ME 748: Box Shifting Mechanism

Assignment 1

Submitted by

Deepak Kumar Thakur
213101001

Under the Supervision of

Prof. Anirban Guha

Department of Mechanical Engineering
Indian Institute of Technology Bombay,400076

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SECTION 1: MECHANISM DESCRIPTION

SECTION 1.1: PICTURE OF MECHANISM

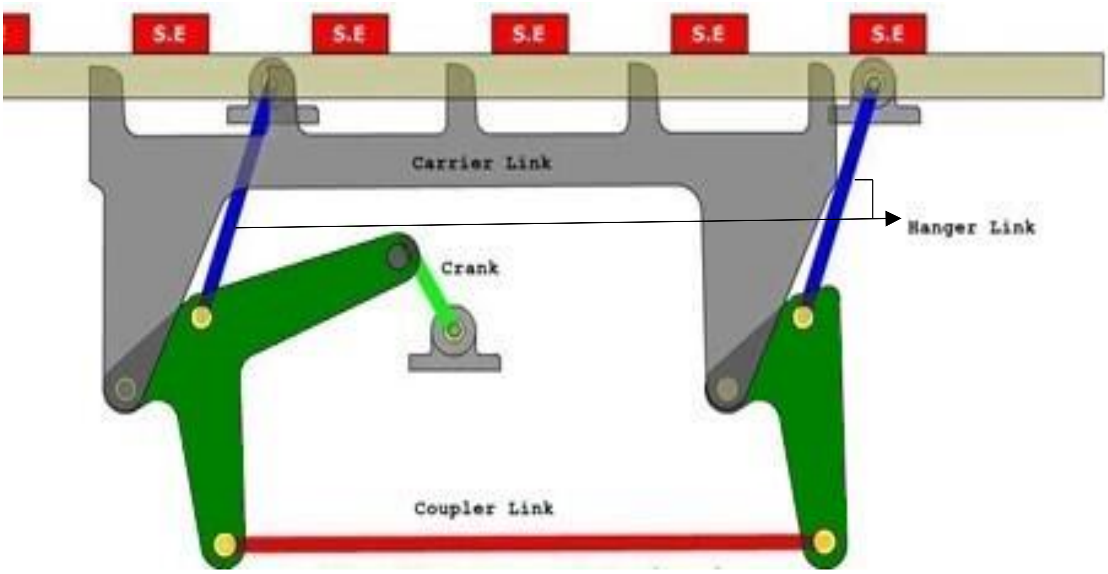


Fig. 1 Box Shifting Mechanism (Edited) [1]

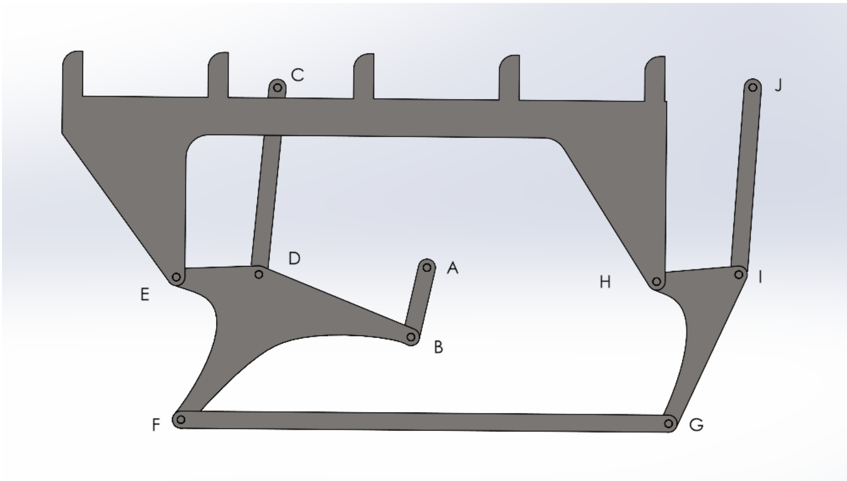


Fig. 2 Solidworks Model of Box Shifting Mechanism

SECTION 1.2: DESCRIPTION OF THE MECHANISM

This mechanism is a crank and rocker mechanism. Thereby, it satisfies the Grashoff criterion. It has a crank connected with a coupler attached to a rocker. It has one degree of freedom. The input is a crank (constant speed) connected to an electric motor, and the output is the carrier link that produces linear reciprocating motion. This mechanism converts the rotary motion of the crank into the linear reciprocating motion of the carrier link. To achieve this mechanism, 8 linkages are connected by 10 revolute pairs. Coupler link and hanger links are connected with other links in such a way that it imitates the motion at the right end of the carrier link. The lengths of all links are taken such that the carrier link has only linear reciprocating motion. The carrier link has teeth at the top, which have equal distance between them. The carrier link with teeth pushes any material (for example, box) in forwarding motion. The output link has two motions, it pushes the object forward for the half rotation (0 to π) of the crank, dips a little, and reverts in backward motion (- π to 0) for the rest half rotation of the crank. Thus, the arrangement produces an intermittent motion with stop and move motion.

SECTION 1.3: PURPOSE OF THE MECHANISM

Fig. 3 Box Shifting Mechanism (Prototype) [3]

In small-scale industries, the cost of using a belt conveyor system is very high; also, the alteration in a product is complex during transportation. Therefore, this box shifting mechanism is used to reduce the cost of production and allow alteration if required during the transportation of boxes for an in-house assembly line.

The mechanism has output with linear reciprocating motion, which allows stop and move motion. Workers can alter the product without disrupting the balance line time because it has intermittent motion. It is used in ice-cream industries for the topping of ice cream in the production line.[2] It can also be used in industries where operations like punching, labeling, pressing, testing, etc., are required.

SECTION 2: CONTEXT OF USE

SECTION 2.1: HISTORY

Box shifting mechanism is generally used in small-scale industries due to low maintenance and intermittent motion which allows alternation during the transportation of boxes. This mechanism has been in the small-scale industries for a long time and has been modified as per need of the industry. But the exact date of first ever used in not mentioned in the literature. One of the possible reasons could be that it has not got the spotlight as compared to conveyors. Conveyors has been dominating in large scale industries. The first ever use of conveyors belt was in 1905. It is used for continuous process of transportation. If the stop and move motion is required, then it has to be programmed which is costly. Also, the maintenance cost of conveyors belt is high because it uses gears, motors and belt. Thereby, the box shifting mechanism comes into picture to reduce cost of large initial investment and maintenance cost in small-scale industries.

There are various other machine handling equipments like forklift, overhead crane and various others. Forklift was first ever used in 1915 and overhead crane has been in use since 1830. Well, they have been modified to increase their strength, durability and availability.

It can be observed that there is a demand of sporadic motion in the industry and this mechanical linkage system can overcome above problems. The intermittent motion helps to alter the product during transportation for in-house assembly line, reduces maintenance cost and initial investment.

Fig. 4 Forklift [6]

Fig. 5 Belt Conveyor [4]

Fig. 6 Overhead Crane [7]

Fig. 7 Manual Trolley [5]

Section 2.2: Alternate mechanisms

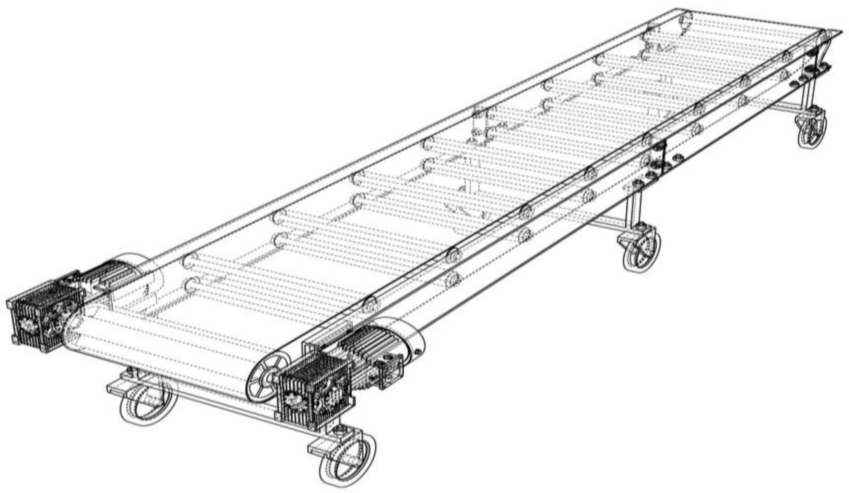


Fig. 8 Conveyor [8]

There are various material handling equipments like conveyor belts, forklift, overhead crane, mechanical trolly etc. But conveyor belt has been dominant in the industries. It can be used for varieties of applications. It is a continuous transportation equipment which can handle large and heavy materials. Conveyor belt has been in industries since 1905. It primarily consists of gears, belt and motor. It can transfer goods from one place to another continuously because of the friction between goods and conveyor belt.

There are different types of conveyors like overhead chain conveyors, roller conveyors, vertical conveyors with forks, flexible conveyors etc. It is used at distribution centres, newspaper print plant, transportation in apparel industries, etc.

SECTION 3: KINEMATICS

SECTION 3.1: KINEMATIC SKETCH

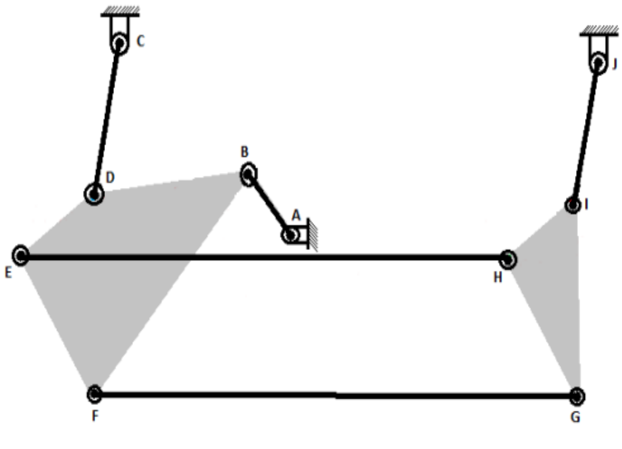
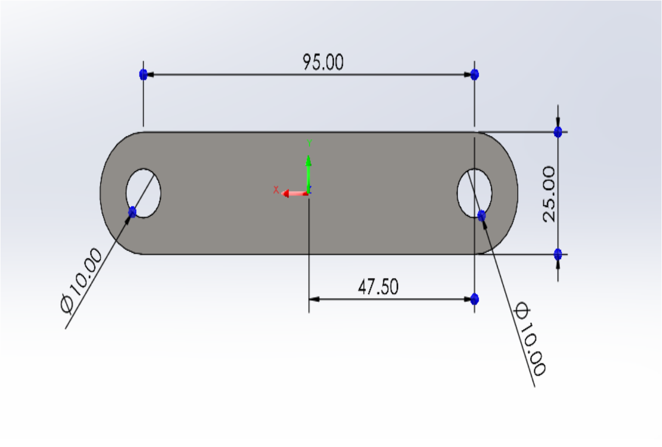
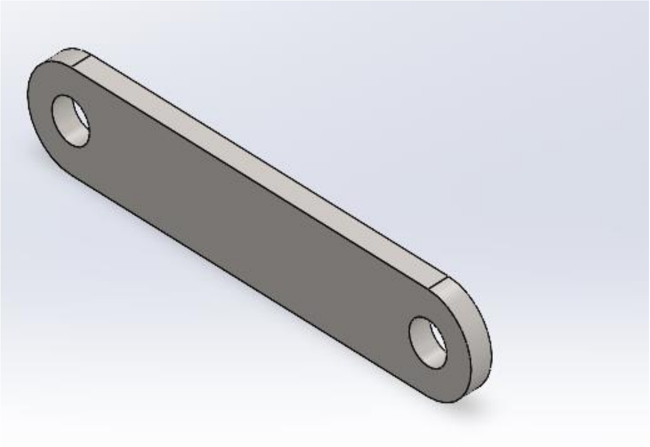


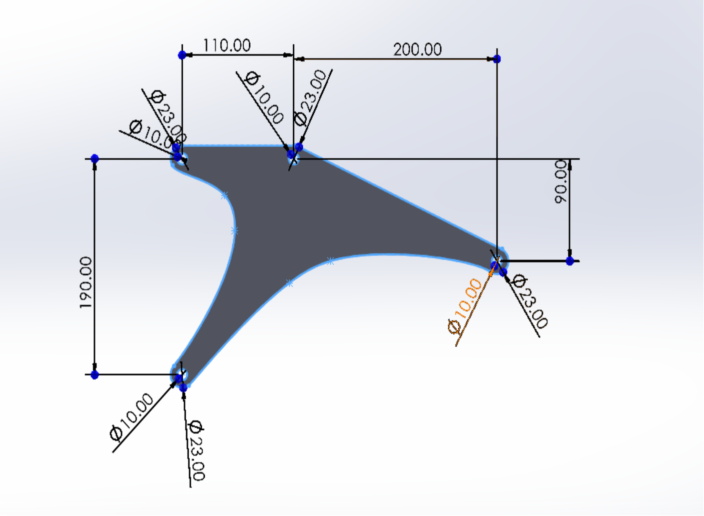
Fig. 9 Kinematic Sketch

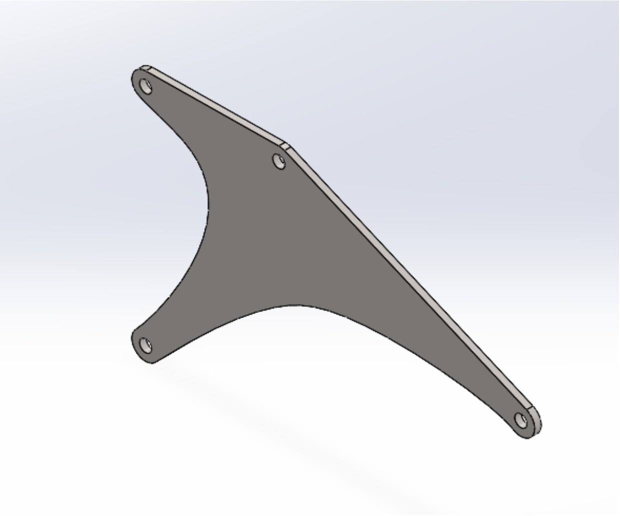
LINK AB:



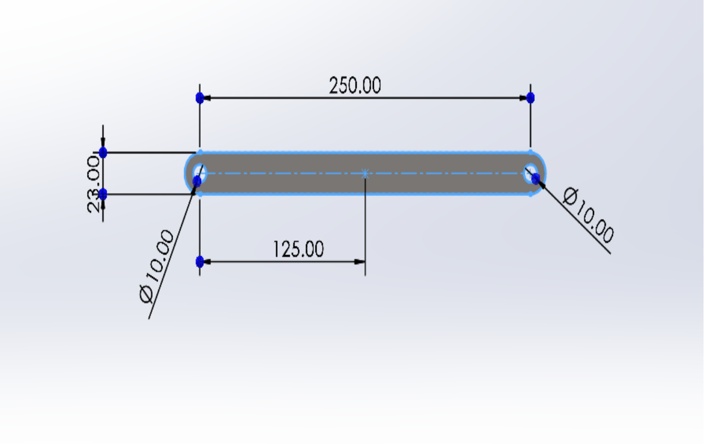


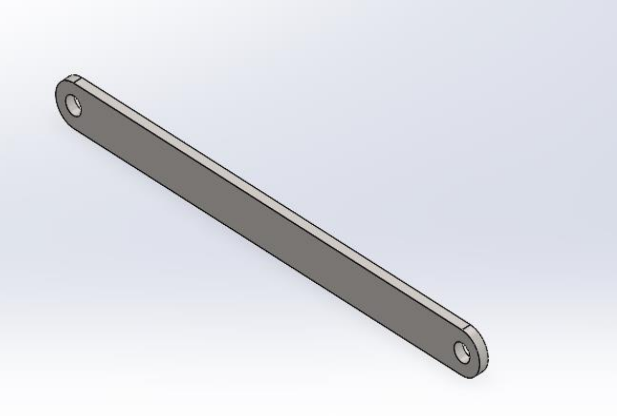
LINK BDEF:



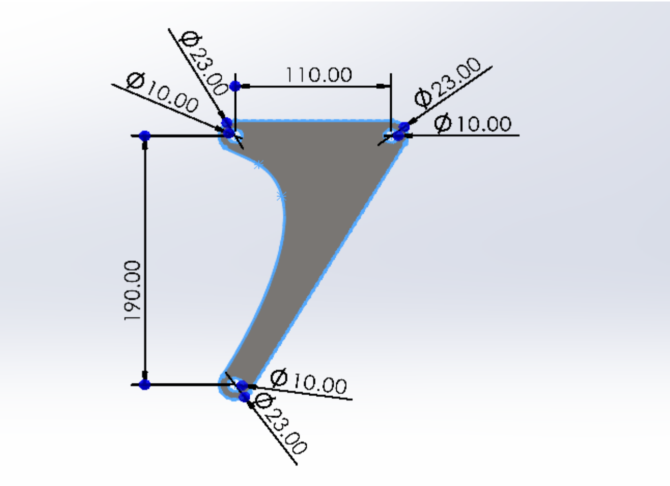


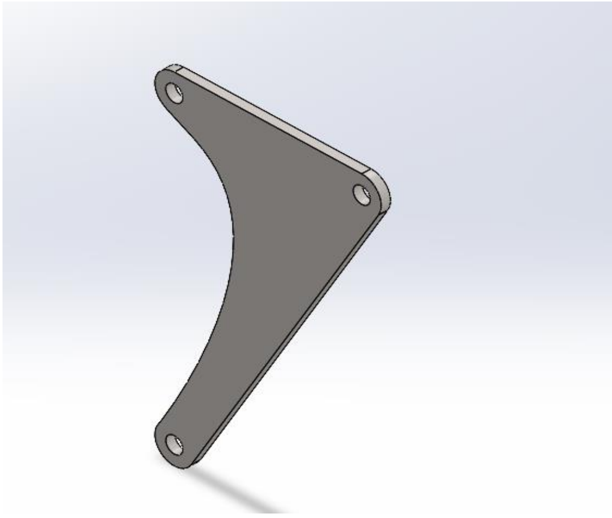
LINK CD AND IJ:



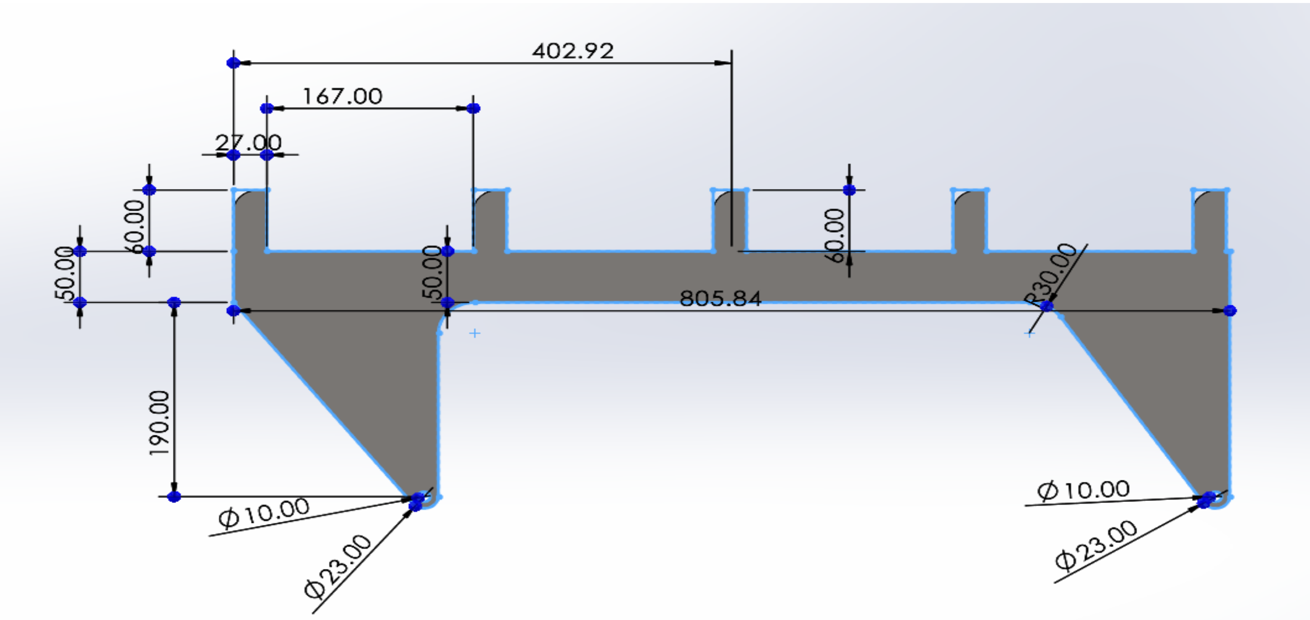


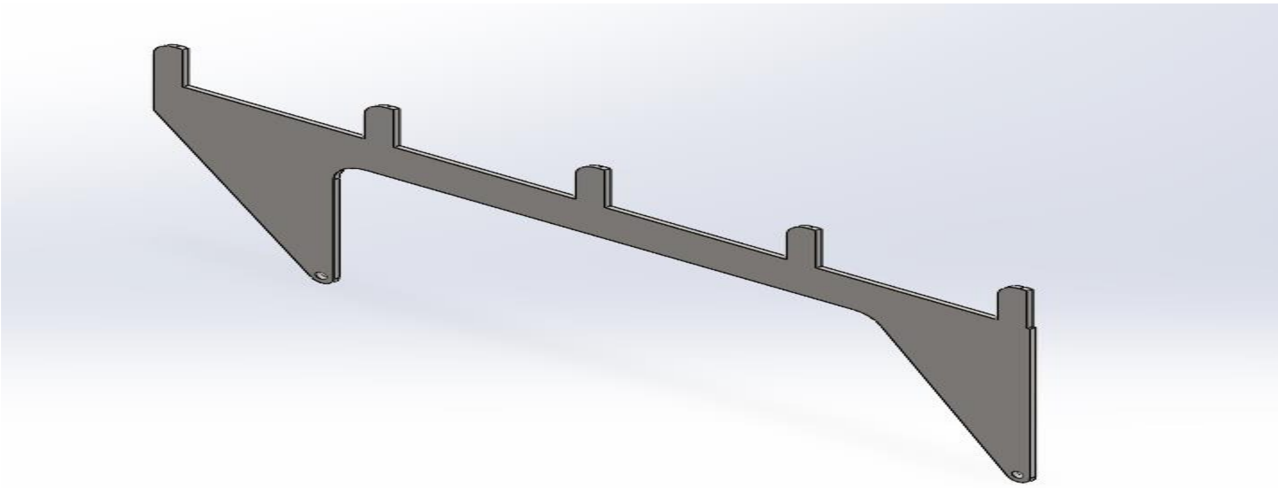
LINK GHI:





LINK EH:





LINK FG:

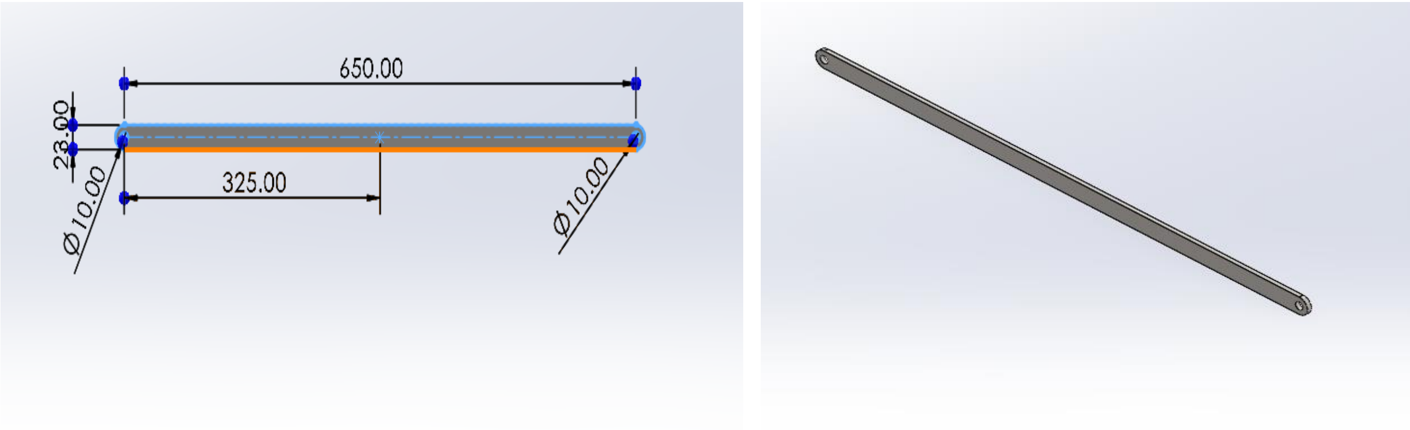


Fig. 10 Dimensions and Solidworks model of link AB, BDEF, CD, IJ, GHI, EH and FG

All links thickness: 11mm *****All dimension in mm*****

SECTION 3.2: DESCRIPTION OF MOTION TRANSMISSION

$F_{eff} = 3(n-1) - 2(j - j_r) - h - F_r + P_r$

$F_{eff:}$ effective degrees of freedom

number of links = n = 8

number of lower pairs = j = 10

number of redundant lower pairs = j_r = 0

number of higher pairs = h = 0

number of redundant degrees of freedom = F_r = 0

number of three-link closed chains having three prismatic pairs in different directions = P_r = 0

F_{eff} = 3(8 - 0) – 2(10 - 0) – 0 – 0 + 0 = 1

Input link: Crank (AB)

Output link: Carrier Link (EH)

Box shifting mechanism is basically a crank and rocker mechanism. It consists of 8 links and 10 revolute pairs connected together in such a way that it gives linear reciprocating motion. The mechanism has one degree of freedom. All links are in parallel plane. All kinematic pairs are revolute. It has one quaternary link BDEF, one ternary link GHI and the rest are binary links. Links A, C and J are fixed links. The input of the mechanism is the crank AB which is connected to an electric motor by revolute pair. The output link is the carrier link EH which has linear reciprocating motion. Link BDEF is connected to link AB, link CD, link EH and link FG by revolute pairs and similarly, link GHI is connected to link EH, link FG and link IJ by revolute pairs.

Because of similarity in triangles in coupler and same hanger link, parallel mechanism is obtained and transferred through link FG. In one complete revolution of link AB, the output link i.e. carrier link moves forward for the half rotation of the crank and it dips a bit and revert back for the rest half rotation of the crank. The mechanism produces intermittent mechanism with stop and move motion. This stop and move mechanism helps to alter the product for in-house assembly line.

SECTION 3.3: EXPECTED DISPLACEMENT PROFILE OF OUTPUT COMPONENT

Carrier link (EH) is the output link, therefore every point on the output link has similar profile. Assuming a point P as shown in Fig. 11 and plot expected displacement, velocity, and acceleration profile with input angular velocity (constant) to be 2 rad/s.

(Length: mm, time: s)

(Point A is at origin)

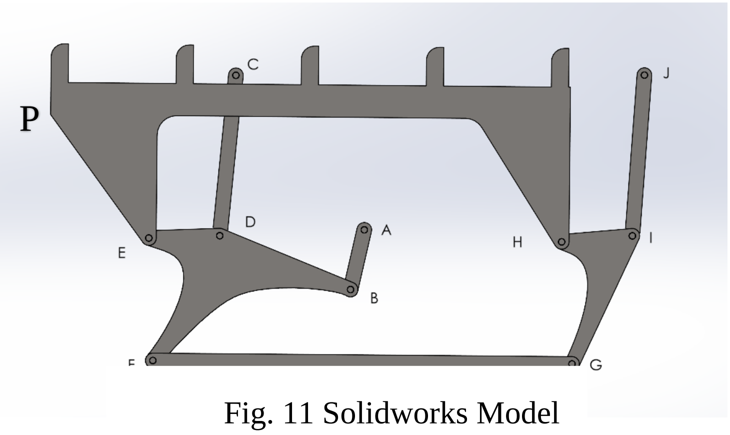
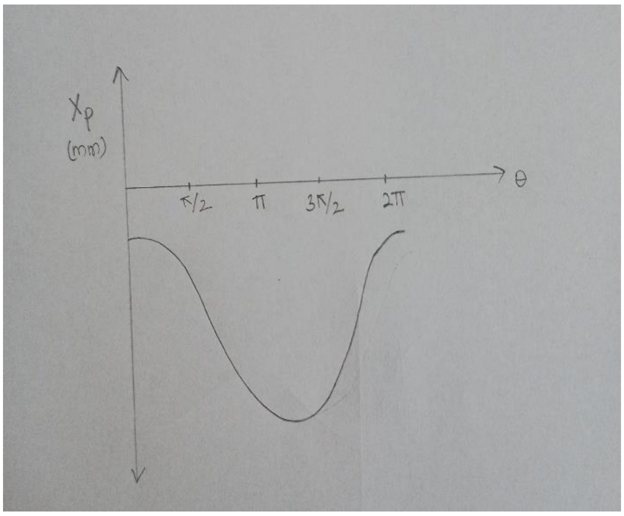


Fig. 11 Solidworks Model



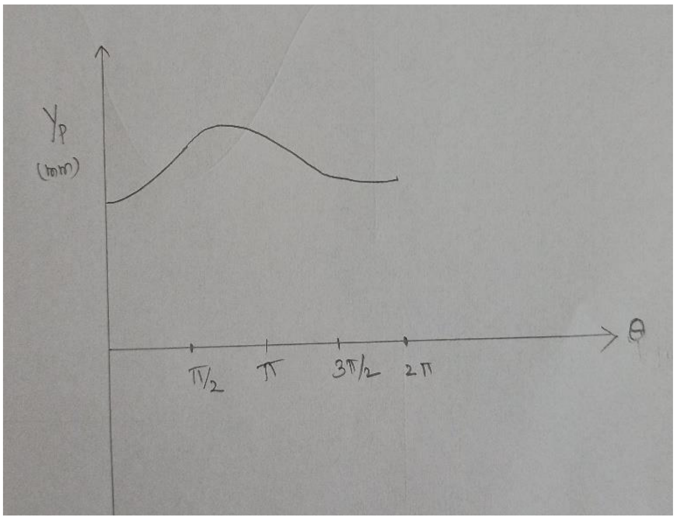


Fig.12 Expected Displacement Profile for Point P

SECTION 3.4: EXPECTED VELOCITY PROFILE OF OUTPUT COMPONENT

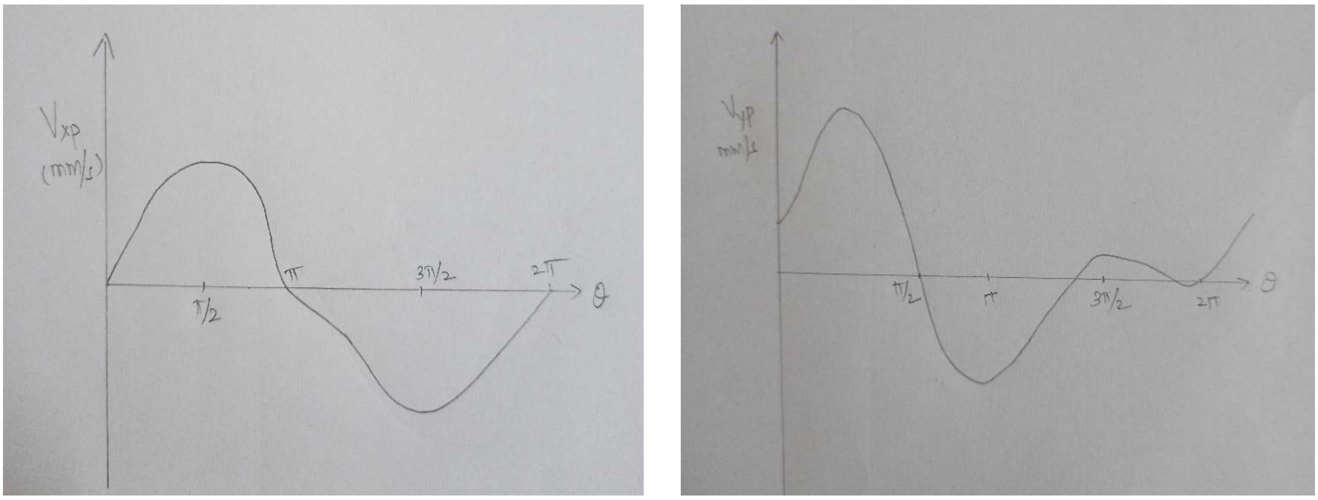


Fig.13 Expected Velocity Profile for Point P

SECTION 3.5: EXPECTED ACCELERATION PROFILE OF OUTPUT COMPONENT

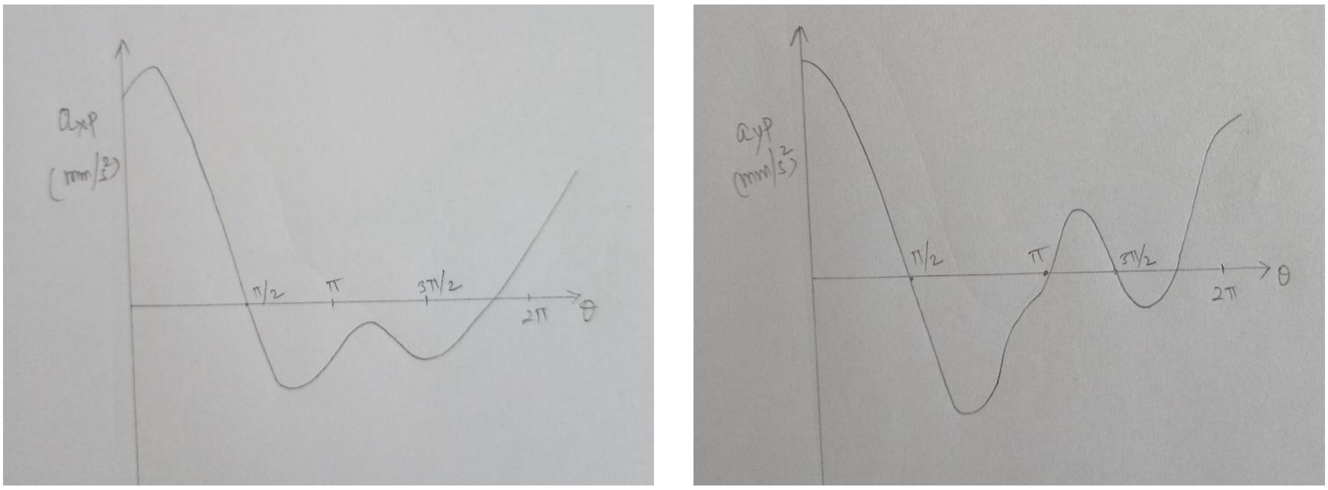


Fig.14 Expected Acceleration Profile for Point P

SECTION 4. KINEMATICS

SECTION 4.1. EXPECTED SPEED OF OPERATION

As per Samuel Doughty et. al [1], maximum velocity is expected to be v_{max} = 923.33mm/s for input of 1rad/s. Since the dimensions and locations are changed for the purpose of study, maximum velocity is expected to change. Further details are to be presented in term 1.

SECTION 4.2. POSSIBLE PROBLEMS WITH EXTREME SPEEDS

Very High speed

At high speed, there will be high impact force on the boxes which will impart velocity to the boxes causing them to disorient. This impact force doesn’t only damage boxes but also causes impact on joints of the mechanism and causes vibration. The transportation of boxes is no more synchronised because of the prior disorientation. The balancing time of line production system is disturbed. The boxes get out of line from transportation system.

Very low speed

At slow speed, the boxes will transport slowly and therefore the production rate decreases.

In both cases there is disturbance in balancing time for the entire in-house assembly.

REFERENCES

[1] Doughty S. (2013). Box Transfer Mechanism Analysis, Mechanizer

[2] Dharmendra Sinha et al. Kinematic Analysis of Package Convey Mechanism, ijraset, volume 4, Issue IV, April 2016

[3] LearnWithFun Final Year Mechanical Project (Box transport Mechanism) - YouTube

[4] Belt Conveyor https://wardcraftconveyor.com/wp-content/uploads/2016/11/horizontal-belt-conveyor-1-1.jpg

[5] Manual Trolley https://5.imimg.com/data5/XP/TS/QH/SELLER-998724/manual-trolley-500x500.jpg

[6] Forklift https://media.istockphoto.com/photos/forklift-truck-with-boxes-and-pallet-picture-id469957102

[7] Over head crane https://www.konecranes.com/sites/default/files/styles/5_7_small/public/cxt_underhung_full_2.jpg?itok=ED63o2-4

[8] 3d outline conveyor belt rendering of Royalty Free Vector (vectorstock.com)