E-ISSN: 2278–179X

JECET; March - May 2013; Vol.2.No.2, 422-426.

Journal of Environmental Science, Computer Science and Engineering & Technology

An International Peer Review E-3 Journal of Sciences and Technology

Available online at www.jecet.org

Engineering & Technology

Research Article

Kinematic synthesis and analysis of four bar Mechanism using expert system

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Received: 26 March 2013**; Revised:** 15 May 2013; **Accepted:** 28 May 2013

Abstract: A considerable amount of research has been carried out on the synthesis of mechanisms with linkages. Such mechanisms can be used in many ways and in general, synthesis is carried out with reference to input positions and output positions. In this study, the expert system analyzes the four bar double rocker mechanism for given set of inputs which includes the distance of the ground pivots depending upon the space constraint for the mounting of the mechanism, the angles of swing of the input link and the angle of swing required by the output link. The results of the kinematic synthesis and analysis module of the expert system have been compared using a standard problem.

Key words: Kinematic synthesis, kinematic analysis, four-bar mechanism, expert system.

INTRODUCTION

The expert system automates the solving of problems in conjunction with the kinematic analysis and the synthesis of plane link mechanisms. Having understood the importance of four bar mechanism in machinery and industry, it becomes imperative to employ an expert system for four-bar mechanism, in order to obtain the best suitable possible mechanism, in the direction of desired motion. In this study, the software 'ExpFbr 1.0' has been used for synthesis and analysis of double rocker four bar mechanism. Synthesis method is carried out with three precision points using the Freudenstein's equation and followed by the position, velocity, and acceleration analysis. This software provides option to the user to select the synthesis and analysis step.

A mechanism is a device that transforms motion to some desirable pattern and transmits power. Kinematic analysis is the study of relative motions associated with the links of a mechanism and is a critical step toward proper design of a mechanism. Kinematic synthesis is a reverse problem to the analysis. In this case, the designer is challenged to devise a new mechanism that satisfies desired motion characteristics of an output link.

Data entry is performed through serial entries of the parameters that form the desired kinematic scheme. The program can immediately enter all the parameters of any kinematic scheme saved in the library. The output data in the kinematic analysis are values that describe the motion of the kinematic scheme. According to the position of the input link, in expert system, angles, velocities, and acceleration are calculated for the operating link (in transmitting mechanisms). Using the results of the kinematic analysis of the input kinematic scheme in the system, a step-by-step animated simulation of the mechanism motion is realized.

LITERATURE REVIEW

Ngale Haulin *et al.*[1] published a case study of optimal synthesis of a planar four bar mechanism used in hand prosthesis. It is shown that through a comparative study, it is able to select the number of points and the position of each to satisfy the performance criteria.

Rundgren Brian[2] developed an approach that found an optimized planar four link mechanism that produced a resistance force curve that matched a desired human strength curve. This work furthers the discipline of mechanism design by combining dynamics into existing linkage synthesis methods, resulting in an improved synthesis method that includes both static and dynamic effects.

Shrinivas Balli and Satish Chand[3] considered transmission angle to reduce the solution space for the design of five-bar mechanism with variable topology and suggested a method to synthesis a planar five bar mechanism of variable topology.

Varbanov *et al.*[4] produced an excellent compilation of expert system for planar mechanisms design. This expert system is developed by including the other classes of planar mechanisms with higher degrees of freedom.

KINEMATIC SYNTHESIS

Dimensional synthesis consists of finding the possible lengths of links necessary to accomplish the desired motions for the set of given input parameters. The inputs for the synthesis are the dimension of the fixed link, angular positions of the input lever (input angles), angular positions of the output lever (output angles) that is desired. A standard problem (write up sheet on worked example of four bar mechanism) is considered. A 4-bar mechanism is required such that the link angles will be coordinated as follows: Input angles: $\Phi1 = 30$ deg ; $\Phi2 = 50$ deg ; $\Phi3 = 80$ deg

Output angles: $\Psi 1 = 0$ deg ; $\Psi 2 = 30$ deg ; $\Psi 3 = 60$ deg

Fixed Link length = R1 = 1.429 units

The above input is given to the software and the results of four bar link lengths have been presented below.

Table I: A comparison of results of synthesis module

	R1	R2	R3	R4
Analytical method	1.429 units	1.000 units	1.797 units	0.780 units
Software	1.429 units	0.999 units	1.808 units	0.797 units

From the table I it has been inferred that the synthesis module's results matches well with the analytical method and with low deviation.

KINEMATIC ANALYSIS

Position analysis: Position analysis generally consists of finding the positions of the coupler and the output link or rocker when the dimensions of all the members are given together with the input link's position. The position analysis is basically performed to check the play space of the mechanism and verify whether all the links are within the space constraints.

Input data: Link1 (Ground) = 90 mm; Link2 (Crank) = 30 mm; Link3 (Coupler) = 60 mm

Link4 (Rocker) = 45 mm. Input angle = $\theta 2 = 65$ deg

The output data i.e. angular positions of Link 3 and Link 4 are presented in Table II.

Table II: A comparison of results of position module

	θ_3 in deg	θ_4 in deg
Analytical method	13.151	114.827
Software	17.131	118.808

Velocity analysis: Velocity analysis is performed to determine the velocities of all the links and points of interest in the mechanism. Input data: Angular velocity of Link 2= $\omega 2 = -10$ rad/s cw

The output data i.e. angular velocities of Link 3 and Link 4 are presented in Table III.

Table III: A comparison of results of velocity module

	ω_3 in rad/s	ω_4 in rad/s
Analytical method	+ 3.901	- 5.353
Software	+ 4.12	- 5.04

Acceleration analysis: Once a velocity analysis is done, the next step is to determine the accelerations of all the links and points of interest in the mechanism or a machine.

Input data: Angular acceleration of Link 2 = $\alpha 2$ = 2 rad/s2 ccw

The output data i.e. angular accelerations of Link 3 and Link 4 are presented in Table IV.

Table IV: A comparison of results of acceleration module

	α_3 in rad/s^2	α_4 in rad/s^2
Analytical method	7.062	69.768
Software	7.12	74.05

The results obtained by the kinematic analysis module are compared with the standard worked examples. The results obtained for the position analysis deviates more when compared with other modules, this is because of the increase in the equations used which in turn effects with decimal points with each equation. The velocity and acceleration module's results matches well with the analytical method and with low deviation.

CONCLUSION

An attempt has been made to compare the results of the kinematic synthesis and analysis module of the expert system using a standard problem. The results indicate that the expert system can be satisfactorily used to obtain the solutions related to four bar mechanism with certain assumptions made for the development of the software.

ACKNOWLEDGEMENT

We thank Dr.S.Selvarajan for his valuable contribution and constant motivation throughout the duration of this study.

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