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Development of Automated Storage and Retrieval System for Small Scale Industries

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ABSTRACT
Automated storage and retrieval system (AS / RS) are warehouse system that are used for the storage and retrieval of products in both distribution and production environments. In industries AS / RS systems are the main task that designed for automated storage and retrieval of things in manufacturing where their application vary widely from simple storage and retrieval system for small parts to central systems where production, assembly, and manufacturing operations are concentrically located around them. The selection of storage systems depends upon the available space, weight of the items to be stored, and method of storage operation. The performance of AS / RS will be the result for interaction of many complex and stochastic subsystems. In this report a cost effective single asile AS / RS system has been developed with nine storage locations (3×3). The AS / RS system is to place the products objects into its defined locations in storage system and then remove it from the storage system in order to distribute from one place to another place. Here, the pick and place operation is done by robots (i.e., S/R machines) by giving instructions to the robots. The robots perform pick and place operation by given code to them, the code is being implemented in the software called Cprog software version12. In this Cprog software it contains different commands to operate and run the code. In this report it will have all argument that needed to construct automated storage and retrieval system in a survey from which will gives us a highlight about the factors that consider the backbone to build the warehouse. The performance of automated storage and retrieval systems will be the result for interaction of many complex and stochastic subsystems.

Keywords – Automated Storage, Retrieval System, Warehouse, Cprog Software, Subsystems.

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NOMENCLATURE

AS / RS - Automated storage and retrieval system
AS - Automated storage
RS - Retrieval system
X - Depth of unit load
Y - Width of unit load
Z - Length of unit load
L - Length of AS / RS rack structure
T_{cs} ***- Cycle time for single command cycle***
V_y ***- Velocity of S/R machine along the length***
V_z ***- Velocity of S/R machine along the vertical direction***
T_{pd} ***- Pickup and deposit time***
T_{cd} ***- Cycle time for dual command cycle***
R_{cd} ***- No.of dual command cycles performed per hour***
N_y ***- No.of load compartments along the length of asile***
N_z ***- No.of load compartments along the height of asile***

I. INTRODUCTION

An automated storage and retrieval system (AS / RS)—also called AS-RS or ASRS—is a type or genre of warehouse automation technology specifically designed to buffer, store, and retrieve product and inventory on demand. AS / RS technology varies substantially, and can consist of shuttles, cranes, carousels, vertical lift modules (VLMs), micro-loads, mini-loads, unit-loads, or other systems. It is often integrated with a warehouse execution software (WES), warehouse management software (WMS), or other controls. As previously mentioned, automated storage and retrieval systems (ASRS) have been in use since the 1950s. It was used in automotive industry for warehousing heavy raw materials, parts, and end product. The technology was originally designed to handle large pallet loads, known as unit-load. Over years, the technology has been developed and high interactions were introduced to handle smaller and lighter loads in totes, trays and pins rather than pallets, this more compact cargo became known as mini-loads. Both mini-load and unit-load AS / RS use one stacker crane that moves horizontally and vertically, forward and back, and up and down an aisle. 1957 has witnessed the birth of new ASRS technology by the American company White Systems; horizontal carousel. It was designed for office filing applications. Later that same year, Sperry Rand another American company and another two German companies; By the end of the 1960’s, the concept began to grow in popularity, expanding beyond office filing into commercial and industrial applications. The late 1980’s saw the introduction of an entirely new type of automated storage: the vertical lift module or VLM Libraries, on the other hand did not begin implementing the ASRS until the 1970s. The first ever ASRS for libraries was installed in 1969 at Erasmus University, Rotterdam, Netherlands. The system is evidently successful. While in US, the five initial experiment automated storage and retrieval systems for libraries installed in small colleges in the early 1970s, proved disappointing and were decommissioned. The Oviatt Library at the California State University, Northridge is the US’s first successful library Automated Storage and Retrieval System, it installed in 1991. There are numerous benefits and possible objectives may a facility desire to achieve by automating its storage such as to increase storage capacity, to increase storage density, to recover factory or warehouse floor space which is used for storing work in process, to reduce pilferage and provide safety to stores, to improve security, to improve customer service and to reduce labor costs. Implementing ASRS reduces the facility's footprint, hence saves the warehouse floor space and increase the storage capacity. Due to automation of most work, Staff doesn't need to have special skills and minimizing time needed for training, and increasing labor safety. Automation reduces the chances of inaccurate picks. ASRS shows significant increase in productivity and decreases retrieving and storing cycle time. Using computerized database that integrates with the control server offers a good way to count items and provide detailed information about each item; it can even be used to send notification about items that approaches expiry.

The literature study is carried out on the researches of automated storage and retrieval system in various fields. The development of literature review is carried out on the Automating Industrial Robotics task through mechatronics systems. Pressing requirements of improved and enhanced productivity in industrial applications has necessitated deployment of robot to automate tasks. Manipulator based articulated robots for today’s industrial applications vary widely in terms of number of Degree of Freedom (DOF), payload capacity, Range of Motion (ROM), control implementation and mountable configurations

This review represents a comprehensive and systematic review of industrial robots with a focus on their application areas. The study of manipulators for diversified applications has highlighted the need of sophisticated algorithms for their control and trajectory planning [1]. The dominant approach of cluster-based allocation in the literature, which decomposes the travel time minimization problem into a clustering problem and an allocation problem, consists of two sequential steps. In the first step, products are clustered based on their correlation. In the second step, these clustered products are assigned to locations close to each other. Note that optimizing both problems in the decomposition approach does not guarantee an overall optimal solution [2]. Robots essentially have the potential to transform the processes in food processing and handling, palletizing and packing and food serving. Therefore, recent years witnessed tremendously increased trend of robot’s deployment in food sector. According to Jamshed Iqbal Zeashan Hameed Khan and Azfar Khalid expressed about usage of automated robots in food serving comparatively to human interference using sensor fusion, CPS design, HMI, robot learning and training software solutions, vision systems, robot structural re-configurability and operation of robots during maintenance [3].

For multi-robot systems in the context of logistics warehouses, the literature has since been enriched by focusing in particular on the following fields of study: guide-path design, fleet-sizing, vehicle scheduling, positioning, battery management, deadlock management. One of the major problems of logistics warehouses is the problem of fleet-sizing which consists in determining the optimal number of vehicles able to perform all requested tasks in a given time interval with a minimum total cost [4]. . The benefit of carousel systems is low cost because it is cheaper than other systems such as mini load AS / RS. Here in this thesis AS / RS and horizontal carousel system will be considered [5]. The system dedicated Cartesian robot transfers parts between storage cells and conveyer pallets stopped at the AS / RS station [6]. The motion of the vehicle is one of the main points should be taken into consideration within working on the design of the (ASRS), it is a change in location or position of an object. Moving an object to a position require a two-dimensional surface of knowing the trend, and be movement by using the format in which the system is used to determine the dimensions of the Place through the axes (X, Y). It can also three-dimensional place through many relationships Between The axes (X, Y, Z), and the motion is divided into many classifications which will show the techniques of how the (ASRS) will be moved from point to point, and then will show also the techniques of rotating the to allow it to move from forwarding path to backward path or in another word how to move the form any path directing to any station to the main station [7-13].

II. METHODOLOGY

This research analysis and literature review set out the need of an automated storage and retrieval system which could work on its own with minimum human interventions also a conveyor belt system for transmission and pick and place objects and sorting and segregating of objects like ideas were proposed by different experts in their researches made the team curious to go in more depth of the concept so our team decided to design one such model which can pick and place objects from conveyor belt which itself is made automated which can start and stop on its own for that we collected data we sensed that different sensors and micro controllers will be required like ultrasonic sensors to stop conveyor belt as soon as a product encounters it and then a robotic arm will come to pick an object and place it in a predetermined position in storage locations. We analyzed different methods and different perspective of authors of robotics and considering the workspace we decided the manipulators attributes and robotic arm configuration like link length and joint values. An automated storage and retrieval system(AS / RS) generally it can be known as material handling support systems those are in majority used in automated factories, distribution centers, warehousing and non-manufacturing environment. In this report, the AS / RS systems consists of 3×3 storage blocks(i.e., 9 blocks of 3 rows and 3 columns) and each storage block dimensions of 10cm×10cm . The product produced in the CNC machine is picked by a robot and place it in the material handling system at one end and the belt is moved, the product reaches at other end and then the other robot picks the product and then places it in the defined position in the storage system. The process is continued upto completion of 9 different storage blocks in the storage system and then they removed from the storage system in order to distribute the products to customers.

This model is simple design as shown in figure 2 which can used in many industrial purposes runs on automated storage and retrieval system using the artificial robots and normal robots and work flow process shown in figure 1. This will help to reduce time loss, reduce minor human errors caused by workers during the manual process.

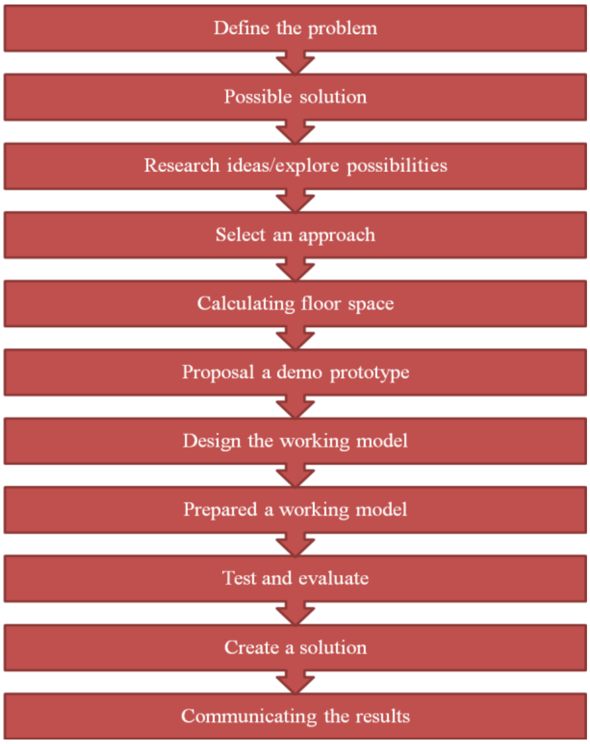

Fig 1. Work Flow Process

Fig 2. Automated Storage and Retrieval System

In this step we found a problem due to manual storage system for industries due to these specific reasons: At the start of a business, manual storing of products can be quick easy and necessary. However, as your business grows manual filing can become a very cumbersome practice. In a busy business world it is important that you can store and retrieve products in a quick and effective way. There are more efficient ways in today's growing technological world that can help keep your organized with a higher productivity level. Here are some disadvantages of manual document filing processes. We have calculated entire floor space for the project and space required for the placing of robot and for placing of storage rack. Flooring space required for placing of robot = 30×30 (square table in cm), Flooring space required for storage racks = 36×12×36, Product dimensions = 5×5×2, Total weight of the product = 150 grams. A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users.

We have prepared a demo prototype according to floor space and robot configuration. For our requirements the racking system of rack has (3*3) storage boxes of each having some dimensions square type configuration .For this demo type we used thermocol sheets as rack and shells. For this prototype we have placed products of ranging 100-250 gm of weight. We observe every and counted every storage location coordinates of 9 storage shells of rack, for every storage shell we put products by using magnetic gripping robot. By using CATIA software we drawn robot design as shown in figure 3 and storage rack system and entire storage and retrieval system according tour designed floor space dimensions.

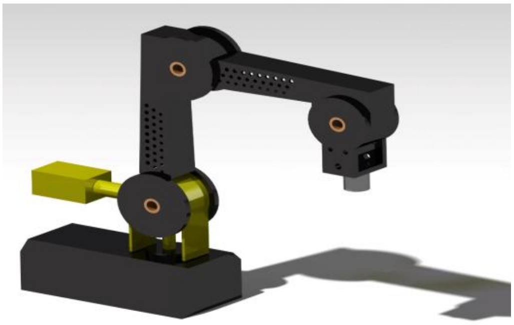

Fig 3. CATIA Design

We tested the robot interfacing time and storage time for all the storage locations and found that correct time and proper placing of products has been observed. The mathematical calculations regarding are shown below.

Size of AS / RS:

Capacity =3×3=9 storage components

Width =12 cm
Length =36 cm
Height =36 cm

Unit load dimensions:
Width =10 cm =0.1m
Length =10 cm =0.1m
Height =10cm =0.1m

Here,

V_y=0.045m/sec L=0.36m
V_z =0.045m/sec H=0.36m

Theoretical calculation of T_{cs}

$$T_{cs}=\max (L/v_y+H/v_z)+2\,T_{pd}$$
$$= \max (0.36/0.045+0.36/0.045)+2(25)$$
$$= 32+50$$
$$T_{cs}= 82 \text{ sec/cycle}$$

Practical value of T_{cs}= 88 sec/cycle
Theoretical value of T_{cs}= 82 sec

$$\therefore \text{Error} = \frac{\text{Practical value} - \text{Theoretical value}}{\text{Practical value}}$$

$$= \frac{88-82}{88}$$
$$= 0.6$$
$$\therefore \text{Error} = 6\%$$

III. RESULTS AND DISCUSSIONS

The below table 1 gives the information that the time taken to pick and place the product in the first storage location is 25 sec and the speed of robot is 30% of its maximum speed. Similarly for second storage location the time taken to pick and place the product is about 25 sec with a speed of 35% of maximum speed of robot and for third storage location the time taken to pick and place the product is 25 sec with a increased speed of robot than previous 2 storage locations with a speed of 40% of its maximum speed and for the fourth storage location the time taken to pick and place the product is 25 sec with a robot speed of 30% of its maximum speed. The fifth storage locations takes 25 sec for pick and place of product with a robot speed of 35% of its maximum speed and for the sixth storage location the time taken to pick and place the product is 25 sec with robot speed of 40% of its maximum speed and for seventh storage location the time taken to pick and place the product is 25 sec with a robot speed of 35% of its maximum speed and coming to eighth position of storage the time taken to pick and place the product is 25 sec with robot speed of 40% of its maximum speed. For ninth storage location the time taken to pick and place the product is 25 sec with a robot speed of 45% of its maximum speed.

Table 1. Speed and time of robot for pick and place operation

Storage position	Pick and place time(sec)	Speed of robot in (%)
1	25	30
2	25	35
3	25	40
4	25	30
5	25	35
6	25	40
7	25	35
8	25	40
9	25	45

From the above information the time taken to pick and place the products in nine storage locations is same with varying the robot speed control. From the table 2 the practical value of T_{cs} is found to be 88 sec/cycle for first storage location and the theoretical value is found to be 82 sec. so, therefore the percentage error is found to be 6% and similarly for remaining storage locations also it is found to be same as first storage locations. The graphical representation between speed and robot position is shown in figure 4.

Table 2. Error Percentage

Performance measure	T_{cs}(sec/cycles)	% Error
Practical value of T_{cs}	88	6%
Theoretical value of T_{cs}	82	6%

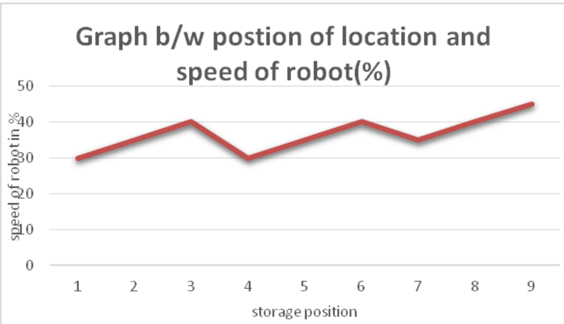

Fig 4. Robot Position v/s Robot Speed

IV. CONCLUSIONS

In this paper, a cost effective single asile AS / RS system has been developed with nine storage locations (3×3) and the size of each location is (10cm×10cm×10cm). The pick and place operation is done by robots by using CPROG software of the latest version. The Cprog software contains different commands like motion commands like linear motion command, joint motion command and gripper command like digital output 25 (enable/Disable). Here the digital output 25 enable command is used to pick the product and digital output 25 disable is used to release the product in defined location in storage system. The cycle time for completing the pick and place operation involved in storage system is practically found to be 88 sec/cycle and theoretically found to be 82 sec/cycle. The percentage error of this cycle time is about 6%.So, therefore the efficiency can be enhanced by minimizing the delays of actuating system. Graph is drawn between storage positions and speed of the robot this graph shows that by changing the positions in storage location from one storage position to nine storage positions. The speed of the robot increases according to the changing of the position. The pick and place time duration as kept constant by varying the storage locations and speed of the robot.

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