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Design Synthesis & Analysis for Circular Path Generation using Adjustable linkages

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ABSTRACT

The informed of 4-bar linkage to hint a favored course is an important part of obtaining the superior geometry of a 4-bar linkage which is utilized in design. When the range of the precision aspects exceeds a special range, it's no longer skills to make use of or it is complex to make use of analytical methods. Nevertheless some intelligence optimization methods will even be utilized headquartered on the complexity of the crisis. Direction synthesis of four-bar linkages with multiple numbers of precision aspects has been illustrated as an optimization organization. A computer programmed situated on this algorithm is utilized in Matlab to collect some of the best dimension of 4-bar linkage. The carried out records are employed to generate preliminary possible picks and mighty object perform.

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I. INTRODUCTION

The principal route new encumbers predominant trouble in 4-bar mechanisms offers with acquiring linkage parameters such that a given factor on the coupler of the 4-bar mechanism follows a prescribed course. There are two varieties of course iteration issues specifically, point-to-point course iteration and continuous route iteration. Inside the case of a planar 4-bar mechanism, there are at most 9 parameters and one Boolean worth which defines the mode of the linkage meeting and in point-to-element direction new free up the coupler point can even be made to go exactly through at most nine prescribed precision elements.

In consistent route new unlock the trail is distinct by way of an massive number of elements (greater than 9) and the coupler factor may just or would probably now not move via all of them precisely. The steady path new release predicament is solved as an optimization quandary, and one could acquire the 4-bar mechanism parameters which minimizes a favoured function participate in. Earlier researchers have worked on optimization headquartered method of adjustable planar 4 bar, crank rocker mechanisms. Some have developed most suitable synthesis process for multiphase steady route generation of adjustable planar 4 bar linkages.

II. OBJECTIVES

The objectives of this experiment are as follows:

- To design and dimensional synthesize path generating mechanism.
- To optimize synthesis of adjustable four bar crank rocker type mechanisms for approximate multi path generation.
- To analyze and simulate adjustable linkages for path generation.
- Testing with working model to verify optimization method.

III. PROBLEM STATEMENT

In profile cutting operation it is essential to move the cutter in particular path and in case of mass production it is difficult to maintain the accuracy for manual cutting. So it is required to design the adjustable mechanism for prescribed path generation. It will give more accurate cutting compared to manual cutting.

IV. LITERATURE REVIEW

Chanekar Prasad Vilas et. al. [2], this paper offers with an optimization centered method for synthesis of adjustable planar four- bar, crank-rocker mechanisms. For more than one exclusive and preferred path to be traced with the aid of a factor on the coupler, a two stage procedure first determines the parameters of the feasible driving dyads. Then the remaining mechanism parameters are decided within the second stage where a least-squares situated circle-fitting approach is used. Compared to present formulations, the optimization process makes use of less quantity of design variables. Two numerical examples exhibit the effectiveness of the proposed synthesis approach. The article grants a brand new optimization founded methodology for synthesizing adjustable planar four- bar mechanisms for approximate multi-course iteration. The changes can be made in each the using aspect and pushed part of the mechanism.. The proposed process is illustrated making use of two examples and for these examples; the results are within affordable error limits.

Dr. R. D. Askhedkar et. al. [3], on this paper the creator provided a procedure to enumerate and codify the options of type synthesis of linkage mechanisms with rotoidal and prismatic joints. The essence of mechanism synthesis is to seek out the mechanism for a given movement. Type Synthesis is the first stage of conceptual design of mechanisms, the place the quantity, form and connectivity of links and joints are determined. It is followed by the Dimensional Synthesis stage, the place the hyperlink lengths and pivot positions are computed to fulfill a given kinematic project. The latter and the subsequent levels of detailing design are very pricey. Consequently, the goal is to advocate all “non-isomorphic topologies” without repetitions pleasurable structural requisites.

Girish Kamat et. al. [4]The author states that adjustable mechanisms are in a position of generating more than one paths with a change in one or more mechanism parameters and with pretty much the identical hardware. Little work has been carried out in the field of synthesis of adjustable linkages for steady direction iteration, mainly of adjustable planar four bar linkages. The path flexibility of adjustable 4-bar linkage is analyzed. The quandary for 4-bar linkages to generate steady paths is that the favored continuous direction can most effective be generated roughly. This problem may also be overcome by using adjustable four-bar linkages. Conventional linkage mechanisms furnish high speed capacity at a low cost; however fail to furnish the pliability required in many industrial functions. However, for most manufacturing automation applications, highly-priced multi-axis robots are employed for simple repetitive operations that require only constrained flexibility. With a view to provide an most useful solution between conventional mechanism-centered automation and overly flexible robots, adjustable mechanisms were introduced. The changeable parameter can either be size of one or more links or a transformation in the function of a constant pivot.

Edmund H.M. Cheung et.al [5], States that Adjustable linkages can generate different paths with a simple adjustment of the fixed pivot position of the pushed side-hyperlink. Constrained work has been accomplished within the discipline of synthesis of four bar linkages for steady direction new release, primarily of adjustable four-bar linkages. There are two types of adjustable 4-bar linkages with entirely rotatable using aspect-links, adjustable crank-rocker and adjustable drag-link linkages. The path flexibility of the two adjustable linkages is analysed. The most appropriate synthesis model is mounted headquartered on the link-length structural error of the driven side-hyperlink presented in this paper, which can effectively reflect the total difference between the desired and the generated paths, can restrict the difficulty of settling on corresponding evaluation aspects on the 2 paths, and will also be calculated readily. A modified genetic algorithm is employed to acquire the worldwide ideal solution. The outcome of two superior synthesis examples confirms the effectiveness of the proposed approach. A 4-bar linkage can generate different paths by way of adjusting the role of the pushed aspect-link fixed pivot.

Chong Peng et.al. [6], this author defines an ultimate synthesis system is developed for multi-phase steady direction generation of adjustable planar four-bar linkages. The non-adjustable driving dyad is first decided optimally using full rotation requisites. With coupler angles in any respect design aspects calculated, the pushed dyad is found through an additional optimization headquartered on the hyperlink length structural error. This method makes use of much less design variables and outcome in compact error capabilities. A numerical illustration demonstrates its effectiveness. A premier synthesis method is developed for planar 4-bar linkages with driven dyad adjustable for multi-segment continuous route iteration. Via synthesizing the adjustable linkage dyad by using dyad, the proposed method avoids the use of input crank angles as design variables and results in compact error features. The non-adjustable riding dyad is first decided optimally utilizing full rotation necessities, and then the coupler angles at all design facets are calculated. The synthesis of the adjustable driven dyad is discovered through a further optimization established on the hyperlink size structural error. Three forms of adjustments are regarded. A numerical illustration verifies the proposed approach.

Hong Zhou [7], he mentioned that a favored steady direction may also be generated precisely by using an adjustable 4-bar linkage. On this paper, a slider is used to adjust the pivot vicinity of the driven side link. The linkage feasibility stipulations and course generation flexibilities are analyzed. The synthesis mannequin is headquartered on the most useful adjustment of the slider region. The global foremost solution is searched with the aid of genetic algorithm. The effectiveness of the synthesis process proposed within the paper is verified via two demonstrated examples. The preferred steady paths may also be generated exactly by adjustable 4-bar linkages with the continuous adjustment of one unbiased parameter. This paper introduces an top of the line dimensional synthesis procedure of adjustable 4-bar linkages for the special iteration of continuous paths. The one-measure-of-freedom parameter adjustment is used in this paper for the specified generation of steady paths. An adjustment P joint is connected to the pivot of the driven aspect hyperlink of the four-bar linkage to make its vicinity adjustable. A closed-loop 4R1P linkage is formed via the adjustable 4-bar linkage. The adjustable 4-bar linkages may also be adjustable crank-rocker or double-crank linkages with exclusive linkage feasibility stipulations and route new release flexibilities. To avert lifeless position, linkage dimensions and slider adjustment tiers must satisfy feasibility stipulations. There is more than one corner on the 2 desired continuous paths. If general nonadjustable 4-bar linkages are used to generate them, the discrepancy is obvious between the roughly generated paths and the preferred paths.

Ashitava Ghosal, et.al. [8], Ferdinand Freudenstein (1926-2006) is largely recounted to be the daddy of latest day kinematics of mechanisms and machines. His Ph. D. Thesis in 1954 and subsequent learn papers by way of him and his students have influenced educational and industrial gain knowledge of, instructing and observe involving the analysis and design of mechanisms and machines for the duration of the arena. In this article, we revisit Freudesteins thesis and the equation named after him. The Freudestein equation end result from an analytical method towards analysis and design of 4-hyperlink mechanisms which, along with its variants, are reward in a massive quantity of machines utilized in daily existence. Freudensteins contribution to the notion of mechanisms and machines is now most often famous and the equation named after him is now reward in practically all textbooks on evaluation and design of mechanisms. It's fascinating to become aware of that when his seminal papers regarded, researchers immediately realized the significance of his work. In his commentary writes that the creator has succeeded in reducing the analytical technique to the four-bar limitation to as easy a style as attainable analytical healing is by and large no longer any extra tricky or time-eating than the older graphical-geometric methods.

V. SYNTHESIS ANALYSIS

Required driving link angular displacement corresponding to the desired coupler curve.
The coordinate system of a four-bar linkage is shown in Fig below,

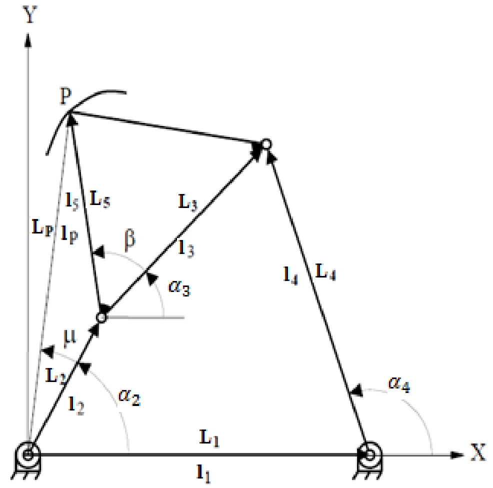

Fig.3. Four bar linkages

The speed trajectory of the driving link, and the lengths of links 1 oL 4 can be adjusted to generate new coupler curves. Figure 12 shows that the relationship between the angular displacement of the driving link 2 α and the coordinate of the coupler point (x y P , P) can be written as

$\alpha_2 + \mu = \tan^{-1} (P_y/P_x)$ (1)

and the vector loop equation can be written as

$L_2 + L_5 - L_P = 0.$ (2)

Separating Eq. (2) into two scalar component equations in the *x*- and *y*-directions yields

$L_2 \cos \alpha_2 + L_5 \cos (\alpha_3+\beta) - P_x = 0$ and (3)

$L_2 \sin \alpha_2 + L_5 \sin (\alpha_3+\beta) - P_x = 0$ (4)

where L_i and αi represent the length and angular displacement of the *i*th link, respectively. Adding Eqs. (3) and (4) after squaring both sides gives

$L_5^2 = P_x^2 + P_y^2 - 2L_2 (P_x \cos \alpha_2 + P_y \sin \alpha_2) L_2^2$ (5)

which, after rearrangement, gives

$(P_x \cos \alpha_2 + P_y \sin \alpha_2) + ((L_5^2 - P_x^2 - P_y^2 - L_2^2)/2 L_2)$ (6)

To reduce Eq. (6) to a form that can be solved more easily, we substitute the half angle identities to convert the cos α_2 and sin α_2 terms to tan α_2 terms:

$\cos\alpha_2 = (1 - \tan^2(\alpha_2/2))/(1+ \tan^2(\alpha_2/2))$; $\sin\alpha_2 = (2 \tan(\alpha_2/2))/(1+ \tan^2(\alpha_2/2))$

This results in the following simplified form, where the link lengths (L_2 and L_5) and the known value (P_x, P_y) terms have been collected as constants *A*, *B*, and *C*:

$A \tan^2 (\alpha_2/2) + B \tan^2 (\alpha_2/2) + C = 0$

Where

$A = ((L_5^2 - P_x^2 - P_y^2 - L_2^2)/2 L_2) - P_x$,

$B = 2 P_y$, and

$C = ((L_5^2 - P_x^2 - P_y^2 - L_2^2)/2 L_2) + P_x$

The angular displacement of the driving link can then be calculated as

$\alpha_2 = 2 \tan^{-1}[(-B\pm\sqrt{(B^2-4AC)})/2A]$ (7)

and the corresponding α_3 can be obtained from Eq. (4)

$\alpha_3 = \tan^{-1} (P_x - L_2 \cos \alpha_2)/(P_y - L_2 \sin \alpha_2) - \beta$ (8)

ADJUSTABLE LENGTH OF LINKS 1

From Figure 12, the vector loop equation can be written as

$\mathbf{L2} + \mathbf{L3} - \mathbf{L1} - \mathbf{L4} = 0$ (9)

If we assume that the length of link 4 can be adjusted, then we separate Eq.(9) into two scalar component equations and rearrange as follows:

$L_4 + \Delta L_4 \cos \alpha_4 = L_2 \cos \alpha_2 + L_3 \cos \alpha_3 - L_1 \cos \alpha_1$ (10)

$L_4 + \Delta L_4 \sin \alpha_4 = L_2 \sin \alpha_2 + L_3 \sin \alpha_3 - L_1 \sin \alpha_1$ (11)

where ΔL_4 is the length of adjustable link 4. By dividing Eq. (11) by Eq. (10) to eliminate ($L_4 + \Delta L_4$) , the angular displacement of link 4, α_4, can be expressed as

$\alpha_4 = \tan^{-1} ((L_2 \sin \alpha_2 + L_3 \sin \alpha_3 - L_1 \sin \alpha_1)/(L_2 \cos \alpha_2 + L_3 \cos \alpha_3 - L_1 \cos \alpha_1))$ (12)

Then ΔL_4 can be calculated as

$\Delta L_4 = (L_2 \cos \alpha_2 + L_3 \cos\alpha_3 - L_1 \cos \alpha_1)/\cos \alpha_4 - L_4$ (13)

Assuming that the length of link 1 can be adjusted, we separate Eq. 9 into two scalar component equations and rearrange them as follows:

$\cos \alpha_4 = L_2 \cos \alpha_2 + L_3 \cos \alpha_3 - (L_1 + \Delta L_1) \cos \alpha_1$ (14)

And

$L_4 \sin \alpha_4 = L_2 \sin \alpha_2 + L_3 \sin \alpha_3 - (L_1 + \Delta L_1) \sin \alpha_1$ (15)

We then square both equations and add them to eliminate one unknown, say α4. The adjustable length of link 1, denoted as ΔL_1, can then be expressed as

$\Delta L_1 = [(-B\pm\sqrt{(B^2-4AC)}/2] - L_1$

Where

$B = -2L_2(\cos\alpha_1 \cos\alpha_2 + \sin\alpha_1 \sin\alpha_2) - 2L_3(\cos\alpha_1 \cos\alpha_3 + \sin\alpha_1 \sin\alpha_3)$

$C = -L_4^2 + L_2^2 + L_3^2 + 2L_2L_3(\cos\alpha_2 \cos\alpha_3 + \sin\alpha_2 \sin\alpha_3)$

The corresponding α_4 is

$$\alpha_4 = \tan^{-1}((L_2 \sin\alpha_2 + L_3 \sin\alpha_3 - (L_1 + \Delta L_1)\sin\alpha_1)/(L_2 \cos\alpha_2 + L_3 \cos\alpha_3 - (L_1 + \Delta L_1)\cos\alpha_1) \quad (16)$$

Generation of a circular coupler curve with the centre at (-105.09, 122.448) and radius = 50 mm.

VI. EXPERIMENTAL SETUP

The experimental set-up is the combination of electronic and mechanical. Links of the mechanism of desired size are made in aluminium. The crank is driven by the steeper motor through gears. The length of the link 1 is adjusted by using screw mechanism.

It consists of:

1. Links
2. Bush Pins and Bearings
3. Screw Mechanism
4. Gears
5. Stepper Motors
6. Electronic controlling unit

1. Links:

4 links are made in the aluminium. These are manufactured by using laser cutting machine for accurate dimensions. The sizes of the links are given below.

Links	R_1	R_2	R_3	R_4	R_5
Dimensions	950mm	100mm	50mm	150mm	150mm

2. Bush Pins and Bearings:

Bush pins and bearings are used for the joints of the links. To minimize the friction between bush pins with bearings are used. Bush pins are manufactured on the lathe machine and standard bearing of 3 mm inner diameter and 10 mm outer diameter is used.

3. Screw Mechanism

Nut and screw mechanism is used to adjust the length of link 1. M 10 bolt having 1.5 mm pitch is used for the mechanism. Nut is fixed at one end of the link 4.

4. Stepper Motor

The Stepper motor is used for driving link 2 and rotating the bolt for adjusting the length of the link 4. The detailed specification of the Stepper motor is as follows:

Voltage: - 3 – 6 V
Current: - 1.5 A
Torque: - 4 kg-cm
Step Angle: - 1.8 deg/step
Shaft diameter: - 5 mm

5. Electronic Controlling Unit:

This unit is used to drive the motor simultaneously to achieve the desired path of the point E. It consists of Microcontroller and motor drivers.

Fig 4. Experimental Setup

VII. RESULT AND DISCUSSIONS

The analytical experiment has been conducted to achieve the desired path. The angular displacement of the driving link, and the corresponding length of link 1 are shown in Fig 4.

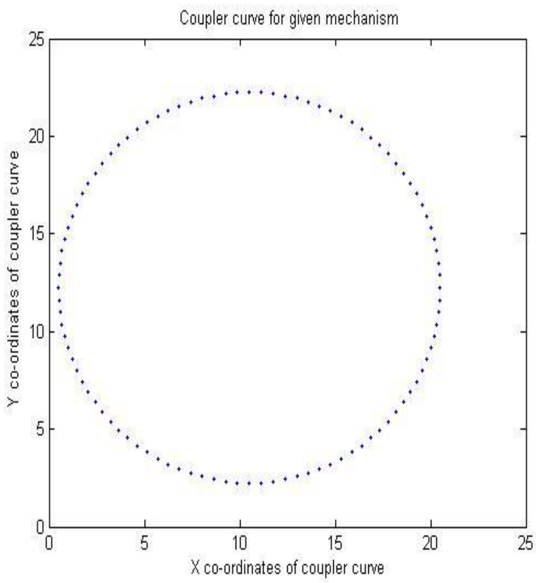

Fig. 5. Circular path obtained analytically.

The actual plot of the path followed by the point E as shown in fig.5 has angular displacement and change in length. The circle obtained experimentally is as shown in fig. 6. The circle drawn in red colour is drawn for calibration purpose whereas the circle in black is the obtained circle experimentally.

Fig6. Circular path obtained experimentally

VIII. CONCLUSION

We have successfully designed and synthesized optimal path generating mechanism. Analysis of the adjustable four-bar mechanism has been successfully performed. According to the crank angle change in angular displacement has been traced. Objective function is optimization process for synthesizing the various parameters which uses the least possible number of variables.

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REFRENCES

1. Theory of Machines, R. S. Khurmi.
2. Prasad Vilas Chanekar, Ashitava Ghosal, "Optimal synthesis of adjustable planar four-bar crank-rocker type mechanisms for approximate multi-path generation". Mechanism and Machine Theory 69 (2013) 263–277.
3. Ajay A. Dhore, Dr. R.D. Askhedkar, "Synthesis of Four bar mechanism by freudenstein Equation", International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 5,September- October 2012, pp.999-1002.
4. Girish Kamat, Gaurav Hoshing, Anand Pawar, Ajinkya Lokhande ,P.P. Patunkar and S.S. Hatawalane, "Synthesis and Analysis of Adjustable Planar Four-bar Mechanism", International Journal of Advanced Mechanical Engg. ISSN 2250-3234 Volume 4, No 3 (2014), pp. 263-268.
5. H. Zhou, Edmund H.M. Cheung, "Analysis and optimal synthesis of adjustable linkages for path generation", Mechatronics 12 (2002) 949–961.
6. Chong Peng, Raj S. Sodhi, "Optimal synthesis of adjustable mechanisms generating multi-phase approximate paths", Mechanism and Machine Theory 45 (2010) 989–996.
7. H. Zhou, Edmund H.M. Cheung, "Analysis and optimal synthesis of adjustable linkages for path generation", Mechatronics 12 (2002) 949–961.
8. Chong Peng, Raj S. Sodhi, "Optimal synthesis of adjustable mechanisms generating multi-phase approximate paths", Mechanism and Machine Theory 45 (2010) 989–996.
9. Hong Zhou, "Dimensional synthesis of adjustable path generation linkages using the optimal slider adjustment", Mechanism and Machine Theory 44 (2009) 1866–1876.
10. Prasad Vilas Chanekar, Michael Angelo Amith Fenelon, Ashitava Ghosal, "Synthesis of adjustable spherical four-link mechanisms for approximate multi-path generation", Mechanism and Machine Theory 70 (2013) 538–552.
11. Ajinkya D. Mude, Prof. N.P. Doshi, Prof. U.D. Gulhane, "Review Paper on Computer Aided Design And Analysis Of Four Bar Mechanism for desired coupler curve with five accuracy point using Matlab", International Journal of Engineering Research-Online Vol. 3., S2, 2015, ISSN: 2321-7758.

