Automatic book rack system with expandable clasp holder

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Abstract. In the light of number of universities and libraries consistently increasing and book storage/maintenance becoming a difficult task, there is a need to design a system which will reduce manual work as well as minimise the problem of using the book racks. The review is done to identify the various shortcomings of the present system and overcome the flaws faced such as accessing books at height, cleaning the shelves at the topmost compartment and holding the books upright in proper position. The automatic book rack system includes shelf, expandable clasp housing that is movable and connected to the shelf. The housing includes a noiseless electric motor and a pair of chain and sprockets. The electric motor, chain sprockets work in conjunction to achieve linear motion of the housing along the shelf. The expandable clasp can support the books in an upright, side by side arrangement on the shelf. Once a book is removed from the shelf the clasp housing is automatically repositioned to push the remaining books together and close any resulting gaps between the remaining books keeping them upright. Exemplary systems according to present disclosure include the mechanism that permit reliable and efficient repositioning of one or more shelves, thereby enhancing utilization and efficiencies associated therewith.

Keywords — Book rack, expandable clasps, motor, chain and sprocket, attachments, shelf assembly, connecting rods.

1. Introduction

The Automatic Book Rack System uses a simple rotary mechanism where the concept is to design and fabricate such a rack in which the shelves will rotate completely giving flexibility in the current system. In ABR System there will be use of chain and sprockets which will help the shelves to move as desired by the user. Advanced racks with constant force spring expandable clasp holder will also be provided in order to stop the books from slipping on the rack. The input will be manually provided by the user by pressing the button. And the output will be observed by the motion of the rack as per the input.

In country like India we can observe that libraries are using more of horizontal space henceforth compromising with the reading space available; whereas in countries like Japan (Osaka) the vertical height is so large that the user cannot easily access it. The main objective of our project is to reduce the problems faced by the user in accessing the books kept at height by introducing the ABR system which uses a simple rotary mechanism where the concept is to design and fabricate a rack in which the shelves will rotate providing flexibility to the current system in use. The housing includes an electric motor and a pair of chain and sprockets. The electric motor, chain sprockets work in conjunction to achieve linear motion of the housing along the shelf.
2. Earlier Works

The history of library is dating back to 2600 BC which then consisted of archives of the earliest form of writing, marking the end of prehistory and start of history. The classical period went by and it was the fore coming of the middle ages. Monastery libraries developed, such as the important one at the Abbey of Monte cassino in Italy in which books were usually chained to the shelves. Later the “stall system” came by in which there were fixed bookcases perpendicular to exterior walls pierced by closely spaced windows which was the characteristic of English institutional libraries. In European libraries the book cases were arranged parallel and against the walls and so it became popular and was first introduced on a large scale in Spain’s El Escorial known as the “wall system”. The 17th and 18th centuries are known as the golden age of libraries during which many libraries were founded in Europe. Thomas Bodley founded the Bodleian library in 1602 as an early public library. After the success of library among people as a source of accessing books the entry of subscription libraries, private libraries and national libraries could be seen. The first true national library was founded in 1753 as part of British museum. Even with the introduction of modern libraries in 19th century, something that remained unchanged was the book shelving system. We can clearly observe how big the library system has become both using a lot of horizontal space as well the vertical space in some cases.

2.1. Automatic Book End System for Shelves.
Yaqoob Saif Al-Habsi et. al. describes a system which consists of shelf, a book end housing that is movably connected to the shelf and a limit switch connected to the book end housing. The electric motor, chain sprockets and roller chain work in conjunction to achieve linear motion of the housing along the shelf bottom. Once a book is removed from the shelf, the limit switch energizes the electric circuit thereby causing the motors to move the housing forward to close any resulting gaps between the remaining books; hence the books are re-shelved in the remaining space.

2.2. Automated Library System with Retrieving and Reposting System.
Yoshiyuki Nakano, Yusuke Kihara, Sakimoto et. al. states the effective application of such a robot in a configuration that is fully compatible with existing the open-shelf-type book racks most commonly used in libraries today. The system consists of memory unit for storing book-to-shelf-section identification information cross-reference data which relates accessing book identification information to corresponding prescribed shelf section. Thus this Retrieving and Reposting system provides the book facility to the book counter as per the input fed by user.

2.3. Shelving System.
Zackary Engel. Shelving systems according to the present disclosure facilitate synchronized vertical motion of shelving units e.g., based on coordinated pulley systems and advantageously include spring designs that facilitate controlled vertical motion of shelving units, e.g., based on fluid movement and/or discharge from the spring design. Shelving units may be readily repositioned at elbow or eye level, and repositioned at their respective initial positions in an efficient and advantageous manner. [1]

2.4. Device in which a book rack moves vertically and horizontally.
Kim Bongki. A bookrack that moves vertically and horizontally is provided with a chain gear of a reduction motor that turns left or rights by the operation of switches. Power is supplied to a rotary wheel to turn an attachment double chain. A rotary wheel of a moving body turns motivated by the
attachment double chain, and a gear connected to the rotary wheel is rotated and engages a rack gear. The moving body is thereby made to move in a direction contrary to the attachment double chain. A bookrack connected to the moving body is caused to move vertically and horizontally around a right-angled tetragonal track with the moving body. The bookrack enables a child, an old or infirm person or a handicapped person to take out or arrange books from a seated position, since the bookrack moves freely and is kept horizontal at all positions as the moving body moves the bookrack horizontally and vertically around the track. [2]

2.5. Automatic Adjustable Book Rack.
Gus Cougias. An automatically adjustable book rack comprising, a pair of end supports, multiple extension means secured to one of said end supports, extension means secured to the other of the said end supports and provided with longitudinal bores there through, said bores extending partly into the other of the said end supports, tension spring means confined in the said longitudinal bores and having their ends anchored to both of the said end supports, tongue and groove means on the said multiple extension means and the said extension means for slidably interconnecting the same, and spring encasing means secured to the first of said end supports slidably fitted within the said longitudinal bores, the said spring encasing means being of greater length than the said multiple extension means to prevent accidental disengagement of the said tongue and groove means while still permitting the said end supports to be retracted to minimum adjustment when the said end supports contact the free ends of the said multiple extension means and the said extension means whereby the added length of the said spring encasing means is received in that portion of the said longitudinal bores extending into the other of the said end supports. [4]

2.6. Automatic Library System.
Uda Kazutaka et. al. The invention is an automatic library system which comprises: a container having a side wall for storing plural books in a standing state and in a state that back covers of the books face one direction a rack for storing the plural containers a take-out station having a work table for taking out the books transport means for transporting the container between the rack and the take-out station. The container is formed so that at least the side wall is transparent so as to allow a user to view the back cover of the book and the transport device and the work table are configured so that an upper surface of the work table and a lower end of the container become almost of equal height.

2.7. Shelving System for Books in Library.
Klaus Zillich. The invention relates to a racking system, in particular a circulating racking system, for the books of a library, with shelves and with receptacles arranged therein for the books. The individual shelves here form two blocks arranged one above the other, in which the individual shelves can be moved by means of rollers. At both front sides of the blocks, transporting frames are used for the vertical displacement of the shelves, which pass through the circulation rack in a continuous circuit. The first shelf of the first shelf block is moved to the second shelf block and forms the last pane there. On the other hand, the foremost shelf of the second shelf block becomes the last shelf of the first shelf block. At each cycle, all the shelves in the blocks advance by one shelf width during the displacement, the individual shelves are moved past a workbench, from which the removal and the resetting of the bookers take place at the same time. In the case of double shelves ordered on both sides, work stands are required at each end of the shelf blocks. In this case, the bins can also be placed in containers, so that the circulation rack system can be used more quickly, since only the containers have to be inserted and removed. Sorting operations are carried out at another work station. The orders of the books can be completed in the half-day period. When the containers, which are mounted on the shelves and receive the books, are designed as addressable containers, the workbench can be replaced by manual handling by means of an automatic end loading and loading mechanism, i.e. by a rack conveyor, as a result of which the circulation racking system, to the fully automatic bearing and conveying system. The circulation racking system then further comprises pick-up robots for the
addressable containers, input and output stations for orders as well as for receiving and returning the books, and finally a central control unit.

3. Automatic Book Rack System – A Prototype

The Automatic Book Rack System (ABRS) belongs to the class of rotary mechanism systems. The previously used rack systems such as multilevel shelf system or revolving table (non-automated) etc have been implemented on a huge scale. But these systems have a major disadvantage of large horizontal space consumption which is successfully eliminated with the use of an Automatic Book Rack System. The main components of the ABRS are: chain and sprocket, attachment, electric motor, expandable clasps, connecting rod, shelving assembly and speed reduction gear box. The characteristics of the ABRS are as follows:

a.) Utilization of vertical space.
b.) Stable and reliable.
c.) User friendly and effortless.
d.) Flexible System.

Moreover, the expandable clasp holder provides the benefit of holding the books in upright position even when there are few numbers of books on a single shelf. The working of Automatic Book Rack System (ABRS) is simple and uses the rotary mechanism. It is easy to operate by pressing the button provided on the side walls of the rack in order to move the shelves from their respective positions i.e. from higher altitude to suitable height as per the requirement of the user. Except automatic book rack system all other systems use a large horizontal surface area, automatic book rack system is developed to utilize maximum vertical area in the available minimum surface area. It is quite successful when installed in libraries/universities which are well established and are suffering with shortage of area for book storage. Although the construction of this system seems to be easy, it will be par from understanding without the knowledge of materials, chains, sprockets, bearings, and machining operations, kinematic and dynamic mechanisms.

4. Methodology

4.1 Phase 1

4.1.1. Market survey.
During this period detail market survey has been done to learn available rack systems and their utility with literatures of different types of book rack systems and its differences have been observed.

4.1.2. Problems in existing systems.
The problems regarding the existing system have been found such as, zero flexibility, no portability, covering of more horizontal space, etc.

4.1.3. Conceptual Design.
Taking problem statement from above and studying the fundamental engineering concepts various concept regarding book rack system are prepared and amongst those best concepts design has been selected for further phases.

4.2 Phase 2

4.2.1. Modelling in Solidworks.
Putting the ideas on the modelling software for visualisation of the prototype and making it more and more compatible so that there will be less complexity in designing.
4.2.2. Material Selection and Procurement.
In this phase material selection is done and also its procurement as per need the dimensions are taken from SOLIDWORKS model. The materials used for structure is Mild Steel (4x4 mm), for shelves the material is wood, the chain is made up of 40Mn Steel and sprocket will be an alloy of A3 Steel and 45Mn Steel.

4.2.3. Fabrication.
This phase includes fabrication of prototype in the workshop from the procured material and preparing the prototype model from the software model.

4.2.4. Assembly.
This phase includes Assembly of all the sub parts, also the arrangement of the motor and its wiring is done, all finishing operations like grinding, trimming, painting is done here.

5. Calculations

5.1. Dimensions of the ABRS prototype.

|                          | Value       |
|--------------------------|-------------|
| Height of the rack       | 60 inches   |
| Length of the rack       | 30 inches   |
| Width of the rack        | 36 inches   |
| Height of the shelf      | 13.7 inches |
| Length of the shelf      | 21 inches   |
| Width of the shelf       | 9.8 inches  |

5.2. Chain design.

Number of links = 152
Length of the chain= pitch x links
= 16 x 152= 96 inches.

5.3. Sprocket Specification.

Number of teeth on sprocket= 14/39
Diameter of driving sprocket= 71mm.
Diameter of driven sprocket = 197mm.

5.4. Load conditions.

1 Rack = 6 Shelves
Dimensions of book
Length: 20 cm
Height: 25 cm
Width: 3.5 cm
1 Shelf = 15 books (Single Tier)
Total books on rack= 90
1 Shelf approx. 15kg
Total book weight on rack: 90kg
6. Conclusion

In this study, the various advancements in libraries have been presented. The various examples of implementation of technologies in advancement of libraries being presented, makes the use of library quite simple. It eases the task of getting the books from higher heights and maintenance of the shelves. It does so by directing the patrons and optimizing the use of reading space by using more vertical space. For completion of this task we have successfully designed the automatic book rack and with suitable material selection the ABR system has been fabricated.

7. Future Scope

1. The shelves can also be equipped with safety sensors guiding the movement of books in the rack.
2. It can be provided with wheels so that it can be easily transported from one place to other.
3. Other material combinations can be used for fabricating the ABRS for higher strength and stability.

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