Design and Fabrication of Box Transfer Mechanism

Sachin Suresh Raut[1], Dnyaneshwar Bhagwanrao More[2], Mahesh Rameshrao Paul[3], Shailesh Anantrao chopade[4], Gaikwad N.M[5]
[1,2,3,4]*Student, Mechanical Engineering, Shri Shivaji Polytechnic Institute, Parbhani*
[5]*Professor, Mechanical Engineering, Shri Shivaji Polytechnic Institute, Parbhani*

***Abstract*—There has been a serious demand for intermittent movement of packages in the industry right from the start. Though the continuous movement is more or less important in the same field of sporadic motion has become essential. The objective of this study is to design a mechanism that delivers this stop and move motion using mechanism linkages. The advantage of this system over the conveyer system is that the system has a time delay between the moving packages and this delay can be used to introduce alterations in the packages or move the packages for any other purpose.**

I. INTRODUCTION

The box moving and shifting has a simple mechanism, operated with crank and linkage arrangement. As by the electric motor rotary motion is converted into To and Fro motion of linkages, it takes very simple. The rotary motion is converted into linear motion with the help of crank and mechanical linkages arrangement. A linkage may be a mechanism formed by connecting two or more levers together. Linkages are often designed to vary the direction of a force or make two or more objects move at an equivalent time. A linkage constructed with combination of rigid links and ideal joints is called a kinematic chain. Linkages may either be modelled from open, closed, or combination of open and closed chains. Each link of a chain is connected by a joint to one or more other links. The movement of an ideal joint is normally associated with a subgroup of the group of Euclidean displacements. The number of parameters in the subgroup is called the degrees of freedom (DOF) of the joint.

The box transfer mechanism is an essential material handling system widely used in modern industrial environments to facilitate the efficient movement of boxes, packages, and goods from one location to another. With the rapid growth of automation in manufacturing, warehousing, packaging, and logistics sectors, the need for reliable and efficient transfer systems has significantly increased. Traditionally, material handling tasks were performed manually, which not only required considerable human effort but also led to inefficiencies, increased operational time, and higher risks of workplace injuries. To overcome these challenges, mechanical systems such as box transfer mechanisms have been developed to ensure smooth, continuous, and controlled transportation of materials within industrial setups.

A box transfer mechanism typically consists of interconnected mechanical components such as conveyors, rollers, belts, pulleys, motors, shafts, and supporting frames that work together to achieve the desired motion. The system operates on fundamental mechanical principles such as power transmission, friction, and rotational motion to transfer boxes efficiently. Depending on the design and application, the mechanism can be configured in various forms, including belt conveyors, roller conveyors, and chain-driven systems. Each type is selected based on factors such as load capacity, speed requirements, type of material, and operational environment. The flexibility of design allows the mechanism to be used for horizontal, inclined, or even vertical transfer of materials.

The importance of a box transfer mechanism lies in its ability to enhance productivity and streamline industrial operations. By automating the process of material handling, it minimizes human intervention, reduces fatigue, and ensures consistent performance. Additionally, it improves safety by limiting direct human contact with heavy or hazardous materials. The system also contributes to better organization within the workspace, enabling systematic flow of goods and reducing bottlenecks in production lines. In industries where time efficiency and accuracy are critical, such as e-commerce warehouses and packaging plants, the role of box transfer mechanisms becomes even more significant.

From an engineering perspective, the design and fabrication of a box transfer mechanism involve careful consideration of various parameters, including load analysis, material selection, power requirements, structural strength, and safety factors. The process requires a thorough understanding of mechanical design principles, manufacturing techniques, and assembly procedures. Engineers must ensure that the system is not only functional but also durable, cost-effective, and easy to maintain. Proper alignment of components, selection of suitable bearings and drives, and optimization of motor power are crucial aspects that directly influence the performance and efficiency of the mechanism.

II. RELATED WORK

This machine basically works on the principle of Single Slider Crank Mechanism. It converts rotary motion into a reciprocating motion. This project can be utilized in industry. As an alternative to the conveyor type, simpler and more comfortable machine using four bar mechanism can be used. This box shifting machine helps in transfer of boxes smoothly by use of four bars with a simple arrangement [2]. The main advantage is that it can transfer box with much more efficiency than the conveyer belt system in all aspects. Unlike conveyer belt system it only focuses on shifting of boxes [1]. Industries right from the start are critically demanding intermittent movement of the packages. Periodic motion is also becoming more essential in the industries where continuous movement is given a significant importance. Linkages can be designed to change the direction of a force or make two or more objects move at the same time. The advantage being that when in transit any alterations needed in packages can be done without much effort Objective is to supersede the conventional conveyers by mechanical conveyers in order to compensate for the comparative low efficiency and high maintenance cost of the conventional ones. Operating of the mechanism is solely based on four bar mechanism and with use of a simple small motor rotary motion is converted to reciprocating motion.

III. AIMS AND OBJECTIVES

A. Aims:

• The aim of the project is to fabricate the work moving mechanism, which may make easier to maneuver jobs from one section to other while processing within the factories.

• In a workstation, production line so as to get the specified production rate and to realize a minimum amount of idle time.

B. Objectives:

- Fabricate a job transport mechanism which can move things from one place to another.
- Understand project planning and execution.
- Understand the fabrication techniques in a mechanical workshop [1].
- Understand the usage of varied mechanical machine tools and measuring tools.

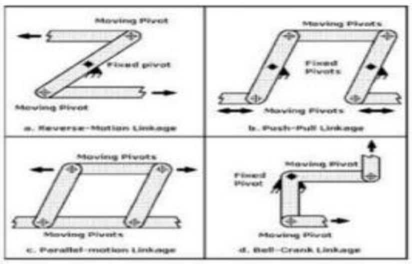
IV. LINKAGE MECHANISM

Linkages are often classified consistent with their primary functions:

- Function generation: the relative motion between the links connected to Frame.
- Path generation: the path of a tracer point.
- Motion generation: the motion of coupler link [2].

A. SIMPLE PLANAR LINKAGES Reverse Motion Linkage: The mechanism can force the job to move in opposite direction; this can be done by using the input link as lever. If the fixed pivot is equidistant from the moving pivots, output link movement will equal input link movement, but it will be in opposite direction. This linkage can also be noted through 360º. Push-Pull Linkage: Can make the object or force move in the same direction, the output link moves in the direction as input link. Technically closed as a four-bar linkage, it can be rotated through 360º without changing its function. Parallel-Motion Linkage: can make objects or forces move in the same direction, but at a set distance apart. The moving and fixed pivots on the opposing links in the parallelogram must be equidistant for this linkage to work correctly. This linkage can also be rotated through 360° without changing its function Bell-crank Linkage: Can change the direction of objects or force by 90°. This linkage rang doorbells before electric clappers were invented.

This was done by pinning two bell cranks bent 90° in opposite directions together to form tongs. By squeezing the two handlebar levers linked to the input ends of each crank, the output ends will move together.



Functions of four basic planar linkage mechanisms

Fig. 1. Types of Planar Mechanism

B. Crank Rocker Mechanism for Job Transport Mechanism

The four-bar linkage is the simplest and offer times, the most useful mechanisms. As we mentioned before a mechanism composed of rigid bodies and lower pairs is named a linkage. In planar mechanism, there are only two kinds of lower parts – revolute pairs and prismatic pairs. Planar quadrilateral linkage, RRRR or 4R linkages have four rotating joints. One link of the chain is typically fixed, and is named the bottom link, fixed link, or the frame. The two links connected to the frame are called the grounded links and are generally the input and output links of the system, sometimes called the input link and output link. The last link is that the floating link, which is additionally called a coupler or rod because it connects an input to the output. Assuming the frame is horizontal there are four possibilities for the input and output links:

- A crank: can rotate a full 360 degrees
- A rocker: can rotate through a limited range of angles which does not include 0° or 180
- A 0-rocker: can rotate through a limited range of angles which includes 0° but not 180° A π-rocker: can rotate through a limited range of angles which includes 180°

C. Function Of Linkages

The function of a link mechanism is to provide rotating, oscillating or reciprocating motion from the motion of crank or vice versa. Stated more specifically linkages may be used to convert:

- Continuous rotation into continuous rotation, with a continuing or variable angular velocity ratio.
- Continuous rotation into oscillation or reciprocation, with a continuing or variable velocity ratio.
- Oscillation into oscillation, or reciprocation into reciprocation, with a constant or variable velocity ratio.

V. CONCLUSION DESIGN AND FACBRICATION

Proper designing of any 4-bar mechanism is very important to get required output motion for specific input motion with keeping in mind to minimize the overall cost of mechanism as well as to maximize the efficiency of mechanism by reducing the unnecessary loss of energy either by unrequired friction and in improper geometry. The length of each link is calculated by process known as dimensional synthesis. Dimensional synthesis involves an iterate- and-analyze methodology which in certain circumstances can be an inefficient process; however, in unique scenarios, exact and detailed procedures to design an accurate mechanism may not exist.

A. Calculating Transmission Angle

First step of the design process is to calculate the transmission angle. Transmission angle is an angle form between connecting link and output link during the entire motion. In fig. 2, if AB is the input link, the force applied to the output link, CD, is transmitted through the coupler link BC. (That is pushing on the link CD imposes a force on the link AB, which is transmitted through the link BC). For sufficiently slow motion (negligible inertia forces), the force in the coupler link is poor tension or compression (negligible bending action) and is directed along BC [2]. For a given force in the coupler link, the torque transmitted to the output bar (about point D) is maximum when the angle β between coupler bar BC and output bar CD is π/2. Therefore, angle BCD is called transmission angle. $\alpha_{max} = |90^{\circ} - \beta|_{min} < 50$

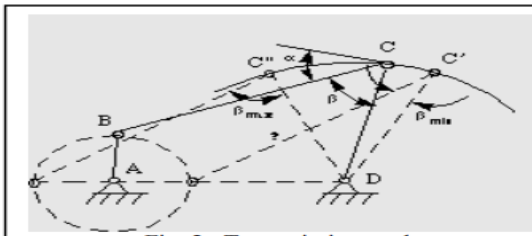


Fig. 2. Transmission angle

When the transmission angle deviates significantly from π/2, the torque on the output bar decreases and may be sufficient to overcome the friction in the system [3]. For this reason, the deviation angle α = |π/2 - β| should not be too great. In practice, there is no definite upper link for α, because the existence of the inertia force may eliminate the undesirable force relationships that are present under static conditions. In the given fig. 3, value of d is the predetermined value and we have to determine the crank radius r, for a given radius value of rocker R. Let the oscillation of rocker is Q degree at point B. From ΔABC, d = 2AC d = 2*R*Sin(Q/2) Q/2 = Sin-1(d/2R) Q = 2Sin-1(d/2R) Now from crank and rocker mechanism: 2r = (R*Q*3.14)/180 Putting the value of Q we get: r = (R*3.14/180) *Sin-1(d/2R)

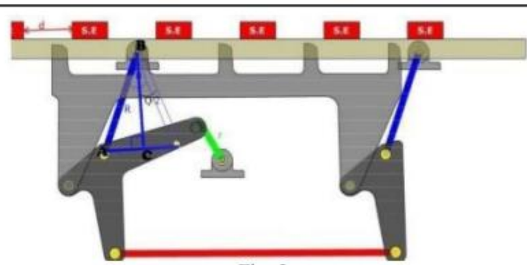


Fig. 3.

Fig. 3.

B. Cad Modelling:

After completing the theoretical calculation for various length of links, I run the entire mechanism in Adam's software to study the dynamics of mechanism and check whether the whole links are following proper geometry or not. After that did the cad modelling of the entire links, upper structure and base structure on Creo 3.0 software using the Adams final geometry.

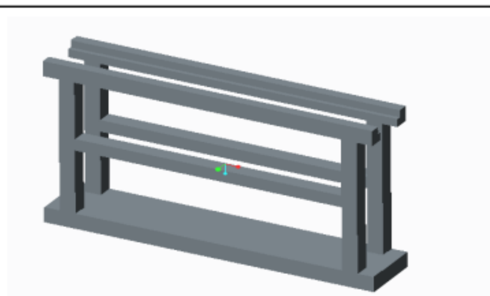


Fig. 5. Base Structure

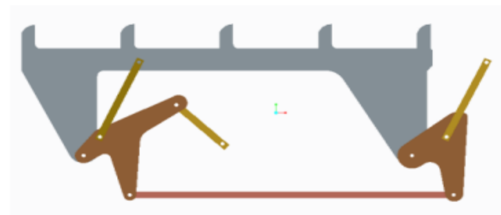


Fig. 4. Linkage Assembly

C. CAE

After modeling different part of mechanism in CAD software, the parts are now analyses on Hyper works CAE software. Firstly, ranthe analysis for 250 kg of weight load with taking material thickness of 5mm. For making the assembly cost chosen mild steel over aluminum. After preprocessing the component in Hyper mesh, the static analysis is done in optistruct. The following results were obtained from analysis:

Table 1 Cae Results

Sr No.	Component	Max. Stress	Max. Displacement
1	Upper Structure	299.9 Mpa	0.48 mm
2	Connecting Rod	132.2 Mpa	0.33 mm
3	Crank Rod	99.6 Mpa	044 mm

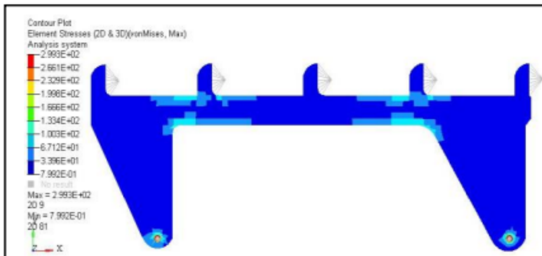


Fig. 6. Upper Structure CAE

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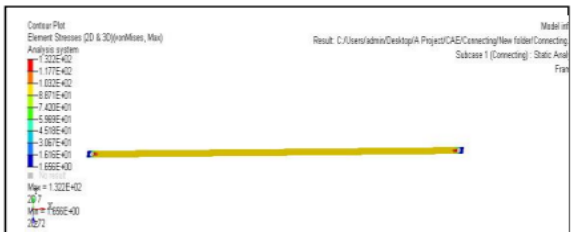

Fig. 7. Connecting Rod CAE

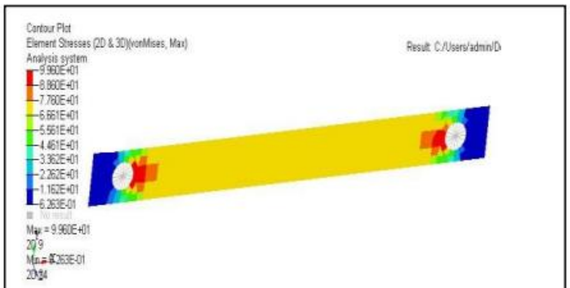

Fig. 8. Crank RoadFig. 8. Crank Road CAE

When all components pass in the CAE with Minimum Factor of safety 1 the project is then proceeded to the fabrication stage. For providing movement to the mechanism, I used the DC Wiper Motor of car because of its low rpm and high torque value. Fabrication is done by using various processes such as cutting, Grinding, Drilling, Machining and Welding.

VI. CONCLUSION

The design and fabrication of a box transfer mechanism represent a significant contribution to the field of material handling and industrial automation. This project successfully demonstrates how fundamental mechanical engineering principles can be applied to develop an efficient, reliable, and cost-effective system for transporting boxes from one point to another. By integrating components such as the frame structure, conveyor system, motor, pulleys, shafts, and bearings, the mechanism achieves smooth and continuous motion, ensuring effective material flow within industrial environments. The system not only reduces manual labor but also enhances productivity, making it highly suitable for modern manufacturing and logistics operations.

Throughout the development of this project, careful attention was given to critical design aspects such as load analysis, selection of suitable materials, power transmission methods, and structural stability. The fabrication process, which involved cutting, welding, drilling, and assembly, provided practical exposure to manufacturing techniques and workshop practices. Proper alignment of components and selection of appropriate mechanical elements ensured minimal friction, reduced wear and tear, and improved operational efficiency. The final system demonstrates satisfactory performance in terms of load handling capacity, speed, and reliability, meeting the intended objectives of the project.

One of the major achievements of this box transfer mechanism is its ability to provide consistent and safe operation. By minimizing human involvement in repetitive and physically demanding tasks, the system reduces the risk of injuries and improves workplace safety. Additionally, it ensures uniform handling of materials, which is essential in industries where precision and consistency are critical. The modular nature of the design also allows for easy modification and scalability, making it adaptable to different industrial requirements and layouts.

However, the project also highlights certain limitations, such as dependency on power supply, initial setup cost, and the need for regular maintenance to ensure long-term performance. Despite these challenges, the advantages of the system far outweigh its limitations, especially when considered in large-scale industrial applications. With proper maintenance and periodic inspection, the durability and efficiency of the mechanism can be significantly enhanced.

In the future, the box transfer mechanism can be further improved by incorporating advanced technologies such as automation using programmable logic controllers (PLC), sensors for object detection and sorting, and energy-efficient motor systems. Integration with IoT-based monitoring systems can enable real-time tracking of performance and predictive maintenance, thereby increasing overall system reliability. These advancements will not only enhance the functionality of the mechanism but also align it with the growing trend of smart manufacturing and Industry 4.0.

REFERENCES

[1] K. Tandel, A. Khutliwala, J. Harvara, and H. Mehta, "Implementation of four bar chain mechanism in box transfer mechanism," *International Journal of Scientific Research in Engineering (IJSRE)*, vol. 1, no. 3, Mar. 2017.

[2] N. Sivakumar, K. Thamaraikannan, R. Kalaiyarasan, S. Veerakumar, and A. Vijay, "Design and fabrication of industrial conveyor using crank mechanism," *International Research Journal of Engineering and Technology (IRJET)*, vol. 3, no. 4.

[3] T. Wen and J. Dargahi, Eds., *Theory of Machines I Laboratory Manual (MECH 343)*.

[4] Q. Chang, C. Pan, and S. Biller, "Integrated modeling of automotive assembly line with material handling," Dec. 19, 2012.

[5] B. S. Manda and U. S. Palekar, "Design and analysis of material handling systems," *Journal of Manufacturing Science and Engineering*, vol. 194, no. 4B, pp. 841–848, Oct. 1996.