrolan numerik yang menggerakan elemen pembawa dengan resolusi tinggi diterapkan untuk bisa menempatkan beban dalam posisi yang berubah. Pengembangan dan pengujian dilakukan untuk memastikan kinerja alat berjalan dengan baik serta data-data penyimpanan yang mencakup akan identifikasi dan ukuran beban bisa dicatat dengan baik.

Kata kunci: ASRS, CNC, Inventory Controls, Database

ABSTRACT

Automated Storage and Retrieval Systems (ASRS) have been widely used in warehousing systems to speed up load movements and save storage space. ASRS is an integrated system that is equipped with a controller and arm for the collection and storage of goods. This paper discusses the results of developing a system for taking and storing goods for various loads. The prototype element consists of a mechanism for retrieving, placing and application for data collection into the database. In this research, the design and development of ASRS was carried out to be applied in the storage of products of various sizes which is suitable for small size industries. The development process includes investigating features that have been developed in the ASRS, operating procedures, hardware selection and software development in accordance with the mechanism designed. Numerical control which moves the carrier element with high resolution is applied to be able to place the load in a changing position. Development and testing is carried out to ensure the performance of the tool runs well and the data storage that includes the identification and size of the load can be recorded properly.

***Keywords**: ASRS, CNC, Inventory Controls, Database*

Introduction

In a dynamically competitive world, Warehousing with Automatic Storage and Retrieval Systems (ASRS) in material handling plays a very important role to move the materials or products of manufacturing companies. ASRS optimizes the utilization of floor space up to the full height of the warehouse, with minimal aisle space. As a system automated by computer-controlled automated warehouse management system, investing in ASRS is an attractive solution for improving the operational efficiency and accuracy order.

The literature review outlined a comprehensive explanation of the state of ASRS design in decades [1]. Various problems such as system configuration, estimated travel times, storage assignments, dwell-point location, and order of requests where discussed. The majority of the models and solution methods reviewed apply to static scheduling and design problems and propose an increasingly dynamic ASRS to be developed to overcome computational time. Improvement of the

model will help increase competition in the market and customer retention rates. In addition, the ease of operation and flexibility of the ASRS system attracts attention to implement it wider industries size.

Automatic storage and retrieval systems have been developed from a variety of computer-controlled methods for automatically placing and taking loads from determined storage locations. Application of the Automatic Storage and Retrieval Systems are usually used in a very high volume of cargo transferred into and out of storage. Storage density is important considerations due to space constraints. Actually, the is no value added to the content of product in the present process, however accuracy is important factor because of the potential cost of damage during loading.

Various applications of the ASRS system has been designed for storage and retrieval automatically. Applications mostly done for large companies in manufacturing, good distribution, retail, and wholesale. Development for synchronizing transportation between buyers is developed with a heuristic solving approach that can be applied to medium / large size supply chain networks in order to reduce total cost [2]. The different dimensions of the product being transported are not explained.

Its application is suitable for six-sigma, lean manufacturing, sustainable, Kanban or Just In Time production and other various processes. Apart from that, the development of a retrieval system for educational purposes was also carried out [3].

Saving the space and increasing some productivity and accuracy and decreasing inventory levels is key benefits of the system. Other benefit of ASRS including increasing material flow and warehousing control, saving in the use of space, increasing security and investment turnover. The operational aspect of conventional warehouses is labor intensive with limited use of machine. ASRS relies heavily on both software including warehouse management systems and hardware such as storage and retrieval machines, and automatic movement systems to operate.

In the several literatures can be found that many automated retrieval systems discussed by many authors about technology of the design. A comprehensive explanation of the current state in the design is provided for various problems such as storage assignments, system configuration, travel time, location of residence points, and system performance [4][5].

Many of the models and solution methods reviewed only apply to static scheduling and design problems. However, the requirements for dynamic automated retrieval systems are increase where new models need to be developed to overcome to computational time, load variations, and better system performance.

Studies for optimal shelter point policies for an evenly distributed storage / retrieval system with shelves are developed with closed form solutions [6]. Here also introduces the optimal occupancy point for various types of transaction requests for return routes to the stationary point for efficient storage / retrieval operations.

The most of the design and control problems is in a static environment. However, in rapidly changing of customer demand, small volume orders, tight delivery schedules, high competition and high service level requirements, it require a performance solution with dynamics techniques. Research in the field of automated storage and retrieval systems now continues to move towards developing new models that are applicable to small industries where have the variability of loads.

Research Method

Methods that aim to develop new skills or new approaches and are applied and evaluated. The method used is to develop and test a prototype ASRS system that can be programmed to be positioned in a variety of locations integrating numerical control and data communication using a database.

The reliability of the system is tested by conducting repeated experiments with data collection related to the accuracy of data placement and data recording. Numerical control is used to position the rack which includes Stepper Motor equipment, Drivers and Positioning Software. This numerical control is widely used in CNC machines where tables or tools can be moved in precise coordinates below 20 microns. The shelves are designed so that they can be positioned according to the size of the object to be placed.

Besides being used as a tool for placement and retrieval, the control system also functions as a changer for the size of each shelf.

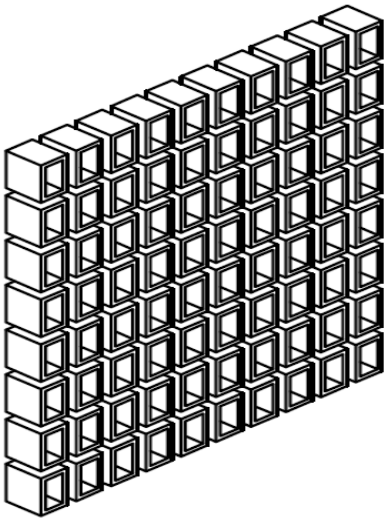

Figure 1. Regular Inventory Model

Shelf positioning for the horizontal direction uses the same location code as the CNC machine. For example, moving a rack by 100,200 mm is carried out with the command X100.200F300. The purpose of using a control like this is to be able to change the speed parameter to the most appropriate as well as more accurate positioning for various locations.

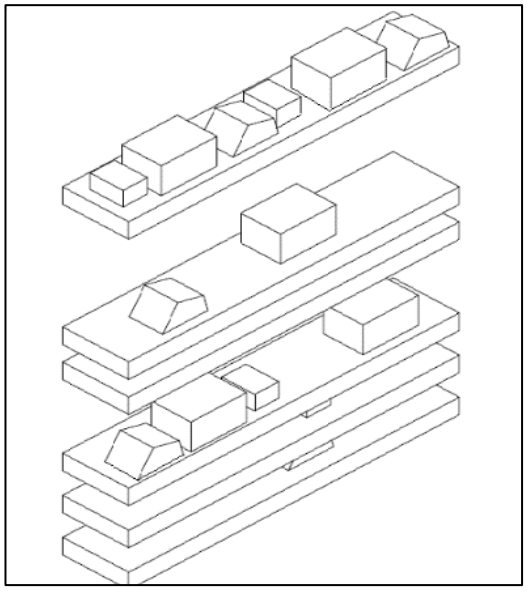

Figure 2. Propose Inventory Model

With this method, the designed equipment can position the pick-up rack with an accuracy of up to 20 microns, so that the placement objectives for various loads can be set in various sizes. A network accessed database is created to record the location and items placed along with other additional data.

Inventory Design Model

This paper introduces an idea and prototype to develop flexible warehousing tools that can store goods of various sizes in a set of shelves. The design starts by creating a design drawing using a CAD application as shown in Figure 3 and Figure 4 respectively.

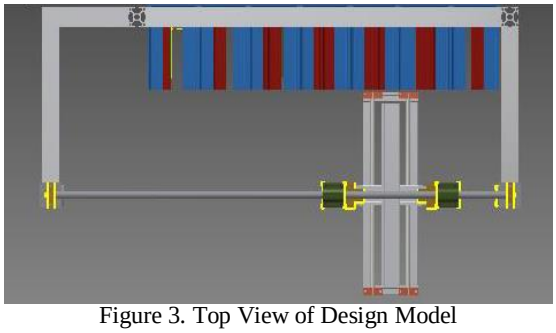

Figure 3. Top View of Design Model

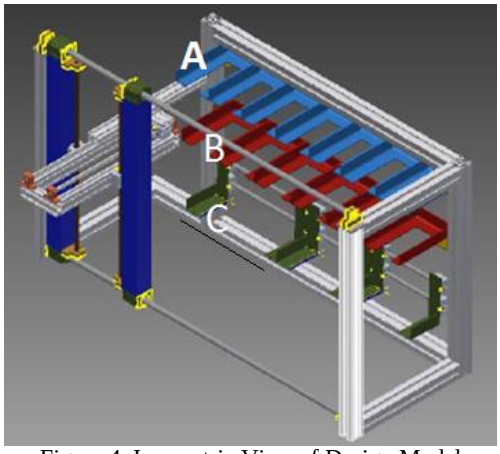

Figure 4. Isomentric View of Design Model

The design has been developed to be able to store loads in various sizes. The design is made with 3D CAD for simulation. The design model in this prototype was made for storage of loads of two different sizes in two shelves A and B. While other additions on the 3rd, C shelf are designed for spaces that can be resized. With this method, it is targeted that various variations in load size can be placed in a series of rack arrangement. This concept is suitable for industries of various product sizes. he function of the software is to integrate with Control and the database. Applications using visual basic are developed. Serial communication with the control system is carried out through the transmission of numerical data movement of the take-up element.

Software and Database

The function of the software is to integrate with Control and the database. Applications using visual basic are developed. Serial communication with the control system is carried out through the transmission of numerical data movement of the take-up element. Transactions will be saved into the database every time a collection and retrieval occur. The following figure shows the sequence of instructions that were executed for taking or storing loads.

To update the data storage is done through a database connected via Internet communication. The database update command is given in SQL language. The database contains product item data as well as storage locations. Besides that, in the database is also stored numerical code movements whose value can be changed according to needs.

Control System

The control system used is a mechanism that provides varying movement to the arm. Various control models are used in the system, the most commonly used is a combination of PLC and microcontroller. The PLC based system controller is

developed with Human Machine Interface screen. The rack number for storing or retrieving operation the stacker crane controller senses the row and column using heavy duty limit switches[8]. The use of limit switches reduces the accuracy of the movement of the crane which can only move in step distance between switches. The remote control of ASRS by RF module where developed to stores or retrieves according to the input from user end. In remote controlled ASRS, The system uses a software stored in a PC and communicated through Internet Network [9].

For the proposed model, movement resolution is designed to be able to move the width of the compartment by 0.05 mm. The purpose of the design is to be able to adjust the movement steps for various product sizes. Control by giving pulses of movement is done to command movement through a servo motor or stepper. The control element consists of a motor, driver, controller and power supply. Inputs for collection and placement are done via barcodes to get the load specifications that will be processed.

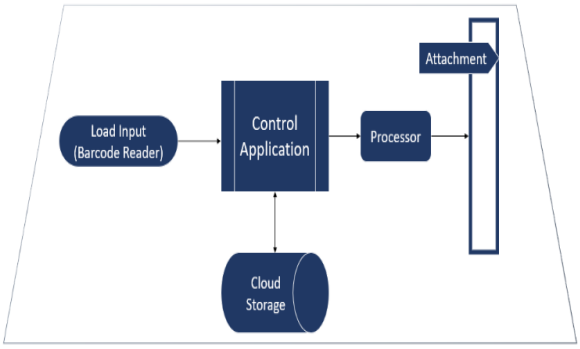

Figure 5. Network Interactions Between Elements

Figure 5 shows the interconnection network of elements of the design sub-system. Application control is central to the system's settings. Load to be processed is entered via a bar code reader. The barcode code is matched with the data base to find out the size of the load. The use of barcodes has been introduced by previous studies [10]. For the proposed models, barcodes reader is used to identify part number directly from part to be stored.

The positioning code is generated to direct the take arm to the destination position based on data information stored in database. Position code is transmitted to the processor to further distribute the driving pulses to each rack driver motor.

Results and Discussion

The results of the development of this prototype are shown in the picture Figure 6 .The top level of the storage rack is used for small loads. Furthermore, the second layer is for large size storage. The bottom layer is designed for placement with varying sizes. The size of the rack for storage varies according to the storage arm by sliding the width of the compartment towards shrinking or enlarging according to the load placed. The location and size of the rack that is moved is stored in the following database with the item code stored.

The movement of the rack size was successfully carried out by giving position commands with smallest division steps movements. The use of components that can be obtained locally allows this tool to be produced at a lower cost.

Figure 6. Prototype of The Take and Storage System

Placement and Retrieval

Placement and retrieval is done by entering the part code through a barcode reader. The barcode reader retrieves location data from a database. From this location data then a movement code is generated according to the position of the part. The coding and data retrieval process can be done well.

Setup Storage size

The storage location preparation is done by entering the load size data via barcode. The take-up arm moves the rack to increase or decrease the size according to the size of the load to be stored.

For further improvements, In this prototype still needs to be modified and tested by adding a lock for each rack that is resized so that it does not move due to vibrations when the system operates.

Conclusion

ASRS with the ability to store varied products successfully developed for applications in industries with high product size variations. The system was developed by using motor control with high precision step. In addition to being used as a storage arm, the take-up is also applied to prepare the placement space according to the size of the load to be stored.

Recording the location of the load and the size of the available compartments that are stored in a database using communication connected to the server is able to enable this tool to be used widely. The use of numerical control modules allows more flexible movement of equipment.

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