ROLLER CHAIN MECHANISMS PART II- INTERMITTENT MOTION MECHANISMS

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ABSTRACT

This work points out the design and constraint equations by which the combined flexible-planar mechanism can be an additional new intermittent motion mechanism. This mechanism can be used to realize finite intermittent motions. Moreover, such mechanism can be designed for a single or multiple dwells. Numerical examples are given to illustrate the simplicity of carrying out the design procedure and the potentiality of such contribution in mechanisms field.

NOMENCLATURE

A	Coefficient or vertical component of the position of joint B,
C	Coefficient or chain length,
D	Horizontal component of the position of joint B,
f	Angular acceleration,
K	Coefficient,
L	Coupler length or distance between the pivot Q and center position O (Figures (1) and (2)),
m and n	Numbers of dwells and sprockets respectively,
r	Radius of circular path (Figure (1)) or of sprocket (Figure (2)) or distance between Q and joint B,
R	Crank radius,
O	Center position of the circular path (Figure (1)) or of the sprocket (axle) (Figure (2)),
Q	Position of the crank pivot which locates the original position of X-Y axes,
S	Input path (Figure (1)) or displacement of joint B (Figure (2)),
X and Y	Horizontal and vertical components of O respectively,
α	Inclination angle of the distance L,
β	Contact angle between the chain and sprocket measured from y-axis of the sprocket axle in direction of the motion,
γ	Total angular displacement,
ζ	Angle between the axles of the two adjacent sprockets i and i1,
Ψ	Inclination angle of the straight portion of the chain,
ω	Angular speed,
Φ	Angular displacement of the crank R or angle between the tangent point I and x-axis,
θ	Angular displacement,
ν	Dwell position,
Δ	Interval,

Subscripts

b	Joint B,
c	Circular portion,
d	Driving,
e	Ending position,
i	Number of sprocket (i=1,2,...,n),
ι	Coupler,
p	For angular position ϕ,
o	Distance Z or X and Y components of position of joint B,
s	Starting position or straight portion,
t	Chain between the two adjacent sprockets,
II	Second case,

Superscripts

'	First derivatives with respect to time,
"	Second derivatives with respect to time.

INTRODUCTION

Intermittent motions can be easily realized by dwell mechanisms. These mechanisms are ,generally, important for their many uses in machine tools ,packing, indexing and textile machines. Usually , there are two groups of dwell mechanisms. The first group is used to accomplish a perfect or finite dwell, these finite-dwell mechanisms are the standard external or internal Geneva, Ratchet and intermittent gearing mechanisms [1-6]. The second group is formed by the combination of two or more simple mechanisms and give imperfect or momentary dwells, such as six-bar planar mechanisms [7-10]. The fundamental difference between the two groups is in the generated motion within the duration of the dwell as will be explained later. Furthermore, the first group mechanisms have a locking device. On the other hand, in the second group, the locking is achieved kinematically i.e. there is no locking device to have dwell. The kinematic and dynamic analysis of the finite dwell mechanisms are presented in [1-6]. A derivation of the displacement equation and dwell characteristic of the spherical geared five-link mechanism have been developed in [5]. Also,a unified analysis formula and optimization procedure on design of external and internal parallel indexing cam mechanisms have been established in [6]. The design equation for single or multiple momentary dwells have been formulated in [7-10]. This survey papers showed that there are few number of dwell mechanisms which can be designed for multiple dwells and that the complexity involved in the analysis of these mechanisms often makes it difficult to obtain either an analytical or a simple numerical solution. The first part of this work [11] presented the general concept of a suggested combined mechanism (rigid crank-coupler links connected in series with roller chain sprocket system). That part showed that such combined mechanism can be designed to achieve different motions including intermittent motion. Consequently, the main purpose of this work is to carry out the design and constraint equations for roller-chain dwell mechmisms, with one or multiple dwells, as a first time.

2- GENERAL CONCEPT OF DWELL

Usually, dwell occurs due to the cancellation of the relative motion of one link of the mechanism with respect to the other. The following sections introduce the mathematical expressions for the criteria and characteristics of the dwell.

2.1 Dwell criteria

In Figure (1) ,R and L are rigid kinematic links connected together by -joint A. L pulls R which rotates by ϕ about the pivot Q, while L -is rotated by θ_ι about joint A due to the given path S. By the previous concept of the dwell, the physical meaning of the dwell in the motion of R states that "For fixing link R (R remains stationary) i.e. ϕ = const., when joint A remains stationary,joint B moves on a circular path of radius L with center at joint A."

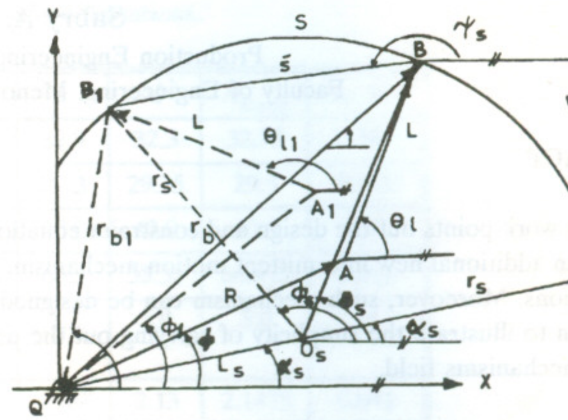


Figure 1. Dwell Representation.

Therefore, the input path S is assumed to be circular arc of radius r_s with fixed center O_s . L_s is the distance between the pivot Q and O_s and inclined by an angle α_s with the X-axis as shown.

The solid lines QA(R) and AB(L) represent the starting position of the circular path S at which r_s has an angular position θ_s , while the dashed lines $QA_1(R)$, and $A_1B_1(L)$ represent the ending position of the circular path S at which ϕ becomes ϕ_1 and both θ_ι and θ_s increase to $\theta_{\iota 1}$ and ϕ_s respectively. Hence, we have two dyads, one is represented by R, L and S and the other is constructed by L, r_s and S. These dyads reveal the following mathematical expressions.

-At starting position

$$R\,e^{j\phi} + L\,e^{j\theta_\iota} = L_s\,e^{j\alpha_s} + r_s\,e^{j\theta_s} \tag{1}$$

-At ending position

$$R\,e^{j\phi 1} + L\,e^{j\theta} = L_s\,e^{j\alpha_s} + r_s\,e^{j\theta_s} \tag{2}$$

Where the right hand parts describe the finite circular arc path which exists if and only if the following necessary conditions are satified;

$$L^2 = (X_s-X_A)^2+(Y_B-Y_A)^2 = (X_{B1}-X_{A1})^2+(Y_{B1}-Y_{A1})^2$$
and (3)
$$r_s^2 = (X_s-X_{os})^2+(Y_B-Y_{os})^2 = (X_{B1}-X_{os})^2+(Y_{B1}-Y_{os})^2$$

By inspection, we can find out the criteria of dwell as; For link R remains stationary (fixed) i.e. $\phi = \phi_1$ = Const., if and only if the following conditions are satisfied.

$$R = L_s,\ L = r_s \text{ and } \phi_1 = \phi = \alpha_s \tag{4}$$

Therefore,

$$\theta_\iota = \theta_s,\ \theta_{\iota 1} = \phi_s$$

If the conditions of Equation. (4) are satisfied, the positions of joint A and O_s coincide, also the conditions of Eq. (3) are verified. This means that joint A is stationary. In the case of approximate verification of conditions of Eq. (4) , the finite dwell could not be existed but a momentary dwell may be occurred where small variation in ϕ is existed. During the finite dwell period, the angular velocity ω and acceleration f of the crank R should be zeros.

2.2. Dwell Characteristics

These characteristics are the positions, period and frequency of the dwell.

i- The dwell duration $\Delta\theta$ can be easily estimated by;

$$\Delta\theta = \nu_e - \nu_s \tag{5}$$

Where;

ν_e Ending angular position of the dwell at which one or more conditions of equation (4) are violated.

ν_s Starting angular position of the dwell at which the conditions of equation (4) are satisfied.

Referring to Figure (1), the following relation can be pointed out;

1-ν_s and ν_s are existed and can be estimated by;

$$\nu_s = \theta_{in} \tag{6}$$

Where θ_{in} at which the following equalities are occurred;

$$\phi = \theta_\iota = \alpha_S$$

and

$$r_b = R + L = L_S + r_S \tag{7}$$

$$\nu_s = \theta_{in} \tag{8}$$

Where θ_{in} at which the following equalities are satisfied;

$$\theta_\iota = \alpha_s + \phi_s$$

and

$$r_b = \sqrt{L_S^2 + r_S^2 - 2L_S r_S \cos(\pi + \alpha_s - \phi_S)} \tag{9}$$

Where ϕ, θ_ι and r_b : Parameters are function of the input angular displacement θ_{in}

2-The dwell period $\Delta\theta$ can be obtained by;

$$\Delta\theta = \phi_S - \alpha_S \tag{10}$$

ii-The dwell frequency M which is the number of dwells per operating cycle, may be obtained by;

$$M = \sum_{i=1}^{m} N_{ci} \quad m = 1, 2, ..., n \tag{11}$$

Where;

N_{ci} is the number of circular arc paths which satisfy conditions of equation (4)

3. DESIGN APPROACH

A general approach for the design of the intermittent motion mechanisms is presented. The approach involves the following steps;

3.1 Suggested Mechanism

The suggested mechanism consistes of a roller chain with two or more sprockets placed in a general orientation.One of the sprockets, called driving sprocket,provides the input angular displcement θ_1 in the counterclockwise direction. The motion of the roller chain is transmitted to a crank R through a coupler L. This motion has either a straight or circular path S as stated in [11]. In order to obtain the relation between ϕ and θ_1 within an operating cycle, consider a portion of the system shown in Figure (2).

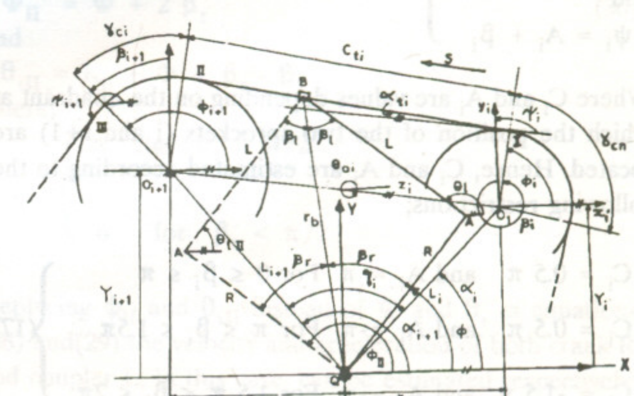


Figure 2. Suggested system, — first case, --- second case.

adjacent sprockets i and i+1, the chain is connected with the crank R through the coupler L. The sprocket center (axle) O_i is located at X_i and Y_i and displaced by L_i from the crank pivot Q. L_i is inclined by an angle α_i with X-axis. The ϕ-θ_1 relation for this part of the system is carried out as follows;

3.2 Geometric Analysis

The geometric analysis of the suggested mechanism, Figure (2) gives;

$$L_i = \sqrt{X_i^2 + Y_i^2} \quad \text{and} \quad \alpha_i = \tan^{-1}(Y_i/X_i) \tag{12}$$

$$Z_i = \sqrt{\Delta X^2 + \Delta Y^2}, \quad C_{ti} = \sqrt{Z_i^2 - \Delta r^2} \tag{13}$$

$$\zeta_i = \tan^{-1}(Y_s/X_s), \; \theta_{oi} = \tan^{-1}(\Delta Y/\Delta X) \tag{14}$$

$$\alpha_{ti} = \tan^{-1}(\Delta r/C_{ti}), \; i = 1,2,......n \tag{15}$$

where $X_s = L_i^2 + L_{i+1}^2 - Z_i^2$, $Y_s = \sqrt{(2 L_i L_{i+1})^2 - X_s^2}$

$\Delta X = X_i - X_{i+1}$, $\Delta Y = Y_i - Y_{i+1}$, $\Delta r = r_i - r_{i+1}$

n:Total number of the sprockets.

For achieving the actual position of the two adjacent sprockets, the following equations should be considered;

$$\left.\begin{aligned} \beta_i &= \theta_{oi} + \alpha_{ti} \\ \Phi_i &= C_i + \beta_i \\ \text{and} \\ \psi_i &= A_i + \beta_i \end{aligned}\right\} \tag{16}$$

Where C_i and A_i are values depending on the quadrant at which the position of the two sprockets (i and i+1) are located. Hence, C_i and A_i are estimated according to the following restrictions;

$$\left.\begin{aligned} &C_i = 0.5\,\pi \quad \text{and } A_i = \pi \quad \text{For } 0 \le \beta_i \le \pi \\ &C_i = 0.5\,\pi \quad \text{and } A_i = -\pi \quad \text{For } \pi \le \beta_i \le 1.5\pi \\ &C_i = -1.5\,\pi \quad \text{and } A_i = -\pi \quad \text{For } 1.5\,\pi \le \beta_i \le 2\pi \end{aligned}\right\} \tag{17}$$

These three conditions verify any possible positions of two adjacent sprockets. The total angular displacements of the driving sprocket 1, τ_{si} and τ_{ci} which are corresponding to the straight and circular portions ,respectively, are estimated by;

$$\left.\begin{aligned} \tau_{si} &= (C_{ti}/r_1).180/\pi \\ \text{and} \\ \tau_{ci} &= (\Phi_{i+1} - \Phi_i).r_{i+1}/r_1 \end{aligned}\right\} \tag{18}$$

Where the condition of i = n reveals τ_{cn} as;

$$\tau_{cn} = K_\iota - (\Phi_i - \Phi_1) \tag{19}$$

where;

$$K_\iota = \begin{cases} 2\pi & \text{for } \phi_n > \phi_1 \\ 0 & \text{for } \phi_n < \phi_1 \end{cases}$$

3.2 Kinematic Analysis

These analysis are carried out as;

3.2.1 Position Analysis

As stated in [11] and referring to Figure (2), the governing equations of the crank R and coupler L are given by;

$$\left.\begin{aligned} R \sin \Phi + L \sin \theta_\iota &= A_o \\ \text{and} \\ R \cos \Phi + L \cos \theta_\iota &= D_o \end{aligned}\right\} \tag{20}$$

Where

$$\left.\begin{aligned} A_o &= L_i \sin \alpha_i + r_i \sin \Phi_i + S \sin \psi_i \\ D_o &= L_i \cos \alpha_i + r_i \cos \Phi_i + S \cos \psi_i \end{aligned}\right\} \tag{21}$$

For $0 \le \theta_i \le \tau_{si}$ which corresponds to the straight portion C_{ti}.
And

$$\left.\begin{aligned} A_o &= L_{i+1} \sin \alpha_{i+1} + r_{i+1} \sin \varepsilon_{i+1} \\ D_o &= L_{i+1} \cos \alpha_{i+1} + r_{i+1} \cos \varepsilon_{i+1} \\ \varepsilon_{i+1} &= \Phi_i + \theta_{i+1}, \theta_{i+1} = S/r_{i+1}, S = r_1\,\theta_1 \end{aligned}\right\} \tag{22}$$

For $0 \le \theta_1 \le \tau_{ci}$ which corresponds to the circular portion of sprocket i (τ_{ci}).

After performing some mathematical manipulations, equations (20) can be transformed to one equation as;

$$A_o \sin \Phi + D_o \cos \Phi = Y_p \qquad (23)$$

Solving for ϕ [12], we get

$$\Phi = \tan^{-1} (Y_p/X_p) - \lambda \qquad (24)$$

Where

$$Y_p = (r_b^2 + R^2 - L^2)/2R$$

$$X_p = \sqrt{r_b^2 - y_p^2},\ r_b = \sqrt{A_o^2 + D_o^2} \qquad (25)$$

$$\lambda = \tan^{-1}(D_o/A_o)$$

Equation (24) yields two values for ϕ since X_p has two values as shown in Figure (2) by ϕ and ϕ_{II}. In the first case joint B leads or pulls the crank R, named leading case. While, in the second case joint B lags or pushes the crank R, termed as lagging case. The analysis of the second case, ϕ_{II}, will be given later on. From the geometry of Figure (2) the coupler angular position θ_ι is expressed by;

$$\theta_\iota = \Phi + \beta_r + \beta_\iota \qquad (26)$$

Where β_ι and β_r are the angles between the coupler L, the crank R and the direction of r_b respectively, therefore these angles are determined by;

$$\beta_r = \tan^{-1}(X_p/Y_p),\ \beta_\iota = \tan^{-1}(X_\iota/Y_\iota) \qquad (27)$$

Where

$$Y_\iota = (r_b^2 + L^2 - R^2)/2L,\ X_\iota = \sqrt{r_b^2 - Y_\iota^2}$$

The design constrains which control the real values of ϕ and θ_ι and give positive values to X_p, equation (25), and X_ι, equation (27), should be considered.

The ϕ-θ_1 relation, during one cycle, can be obtained by the previous analysis in addition to the response of other successive two adjacent sprockets, until it reaches to the last two adjacent sprockets n and n+1. Where the sprocket n+1 is the driving sprocket 1.

3.2.2 Velocity Analysis

Differentiating Equations (20) with respect to time gives two equations which could be solved for crank and coupler speeds ω and ω_ι respectively as;

$$\omega = (A_1 a_{22} - D_1 a_{12})/D_t,\ \omega_\iota = (D_1 a_{11} - A_1 a_{21})/D_t \qquad (28)$$

Where;

$$a_{11} = R \cos \Phi \ ,\ a_{12} = L \cos \theta_\iota$$

$$a_{21} = R \sin \Phi \ ,\ D_1 = L \sin \theta_\iota$$

$$A_1 = A'_o \ ,\ D_1 = -D'_o \ ,\ D_t = a_{11}a_{22} - a_{21}a_{12}$$

$(\ )'$ denotes the derivative with respect to time.

3.2.3 Acceleration Analysis

The differentiation of Equations (28) gives the following angular accelerations of the crank f and of the coupler f_ι as;

$$f = (A_2 a_{22} - D_2 a_{12})/D,\ f_\iota = (D_2 a_{11} - A_2 a_{21})/D_t \qquad (29)$$

where

$$A_2 = (A''_o + a_{21}\omega^2 + a_{22}\omega_\iota^2),\ D_2 = (D''_o + a_{11}\omega^2 + a_{12}\omega_\iota^2)$$

$(\ )''$ denotes the second derivative with respect to time.

3.3 Analysis of the Lagging Case

Referring to Figure (2), the second case is represented by dashed lines. The angular position of the crank ϕ_{II} and the coupler $\theta_{\iota II}$ can be derived as;

$$\Phi_{II} = \Phi + 2\beta_r \qquad (30)$$

and

$$\theta_{\iota II} = K_p + \Phi + \beta_r - \beta_\iota$$

where;

$$K_p = \begin{cases} 2\pi & \text{for } \beta_\iota > \pi/2 \\ 0 & \text{for } \beta_\iota < \pi/2 \end{cases}$$

Replacing ϕ_{II} and $\theta_{\iota II}$ instead of Φ and θ_ι in equations (28) and(29) the velocity and acceleration of both crank R and coupler L, in this case, can be estimated respectively. The total driving angular displacement θ_d, which corresponds to θ_{in} of Eqs. (6) and (8), is computed by;

$$\theta d = \sum_{j=1}^{2n} \theta_{1j} = (S_t/r_1)180/\pi \quad (31)$$

Where;

θ_{1j} Total angular position of the driving sprocket within a straight or circular portion i.

S_t Total input displacement of joint B within one operating cycle and is given by;

$$S_t = \sum_{i=1}^{n} C_{ti} + \tau_{ci}\, r_{i+1} \quad (32)$$

It should be noted that $r_{n+1} = r_1$ and that c_{ti} and τ_{ci} are given previously.

3.4. Design Constraints

The necessary constraints for insuring continuous operation are stated in the following sections.

3.4. General Constraints

To avoid locking of the system and to eliminate jamming during operation,the following constraints and limitations must be taken into account;

I- For working domain

$$r_{il} \le r_i \le r_{iu}\ ,\ L_i > r_i$$

$$r_i + r_{i+1} \le Z_i \le L_i + L_{i+1} \quad (33)$$

$$R + L \le (L_i + r_i)_{max}$$

$$R\text{-}L < r_{b\,min} \text{ and } \sum_{i=1}^{n} \zeta_i = 2\pi$$

Where subscripts ι and u denote lower and upper limits of r_i.

II- For controlling the values of ϕ and θ_ι [Eqs.(24) and (26)]

$$L > 0.5\, r_b + (R+L)(L\text{-}R)/2r_b$$

and (34)

$$R > 0.5\, r_b + (R+L)(R\text{-}L)/2r_b$$

Where r_b is given by Eq. (25)

3.4.2 Constraints For Dwell Occurrence

The occurence of the dwell by the mechanism requires verification of Eq. (4)., this can be achieved if and only if the crank R and the coupler L are designed to be as;

$$R = L_i \text{ and } L = r_i \quad i = 1,2,...m \quad (35)$$

Where m is the number of dwells ($m \le n$). The starting and ending positions of the dwell , υ_s and υ_e respectively, are determined if and only if the following equalities are achieved,

$$\upsilon_s = \theta_d$$

if $r_b = R+L = L_i + r_i$ and $\phi = \theta_\iota = \alpha_i$ (36)

and

$$\upsilon_e = \theta_d$$

if

$$r_b = \sqrt{L_i^2 + r_i^2 - 2L_i r_i \cos(\pi + \alpha_i - \phi_i)} \text{and} \quad (37)$$

$$\theta_\iota = \phi_i + \alpha_i$$

Where;

ϕ, θ_ι and θ_d Given by Eqs. (24), (26) and (31) respectively.

r_b Given by Eq.(25).,

3.4.3 Rotatabilty And Transmission Angle Conditions

The rotatability of the crank R should be examined by the use of Grashof criterion. Also,the transmission-angles of the slider-crank mechanisms (within straight portions) and of the four-bar linkages (within circular portions) should be restricted in condition that the maximum variation of this angle from the right angle on the entire operating cycle should be minmized [13], if the optimization of such system is required.

4.IMPLEMENTATION

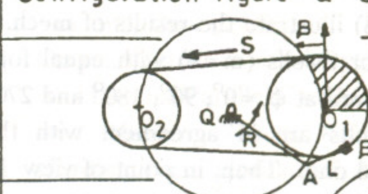
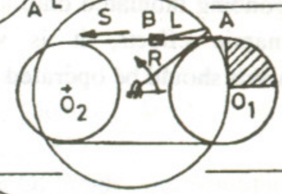
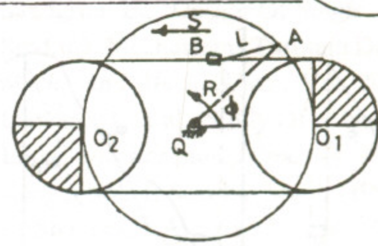
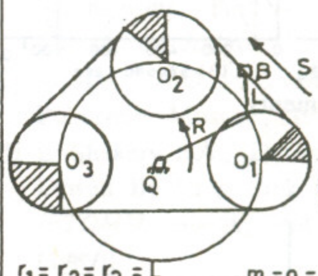
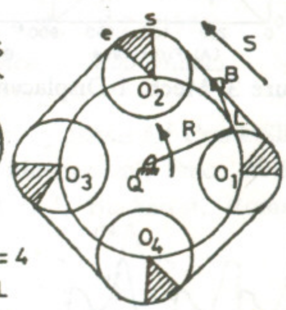
The following mechanisms data which are considered to illustrate the results of the presented analysis, are some of several examined data;

Mech No.	i	r_i cm	X_i cm	Y_i cm
1	1	3	5	0
	2	3	0	5
	3	3	-5	0

$\omega_1 = 1\ ra_d/s$, $R = L_i = 5$, $L = r_i = 3$ cm

Mech No.	i	r_i cm	X_i cm	Y_i cm
2	1	3	5	0
	2	3	0	5
	3	3	-5	0
	4	3	0	-5

Table 1.

n	i	r_i	L_i	ϕ_i	α_i	$\Delta\theta$	m	Configuration figure & Constraints
2	1	L	R	$\pi/2+\beta$	0	$\pi/2+\beta$	1	 $r_1=L$, $r_2<r_1$, $L_1=L_2=R$, $n=2$, $m=1$
	2	$<L$	R	$1.5\pi-\beta$	π	—	—	
2	1	L	R	$\pi/2$	0	$\pi/2$	1	$r_1=r_2=L$, $L_1=R$, $L_2<L_1$ 
	2	L	$<R$	$3/2\,\pi$	π	—	—	
2	1	L	R	$\pi/2$	0	$\pi/2$	2	 $r_1=r_2=L$, $L_1=L_2=R$, $m=n=2$
	2	L	R	$3/2\,\pi$	π	$\pi/2$		
3	1	L	R	$\pi/4$	0	$\pi/4$		 $r_1=r_2=r_3=L$, $L_1=L_2=L_3=R$, $m=n=3$
	2	L	R	$3/4\,\pi$	$\pi/2$	$\pi/4$	3	
	3	L	R	$3/2\,\pi$	π	$\pi/2$		
4	1	L	R	$\pi/4$	0	$\pi/4$		 $m=n=4$, $r_i=L$, $L_i=R$
	2	L	R	$3/4\,\pi$	$\pi/2$	$\pi/4$		
	3	L	R	$5/4\,\pi$	π	$\pi/4$	4	
	4	L	R	$3/4\,\pi$	$1.5\,\pi$	$\pi/4$		

5. RESULTS AND DISCUSSION

5.1. Geometric Analysis And Constraints Results

Some results of the geometric analysis and constraint equations are listed in Table (1). This table indicates that the dwell characteristics υ_s, υ_e, $\Delta\theta$ and m can be easily determined as the constraints are known. The shaded areas represent the dwell period and frequency. The dwell duration $\Delta\theta$ increases either as the inclination angle α_i decreases or as ϕ_i increases

5.2. Kinematic Analysis Results

Some results of ϕ, θ_ι, ω, ω_ι, f and f_ι of the first case and ϕ_{II}, $\theta_{\iota II}$, ω_{II}, $\omega_{\iota II}$, f_{II} and $f_{\iota II}$ of the second case are plotted versus θ_d in Figures (3-8). These figures indicate the following observations;

1 For the first case, υ_s occurs when $\theta_\iota = \phi_i = \alpha_i$. This verifies conditions of equations (7) and (36).

2 ϕ delays ϕ_{II} while they are equal during the dwell periods

3 ϕ_{II} lags θ_ι, while ϕ_{II} leads $\theta_{\iota II}$.

4 ϕ_{II} equals to $\theta_{\iota II}$ at the end position of each dwell period, this means that υ_e occurs when $\theta_{\iota II} = \theta_{II} = \alpha_I$ for the second case

5 ω and (ω_{II}) are suddenly decreased and (increased) at υ_s and (υ_e) of each dwell respectively, and,

6 f_{II} and $f_{\iota II}$ are much greater in magnitude than f and f_ι respectively.

In addition, Figures. (3-5) show the results of mech. 1

where n=3 sprockets, three dwells (m=3) periods of 45°, 45° and 90°, respectively, are occurred at $\phi=0^{\circ}$, 90° and 180°. Also, Figures. (6-8) illustrate the results of mech. 2 where n=4 sprockets for dwells (m=4) with equal four periods of 45° are occurred at $\phi=0^{\circ}$, 90°, 180° and 270° respectively. These results are in agreement with the -corresponding tabulated one. Then, in point of view of the dynamic effects, it is worth noting that such mechanisms should be operated according to the first case.

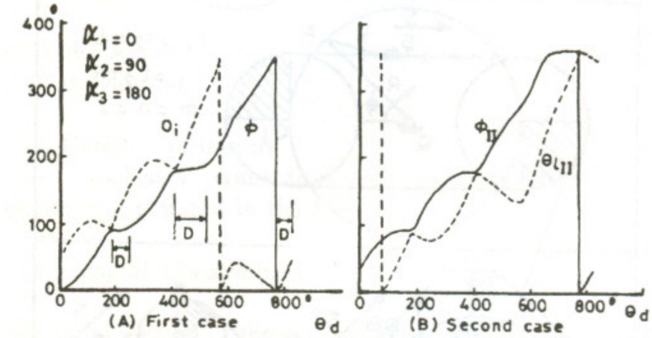


Figure 3. Mech. 1-Displacements.

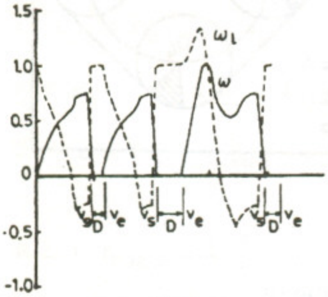


Figure 4-A. Velocity

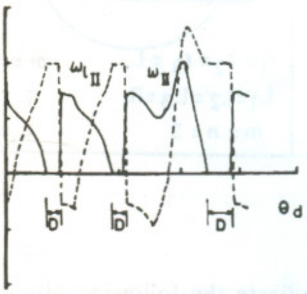


Figure 4-B. Velocity.

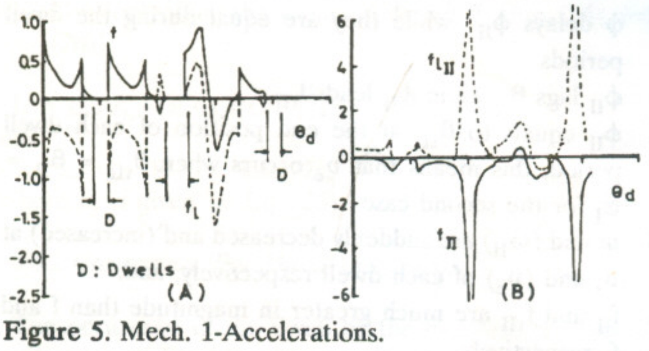


Figure 5. Mech. 1-Accelerations.

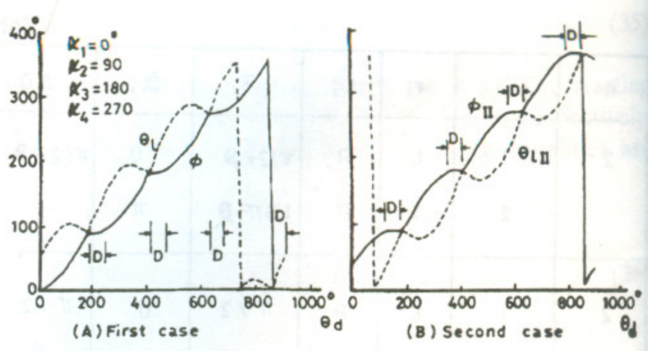


Figure 6. Mech. 2-Displacements.

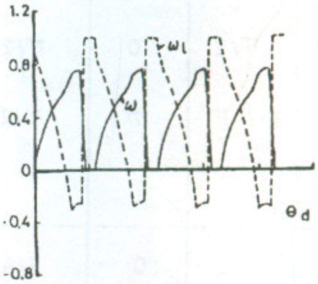


Figure 7-A. Velocities.

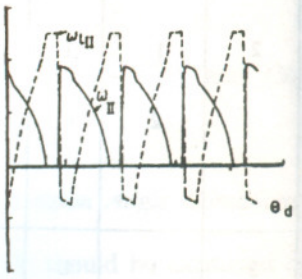


Figure 7-B. Velocities.

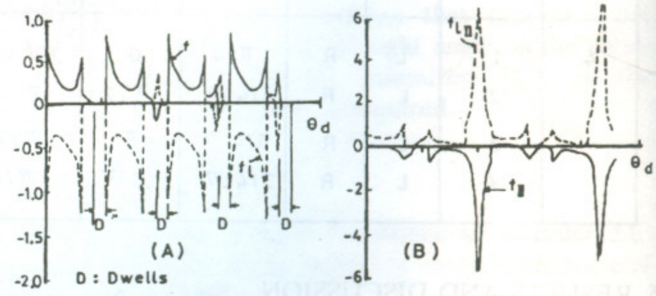


Figure 8. Mech. 2-Accelerations.

6. CONCLUSIONS

As a result of the presented analysis, one easily concludes the following,

1 The combination of the flexible system (roller chain) with crank coupler links gives useful and an additional new intermittent motion mechanisms. These mechanisms can be designed to accomplish a single or multiple dwells without the need of locking device.

2 The analysis and constraint equations could easily be modified to optimize or synthesize such system for specifying a desired motion characteristics. The desired motion would be either reversing or

nonreversing one with or without dwells.

3 The main advantages of the mechanism presented are.,

i The structure of the system is simple.

ii The nature of the analysis procedure is rational.

iii The formulation don't lead to tedious algabraic manipulation in finding the solution for multiple dwell requirements. and,

iv The mechanism can provide dwells with various characteristics (positions, periodes and frequences) within, one cycle. This may be useful in certain industrial applications.

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