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Mohd Najib Ali Mokhtar[1,a*], Nik Syahrim Nik Anwar[2,b], Mohd Nazrin Muhammad[3,c], Masni Azian Akiah [4,d] and Saifudin Hafiz Yahya[5,c]

[1,3,4,5] Faculty of Manufacturing, UTEM ,Malacca, Malaysia, [a]Email najibali@utem.edu.my
[c]Email: nazrin@utem.edu.my
[d]Email: masni.azian@utem.edu.my
[e]Email: saifudin@utem.edu.my
[2] Faculty of Electrical, UTEM, Malacca,Malaysia. [b]Email: syahrim@utem.edu.my

Abstract

Designs methods for four linkages encompass mathematical approach, trial and error method, function generation, motion synthesis and path synthesis. Various literatures found used mathematical approach to find specific solution. This main goal of this paper is to provide study of motion synthesis of four bar mechanism to find solution for mobile parts flipping application. Systematic procedures for motion synthesis to determine the length and position of the links in case of desired positions of a coupler are presented. The graphical method provides quick solution for designer regarding kinematic problem without involvement of complicated mathematical equation. Part of the solution is compared with mathematical approach and simulation approach. As a conclusion, the graphical approach result match with other method and helpful to provide better insight of the system during designing the solution. .

Keywords—Four Bar Linkages; Motion Synthesis; Slider Crank Mechanism; Analytical; Simulation

I. INTRODUCTION

A lot of working processes require flipping motion of an object especially during assembly and manufacturing process like casting. The problem can be solved using various methods by considering transmission angles, linkages dimensions, Grashof law and finding mechanism that perform the task. Constrained system of equations are solved mostly using numerical techniques [1][2][3]. Mixed numerical and graphical methods for optimal four-bar synthesis have been presented by Yao and Angeles [4]. They allow identification of all critical points of the underlying optimization problem. Adjustable link to fit all different linkage position via mathematical model is studied by Tzong [5]. Kinematic synthesis of linkages without analytical approach is presented by L.G. Reifschneider [6].

The aim of this document is to provide information for engineer and designer using motion synthesis to solve the problem using four bar linkages. The solution is compared with other methods.

II. PROBLEM STATEMENT

In a substation of casting process, object needs to be flipped over before the next task is performed. Linkages of mobile robot are to be designed and used to flip the box 180 degree. Four bar mechanism will be used to flip the object. The flipping mechanism has to be able to be navigated at working area of 45 degree as shown in Figure 1. For the navigation, slider crank mechanism is used to transfer linear movement to the rotational motion and move the flipping mechanism.

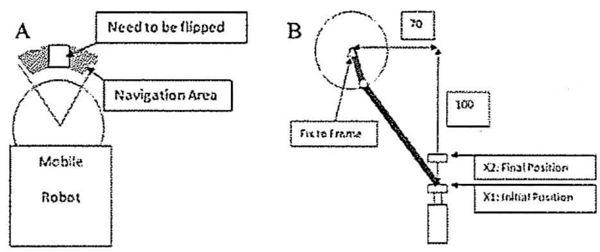


Figure 1a) Mobile robot for flipping application b) Slider crank mechanism for movement control in navigation area

III. MECHANISM DESIGN

The designs involve two mechanisms which are flipping mechanism and navigation mechanism.

A. Flippling mechanism using four bar linkage

The design of flipping mechanism involved four bar mechanism and graphical approach is used to design solution of certain linkages. The values are then compared with the analytical approach. Some of the parameters are predetermined due to the design specifications and constraints. The Table 1 lists the predetermined values for the four bar linkage solution. There are 3 unknown that have to be determined using motion synthesis, motion linkage (L1), coupled linkage (L2) and the angle between them.

Table 1: Predetermined value for four bar mechanism

Frame linkage	100 cm
Driver linkage	60 cm
Initial angle of driver linkage	10°
Final angle of driver linkage	90°
Initial angle of motion linkage	35°
Final angle of motion linkage	165°

The frame linkage is the one that mounted on rotational body of mobile robot which placed at the front of the main body of mobile robot. The length between the joint to joint is fixed to 100 centimeter. The driver linkage is used to control the motion of the flipping part and transmit the force to the front linkage when the final angle is reached. The length of the driver linkage is 60 centimeter. For graphical approach, scale of 1:10 is used in the drawing.

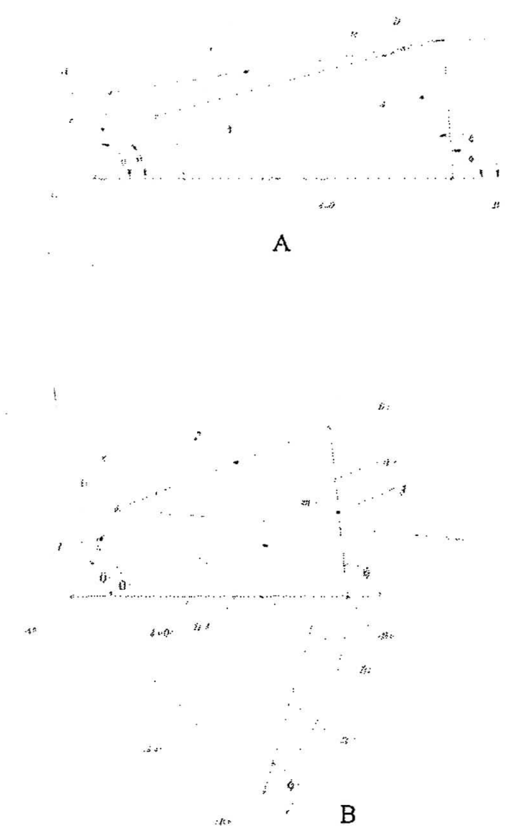


Figure 2: 2 positions motion synthesis of 4 bar linkages a) 2 defined positions b) Graphical approach to determine linkage

For the analytical approach, trigonometric laws are used to determine the remaining linkages based on the given positions.

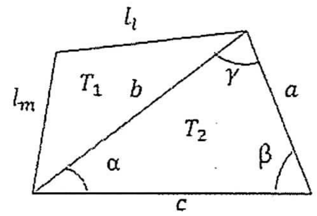


Figure 3: Triangular forming in for bar linkage problem

Using notation as Fig. 3, Eq. (1) can be derived according to the law of cosine and Eq. (2) is stated according to the law of sine.

(1)

— — — (2)

Solving the lower triangular, and based on the chosen parameters at two positions, the length of and can be calculated using Eq. (1) and Eq. (2). Notation represents length of b at initial position and represents length of b at final position. From the initial calculation,

and = 116.62 mm

Then, upper triangular is solved for both positions and using cosine law, following Eq. (3) and Eq. (4) are formed;

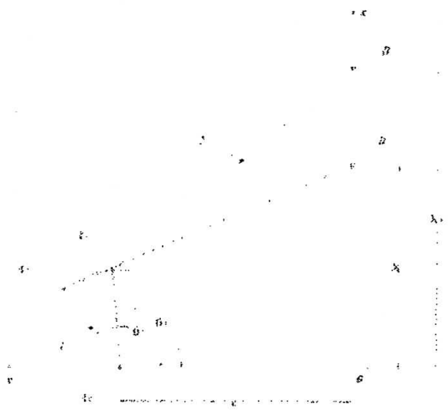
(3)

(4)

Solving both equations 3 and 4, the remaining linkages can be determined as:

B. Navigation using slider crank mechanism

The design of navigation part involved slider crank mechanism to transmit linear motion to the rotational motion about 45° from initial position. The slider mechanism is placed 100 centimetres below the centre of rotation and at radial distance of 70 centimetres from the centre as shown in Figure 1. Base on the constraint parameter, remaining linkages are determined via graphical approach. Using motion synthesis via graphical approach as shown in figure



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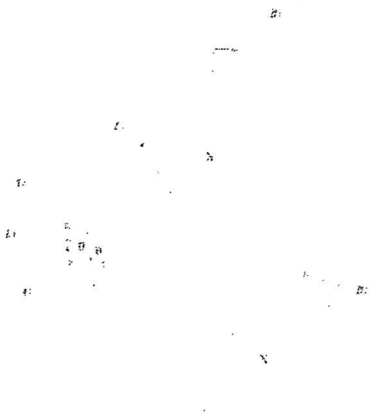
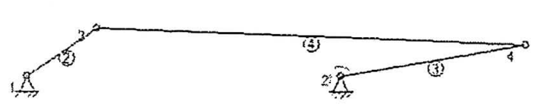


B

Figure 4: 2 positions motion synthesis of slider crank mechanism a) 2 defined positions b) Graphical approach to determine linkage

C. Kinematic Simulation

Simulations of all linkages are conducted using software SAM 6.1. Using the software, try and error method is used to achieve the solution.



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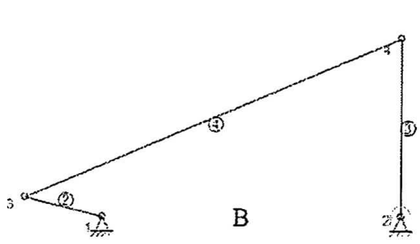

Figure 5: 4 bar linkage design using try and error method a) initial linkage position b) final linkage position

The lines in the simulation represent linkages and the small circles represent joint. From the predetermined parameters, linkages are drawn and various le

A B

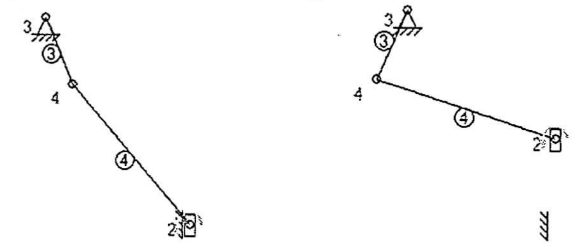

Figure 6: Try and error method of slider crank mechanism a) Initial linkages position b) final linkages position

IV. Result

The results of motion synthesis, simulation and analytical approach are presented in Table 2. The graphical approach shows similar results with the mathematical approach and achieves the wanted angle for both 4 bar linkage mechanism and slider crank mechanism. Using the try and error method, the percentage error decrease proportional to the number of trials.

Table 2: Results of various methods

Method	Linkage	4 bar linkage Mechanism	Slider Crank Mechanism		
			x2= 60mm	x2=70mm	x2=80mm
Graphical Method	L1	27.18	35.34	32.02	24.19
	L2	136.92	87.88	91.06	97.83
Try and error Method	L1	27.00	35.00	29.00	22.00
	L2	136.00	88.00	93.00	99.00
Mathematical Method	L1	27.19	-	-	-
	L2	137.91	-	-	-

V. Conclusion

The main contribution of graphical approach from motion synthesis is quick solution and better insight to the problem. Approach of two position motion synthesis via graphical approach for slider crank mechanism and four bar linkage are presented.

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