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Kinematic Synthesis of Four Link 4R Mechanism using Freudenstein Equation

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Abstract- *The paper presents kinematic synthesis of four link mechanism with the aid of Freudenstein Equation for two finitely separated positions. The synthesis is carried out considering the relationship between input and output link. This process is illustrated with an example. The synthesized mechanism consists of for revolute joints. Thus, Freudenstein Equation focuses on a non-iterative and simplified way of mechanism synthesis.*

Keywords: Kinematic Synthesis; Four Link Mechanism; Freudenstein Equation

1. INTRODUCTION

The four link mechanism is the fundamental mechanism which always plays its role in the industrial sector. Major parts of research work and applications have been dealt by design engineers considering the four link mechanism. The foremost aspect in kinematics of mechanisms is the synthesis of mechanism. This mechanism is synthesized on the basis of Freudenstein equation method. Synthesis consists of dimensional, type and number synthesis to perform various tasks. Synthesis and Analysis are the two major categories of design process of mechanism. Synthesis process involves devising a mechanism to perform the desired task and analysis process involves functioning of the mechanism.

2. LITERATURE REVIEW

This text deals with the literature review on four link mechanism and method adapted for synthesis by different people working in this area. Ashitava Ghosal [1] discussed on Freudenstein equation method. Ajay A. Dhore and R.D.Askhedkar [2] dealt with synthesis of four bar mechanism. A mechanism is a mechanical device that has the purpose of transferring the motion or force from an input link to an output link [3]. The mechanism consists of links or bars connected by joints to form a closed loop. The mechanism may also consist of lower pairs, higher pairs or combination of both pairs. H. M. Naveen, Shrinivas S. Balli and Umesh M. Daivagna [4] dealt with synthesis of geared slider crank mechanism. The technological development made an improvement of life style in the present world. Machines play a vital role in day to day life. Machines consist of mechanism or combination of mechanisms to do useful work. Design of mechanisms and machines is of major importance in mechanical design [6]. The study of mechanisms began in antiquity under the pressure of necessity [7]. The importance and the applications of machines and mechanisms are realized throughout the history. The study of mechanisms involves synthesis, analysis and their practical applications.

Dimensional synthesis seeks to determine the significant dimensions, the starting position of a mechanism of preconceived type for a specified task and prescribed performance [6, 7]. A mechanism of preconceived type may be a slider-crank, a four-bar linkage, etc. There are graphical and analytical synthesis methods available [8].

3. SYNTHESIS OF FOUR LINK MECHANISM USING FREUDENSTEIN EQUATION

Synthesis of four link mechanism considered in this case is carried out using Freudenstein Equation. The four link mechanism is represented in fig.1.

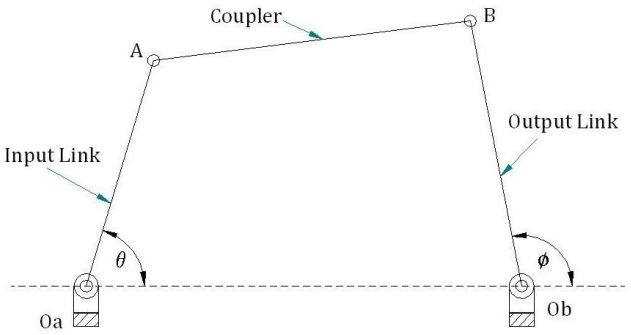

Fig.1 Four Link Mechanism

The four link mechanism consists of input link O_aA and output link O_bB. These links are connected by the coupler AB. O_aO_b represents the ground link. When input motion is given to the input link by θ, the output link produces the output as φ. This fundamental configuration of the mechanism is considered for the synthesis process.

The Freudenstein Equation [5] is given by

$K_1 \cos \varphi - K_2 \cos \theta + K_3 = \cos(\theta - \varphi)$ ---------- Eq. 1

$K_1 = \frac{d}{a}$, $K_2 = \frac{d}{c}$ and $K_3 = \frac{a^2 - b^2 + c^2 + d^2}{2ac}$ ---------- Eq. 2

The link lengths of the considered mechanism are given by

$O_aA = a$, $AB = b$, $O_bB = c$ and $O_aO_b = d$

$l_1 = d$, $l_2 = a$ $l_3 = b$ and $l_4 = c$

Solving the above equations for three positions determines the link lengths.

4. AN ILLUSTRATION

Synthesize a four link mechanism such that the input and output angles are coordinated as provided.

Input Crank Angle: 20^0 35^0 50^0
Output Follower Angle: 35^0 45^0 60^0

Solution: Consider the four link mechanism as represented in fig.1

Consider the Freudenstein Equation
$K_1 \cos \varphi - K_2 \cos \theta + K_3 = \cos(\theta - \varphi)$
$K_1 \cos 35^0 - K_2 \cos 20^0 + K_3 = \cos(20^0 - 35^0)$
$K_1 \cos 45^0 - K_2 \cos 35^0 + K_3 = \cos(35^0 - 45^0)$
$K_1 \cos 60^0 - K_2 \cos 50^0 + K_3 = \cos(50^0 - 60^0)$

Solving the above equations for three positions determines the values of K_1, K_2 and K_3 as

$K_1 = 0.6399$, $K_2 = 0.7514$ and $K_3 = 1.1478$

Substituting the above values in Freudenstein Equation and assuming the ground link length as 10 cm, lengths of links are determined.

$l_1 = d = 10$cm
$l_2 = a = 15.627$cm
$l_3 = b = 6.625$ cm
$l_4 = c = 13.30$ cm

Synthesized mechanism is represented in the initial position in fig.2.

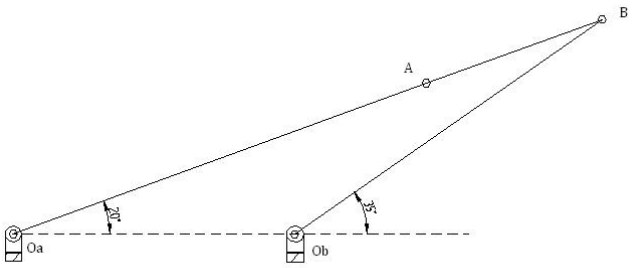

Fig. 2 Synthesized Four Link Mechanism

CONCLUSION

Any four link mechanism can be synthesized using Freudenstein Equation which is a non iterative process. The synthesized mechanism can be applied for numerous applications. The comparative study of characteristic behavior of synthesized mechanism using Linkage Software can be considered for simulation under linkage program to study the working condition of the mechanism. This helps the designer to verify the results obtained and develop a defect free operating mechanism to serve the society.

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