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A NEW APPROACH FOR DESIGN AND ANALYSIS OF GENEVA MECHANISM

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I. ABSTRACT

A NEW APPROACH IS PROPOSED FOR GENEVA WHEEL WITH CURVED SLOTS AS AN INTERMITTENT ROTARY MOTION GENERATING MECHANISM. BY CHANGING THE SLOT SHAPE FROM A STRAIGHT RADIAL LINE TO A CURVED LINE, THE SHOCK LOADING AT THE BEGINNING AND END OF THE MOTION IS ELIMINATED. THIS MECHANISM REDUCES THE WHEEL PEAK VELOCITY AND PEAK ACCELERATION VALUES, AND ALSO SUITED FOR HIGH-SPEED APPLICATIONS. PRESENT WORK SHOWS A GREAT IMPROVEMENT IN THE DESIGN OF A CURVED SLOTTED GENEVA WHEEL, BY INTRODUCING AN OFFSET TO THE CURVED SLOT. THE OFFSETTING TECHNIQUE, WHICH DOES NOT ALTER THE KINEMATIC CHARACTERISTICS OF THE MECHANISM, MODIFIES THE SHAPE OF THE SLOT. THIS DEVELOPMENT PROVIDES AN IMPORTANT TOOL FOR DESIGNING A SIMPLE, PRACTICAL AND RELIABLE INTERMITTENT MOTION GENERATING MECHANISM WITH EXCELLENT KINEMATIC CHARACTERISTICS

Key words: Geneva Wheel; Intermediate rotary motion; Curved slots

INTRODUCTION

A number of different mechanisms can be used for converting "uniform rotary motion into intermittent rotary motion", one of these mechanisms is the Geneva mechanism. In many kinds of automatic machinery a shaft is required to turn intermittently through regular steps, and to be held locked in position between movements. The Geneva mechanism is the simplest and most widely used for its accuracy and self-locking function. One early application of this mechanism is to prevent over winding a watch. Presently Geneva mechanism is widely used in indexing devices, milling machine with an automatic tool changer.

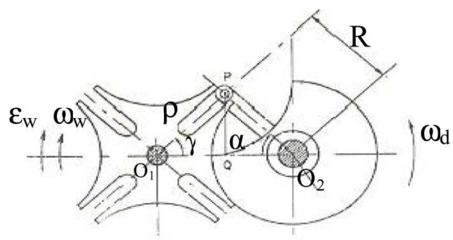
Fenton [1] proposed two Geneva mechanisms connected in series to eliminate the shock loading caused by initial and final accelerations. Fenton and zhenbiao [2] analyzed the deformation of Geneva wheels resulting from a unit normal unit force applied at the point of contact between the driving pin and the wheel by finite element method. Hunt et al [3] proposed a four –bar linkage with a drive pin located at a coupler point proves an appealing solution to reduce acceleration and jerk. Compound mechanisms with linkages, gears, cams and chains have been used in combination with the Geneva mechanism in order to generate improved motion characteristics and there by reduce the shock loading. Lee [4] proposed a compound Geneva is not always feasible as it leads additional problems like space, weight, inertia and stress.

In present analysis a new approach is proposed to eliminate the initial and final shock loading of the Geneva mechanism by changing the shape of the slot. The parametric functions of suitable curved slots are derived and specified in polar coordinates. Selecting an appropriate function to describe the shape of the slot and satisfying the appropriate constraint equations. The output motion of the proposed Geneva mechanism starts and ends with zero acceleration. However, the proposed mechanism still maintains the simplicity of the original mechanism. An additional advantage of the curved slotted Geneva mechanism is the dwell to motion time ratio can be freely selected by the designer. The only disadvantage of the curved slot is that its shape is often unsuitable for practical purposes due to looping of the slot or due to the existence of sharp cusps. The offsetting technique is introduced in the present analysis to overcome acceleration and deceleration is zero approaching and leaving the maximum velocity point. Maximum acceleration is preferably minimized.

(a) DESIN OF CONVENTIONAL GENEVA MECHANISM

The basic elements of a conventional Geneva mechanism are the driving crank and the slotted wheel is shown in Fig.1. The wheel contains 'n' equally spaced radial slots. The driving pin slides in the slots to drive the wheel. The centerlines of the slots and crank are mutually

perpendicular at engagement and disengagement. The crank, which rotates at a uniform angular velocity, carries a roller to engage with slots. During one revolution of the crank the Geneva wheel rotates a fractional part, which depends on the number of slots. The circular segments attached to the crank effectively lock the wheel against rotation when the roller is not in engagement and also positions the wheel for correct engagement of the roller with the next slot.
In Geneva mechanism the driven wheel (Geneva) O_1, makes one fourth of a turn for one turn of the driver, O_2.



(i)

(ii) Fig.1. External Geneva Mechanism

Design of Geneva wheel (Fig.1) is initiated by specifying the crank radius, the roller diameter and the number of slots, half the angle subtended by adjacent slots, $\theta_0=360^0/2n$, where n = number of slots
Distance between center of driving and driven wheel
$L=R/\sin\gamma$
The wheel angle, γ is related with the crank angle, α

$$\tan\gamma = \frac{\sin\alpha}{\left(L/R\right) - \cos\alpha} \quad (1)$$

By differentiating the equation (1) with respect to time, the wheel velocity for various values of α is obtained as

$$\omega_w = \omega_d \frac{\left(L/R\right)\cos\alpha - 1}{1 + \left(L^2/R^2\right) - 2\left(L/R\right)\cos\alpha}$$

(2)
Angular acceleration is obtained by differentiating equation (2)

$$\varepsilon_w = \omega_d^2 \frac{\left(L/R\right)\sin\alpha\left(1 - L^2/R^2\right)}{\left(1 + \left(L/R\right)^2 - 2\left(L/R\right)(\cos\alpha)\right)^2}$$

(3)

Basic Geometry of Geneva Mechanism

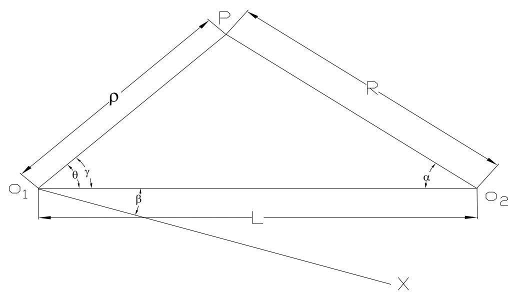


Fig.2. Design Model of Geneva Wheel

The angular position of the effective radius,ρ, relative to O_1O_2 is denoted by γ. The corresponding angular position of the crank, O_2P, is α.

When the pin enters the slot at time t = 0: $\alpha = -\alpha_0$ and $\gamma = -\gamma_0$. When the pin exists the slot at time $t = t_c$: $\alpha = +\alpha_0$ and $\gamma = +\gamma_0$
β is the angular displacement of the wheel and it is a function of time. For any crank position, it is found from triangle the relation between L, the distance from crank axis, O_2 to the wheel axis O_1 and R, is the crank radius.

$$\frac{R}{\sin|\gamma|} = \frac{L}{\sin(180 - |\alpha| - |\gamma|)} \quad (5)$$

and $\rho^2 = L^2 + R^2 - 2LR\cos\alpha$ (6)

from equation (5) and (6) the following relations can be obtained,

$$\gamma = \arctan\frac{R\sin\alpha}{(L - R\cos\alpha)} \quad (7)$$

$$\rho = \sqrt{L^2 + R^2 - 2LR\cos\alpha}$$

(8)

Kinematics of Geneva wheel

A. Motion and Dwell Times: For constant crank velocity, the ratio of the wheel dwell to motion time is:

$$\eta = \frac{t_d}{t_c} = \frac{180 - \alpha_0}{\alpha_0} \quad (9)$$

In conventional Geneva wheel with straight slots α_0 is a fixed, which is a function of the number of slots. $\alpha_0 = 180\frac{n-2}{2n}$, where 'n' is the number of the slots in the wheel. The dwell to motion time ratio for a conventional Geneva mechanism is fixed and it cannot be altered, i.e.

$$\eta = \frac{n+2}{n-2} \quad (9a)$$

However in Geneva wheel with curved slots α_0 can be choose arbitrarily

B. The Angular Velocity of the Wheel:

The angular velocity, ω_w, of the wheel is a function of the angular position,α, of the crank. The angular velocity corresponding to any crank position is

$$\omega_w = \frac{d\beta}{dt} = \frac{d\beta}{d\alpha}\frac{d\alpha}{dt} = \omega_d \frac{d\beta}{d\alpha}$$

(10)
where ω_d is the input crank velocity.

C. The Angular Acceleration of the Wheel:
The angular acceleration, ε_w, of the wheel is also a function of the crank position,α. For constant input crank velocity,ω_d, the angular acceleration of the wheel is

$$\varepsilon_w = \frac{d^2\beta}{dt^2} = \omega_d^2\frac{d^2\beta}{d\alpha^2} + \frac{d\omega_d}{dt}\frac{d\beta}{d\alpha} = \omega_d^2\frac{d^2\beta}{d\alpha^2}$$

(11)

Conventional Geneva Mechanism-Straight Radial Slot

The axis, O_1X, moves together with the wheel during its entire motion. It is clear from the diagram that angle θ can be expressed as: $\theta = -\gamma+\beta$. Since the angular position,γ, and the angular displacement, β, are both functions of α, the angular position, θ, of the pin is also a function of the angular position, α, of the crank, i.e.,

$$\theta = \theta(\alpha) \quad (12)$$

Parametric equations of the slot can be expressed as follows:

$$\rho = \rho(\alpha) \quad (13)$$

$$\theta = -\gamma(\alpha) + \beta(\alpha) = \theta_0 \quad (14)$$

In straight slot of the conventional Geneva mechanism

$\theta = \theta_0 = \frac{\Pi}{n}$ (15)

and

$\rho(\alpha) = \sqrt{L^2 + R^2 - 2LR\cos(\alpha)}$

(16)

Therefore

$\beta(\alpha) = \theta_0 + \gamma(\alpha)$ (17)

Substituting equation (7) into equation (17), β becomes

$\beta(\alpha) = \theta_0 + \arctan\left(\frac{R\sin\alpha}{L - R\cos\alpha}\right)$

(18)

considering that $R = \frac{L\sin\theta_0}{\sin(\theta_0 + \alpha_0)}$, hence

$\beta(\alpha) = \theta_0 + \arctan\left(\frac{\sin\theta_0 \sin\alpha}{\sin(\theta_0 + \alpha_0) - \sin\theta_0 \cos\alpha}\right)$

(19)

The velocity ratio can be determined as:

$\frac{\omega_w}{\omega_d} = \frac{d\beta}{d\alpha} = \frac{\sin\theta_0[\sin(\theta_0 + \alpha_0)\cos\alpha - \sin\theta_0]}{\sin^2(\theta_0 + \alpha_0) + \sin^2\theta_0 - 2\sin(\theta_0 + \alpha_0)\sin\theta_0\cos\alpha}$

(20)

at the beginning and end of each motion cycle, the angular velocity of the wheel must be zero, i.e.,

when $\alpha = -\alpha_0$ and $\alpha = +\alpha_0$, $\omega_w = 0$

Hence, $\left.\frac{d\beta}{d\alpha}\right|_{\alpha=+\alpha_0} = 0$ (21)

It is found that $\alpha_0 + \theta_0 = 90^0$. Therefore, α_0 cannot be arbitrarily selected. As the ratio of the dwell time to motion time is a function of the number of slots in the wheel as given in the equation 9(a). Since $\alpha_0 + \theta_0 = 90^0$, equation (20) is simplified as

$\frac{\omega_w}{\omega_d} = \frac{d\beta}{d\alpha} = \frac{\sin\theta_0(\cos\alpha - \sin\theta_0)}{1 + \sin^2\theta_0 - 2\sin\theta_0\cos\alpha}$

(22)

From equation (23), the angular acceleration is derived

$\frac{\varepsilon_w}{\omega_d^2} = \frac{d^2\beta}{d\alpha^2} = \frac{-\sin\theta_0 \cos^2\theta_0 \sin\alpha}{(1 + \sin^2\theta_0 - 2\sin\theta_0\cos\alpha)^2}$

(23)

when $\alpha = |\alpha_0|$ $\quad \frac{\varepsilon_0}{\omega_d^2} = +\tan|\theta_0|$ (24)

Where ε_0 is the non-zero angular acceleration of the wheel at the instant when pin enters and exits the slot. In straight line Geneva mechanism the initial and final shock loads are large. To reduce these loads a new approach is developed by changing the shape of the slot

Curvilinear Slot Design:

The basic element of the proposed mechanism is chosen similar to the conventional Geneva mechanism: the driving crank and the slotted wheel. The wheel contains n identical and equal spaced curved slots.

In order to ensure that undesirable shock loadings are completely eliminated, the acceleration of the wheel at the beginning and end of each motion cycle must be zero. Considering equations (10) and (11), the following constraint equations are obtained:

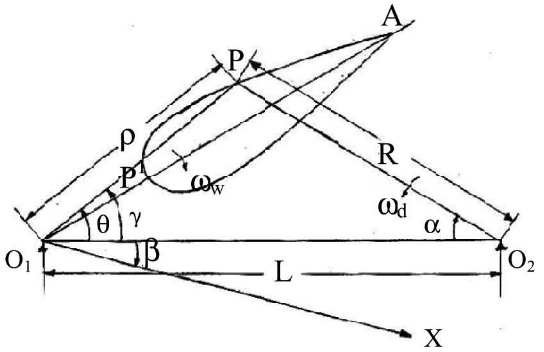


Fig.3. Geneva Wheel with Curved Slot

$\left.\frac{d\beta}{d\alpha}\right|_{\alpha=-\alpha_0} = 0$ (25)

$\left.\frac{d\beta}{d\alpha}\right|_{\alpha=+\alpha_0} = 0$ (26)

$\left.\frac{d^2\beta}{d\alpha^2}\right|_{\alpha=-\alpha_0} = 0$ (27)

$\left.\frac{d^2\beta}{d\alpha^2}\right|_{\alpha=+\alpha_0} = 0$ (28)

The polar coordinates of the center of the driving pin, P, located at a radial distance,ρ, from the wheel axis and having an angular position,θ, measured from axis O_1X, is considered as shown in Fig.3.

The parametric equation is similar to straight line Geneva mechanism

$\theta = -\gamma(\alpha) + \beta(\alpha)$ (29)

This function, β(α), must satisfy the constraint equation (25), (26), (27) and (28), and the following geometric conditions:

$\beta(\alpha)\big|_{\alpha=-\alpha_0} = 0$ (30)

$\beta(\alpha)\big|_{\alpha=+\alpha_0} = 2\theta_0$ (31)

Where θ_0 is the half angle between any two consecutive axes of symmetry of the curved slots of the wheel, i.e., θ_0 =180/n deg, where n is the number of slots.

3.4 Polynomial Expression for β(α)

It is possible to select a polynomial expression to represent β(α). The function β(α), must satisfy equation (25), (26), (27), (28), (30) and (31). i.e.

$\beta(\alpha) = a_0 + a_1\alpha + a_2\alpha^2 + a_3\alpha^3 + a_4\alpha^4 + a_5\alpha^5$

(32)

Then satisfying equations (25), (26), (27), (28), (30) and (31) results in the following set of linear equations for a_1:

$$\begin{bmatrix} 1 & -\alpha_0 & \alpha_0^2 & -\alpha_0^3 & \alpha_0^4 & -\alpha_0^5 \\ 1 & \alpha_0 & \alpha_0^2 & \alpha_0^3 & \alpha_0^4 & \alpha_0^5 \\ 0 & 1 & 2\alpha_0 & 3\alpha_0^2 & 4\alpha_0^3 & 5\alpha_0^4 \\ 0 & 1 & -2\alpha_0 & 3\alpha_0^2 & -4\alpha_0^3 & 5\alpha_0^4 \\ 0 & 0 & 2 & 6\alpha_0 & 12\alpha_0^2 & 20\alpha_0^3 \\ 0 & 0 & 2 & -6\alpha_0 & 12\alpha_0^2 & 20\alpha_0^3 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 2\theta_0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

(33)

The solution of this set of linear equations is:

$a_0 = \theta_0$, $a_1 = \frac{15\theta_0}{8\alpha_0}$, $a_3 = -\frac{5\theta_0}{4\alpha_0^3}$, and $a_5 = \frac{3\theta_0}{8\alpha_0^5}$;

while $a_2 = a_4 = 0$

Therefore the polynomial in equation (32) becomes

$$\beta(\alpha)=\theta_0+\frac{15\theta_0}{8\alpha_0}\alpha-\frac{5\theta_0}{4\alpha_0^3}\alpha^3+\frac{3\theta_0}{8\alpha_0^5}\alpha^5$$

(34)

Substituting equations (7) and (34) into equation (29), the parametric equations of the curved slot are obtained

$$\theta(\alpha)=-\arctan\left(\frac{R\sin\alpha}{L-R\cos\alpha}\right)+\left[\theta_0+\frac{15\theta_0}{8\alpha_0}\alpha-\frac{5\theta_0}{4\alpha_0^3}\alpha^3+\frac{3\theta_0}{8\alpha_0^5}\alpha^5\right]$$

(35)

and $\rho(\alpha)=\sqrt{L^2+R^2+2LR\cos\alpha}$ (36)

Where $-\alpha_0 \le \alpha \le \alpha_0$, α_0 can be selected freely within some practical design limitations (i.e., $20^0 \le \alpha_0 \le 70^0$). In this case, the wheel to crank angular velocity ratio, considering equation (10), becomes

$$\frac{\omega_w}{\omega_d}=\frac{d\beta}{d\alpha}=\frac{15\theta_0}{8\alpha_0}\left(1-\frac{2\alpha^2}{\alpha_0^2}+\frac{\alpha^4}{\alpha_0^4}\right)$$

(37)

and the maximum value occurs when $\alpha = 0$

$$\frac{(\omega_w)_{\max}}{\omega_d}=\frac{15\theta_0}{8\alpha_0} \quad (38)$$

The ratio of the angular acceleration of the wheel to the square of the angular velocity of the crank, considering equation (11), becomes

$$\frac{\varepsilon_w}{\omega_d^2}=-\frac{15\theta_0}{2\alpha_0^3}\alpha\left(1-\frac{\alpha^2}{\alpha_0^2}\right) \quad (39)$$

The maximum value of this ratio is

$$\frac{(\varepsilon_w)_{\max}}{\omega_d^2}=+\frac{5\sqrt{3}\theta_0}{3\alpha_0^3} \quad (40)$$

When $\alpha=-\frac{\sqrt{3}\alpha_0}{3}$; Both of these ratios are rapidly decreasing for any given $\theta_0=\frac{180^0}{n}$ with increasing value of α_0.

For three slotted wheel ($\theta_0= 60^0$) the polynomial curved slots are shown on Figs.4.(a), 4.(b), and 4.(c) for various values of initial angular position of crank, α_0. Fig.4(a) shows curved slot with looping. However it is not practical from operational point of view. Looping of the slots can easily be avoided by using larger value of α_0 or using offset slot design.

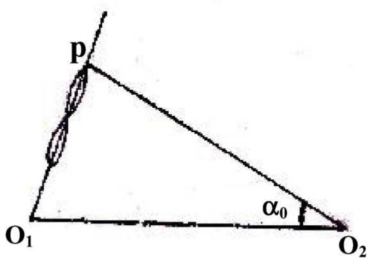


Fig.4.(a). Curved Slot in Geneva Wheel. No. of Slots = 3, α_0=20^0

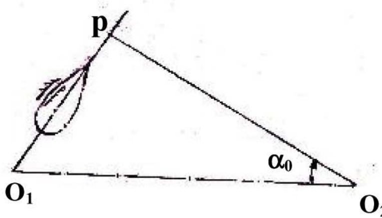


Fig.4.(b). Curved Slot in Geneva Wheel. No. of Slots = 3, α_0=30^0

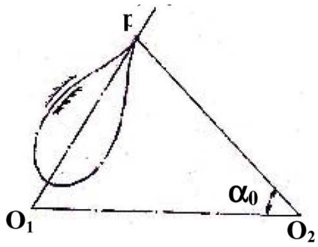


Fig.4.(c). Curved Slot in Geneva Wheel. No. of Slots = 3, α_0=45^0

For four slotted wheels, when n=4 (θ_0=45^0), the polynomial curved slots can be drawn in same manner.

Offset Curvilinear Slot Design

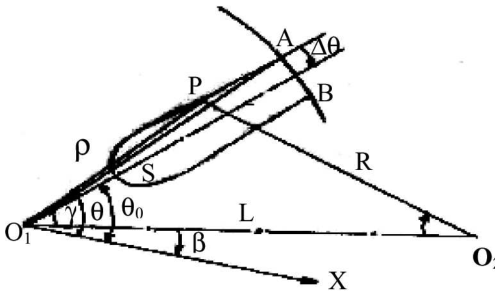


Fig.5. Geneva Wheel with Offset Curved Slot

The geometry of the proposed offset curved slot is shown in Fig.5. The centre line of the slot in the Geneva wheel is represented by line APSB. When the pin is about to enter the slot at point $\alpha = -\alpha_0$, $\gamma = -\gamma_0$ and $\gamma_0 = \theta_0 + \Delta\theta_0$, where $\Delta\theta_0$ is one half of the offset between the entry point, A, and the exit point B, of the slot. When the pin exits the slot at point B, $\alpha = +\alpha_0$ and $\gamma = +\gamma_0$. Now the relationship of L, the distance of the crank axis, O_2 to the wheel axis, O_1, and R, the crank radius becomes:

$$R=\frac{L\sin(\Delta\theta_0+\theta_0)}{\sin[180\deg-(\alpha_0+\theta_0+\Delta\theta_0)]}$$

(41)

Angle β is the angular displacement of the wheel at a time t, β is a function of α. Equations (10),(11),(19) and (20) are still valid. It is important to note that as β is independent of the offset, $\Delta\theta_0$, therefore the wheel output angular velocity, ω_w, and its angular acceleration ε_w are also independent of the $\Delta\theta_0$. i.e., the kinematic characteristics of the wheel does not change if an offset, $\Delta\theta_0$, is introduced.

The polar parametric expressions for the offset curved slot are:

$$\rho=\rho(\alpha) \quad (42)$$

$$\theta=-\gamma(\alpha)+\beta(\alpha) \quad (43)$$

The only unspecified function is $\beta(\alpha)$, if a polynomial expression is selected for $\beta(\alpha)$, the same results as equations (34) and (35) are obtained. However, R in the equations is determined by equation (41) now. It is a function of α_o, $\Delta\theta_0$, and θ_0. The designer is free to select the values of α_o and $\Delta\theta_0$ in equation (41), and $\theta_0 = \frac{180\deg}{n}$ where n is the number of slots in the wheel.

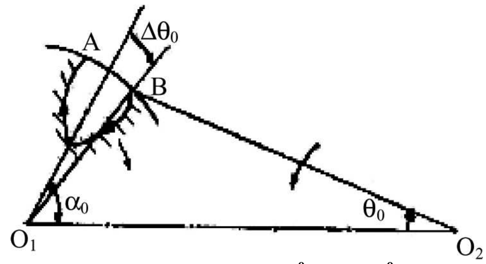


Fig.6. Curved Slot, n=3(θ_0=60^0), α_0=20^0, $\Delta\theta_0$= -10^0

Fig.6. shows the slot for n = 3 (θ_0 = 60^0), α_0 = 20^0 and -10^0 offset. The entry and exit points of the driving pin are indicated on the diagram with A and B, respectively. Comparing this diagram with Fig.4(a), it observed that the loop disappears. It noticed that the shape of the slot and the relative location of the entry and exit points (A and B) are dependent on magnitude as well as the sign of the offset. The kinematic characteristics of the Geneva wheel are independent of $\Delta\theta_0$, therefore, the output angular velocity and acceleration curves are identical for the slot show in Fig.6.

RESULTS AND DISCUSSION

The variations of velocity, accelerations for conventional, curved slots are presented in Fig 8 to 11. These diagrams indicate that both the peak angular velocity and the peak angular acceleration values are reduced if α_0 is increased and that the peak values of the curved slotted Geneva mechanism compare favorably with corresponding values of the conventional Geneva mechanism.

The output velocity of three slotted Geneva wheel, when n=3(θo=60^0) is shown in Fig 8. The angular velocity ratio is plotted against angular position of the crank for different α_0 values. These figures indicate that the peak angular velocity is reduced, if α_0 is increased. If α_0 is 45^0, the peak velocity is less than 40% of that of the conventional Geneva mechanism.

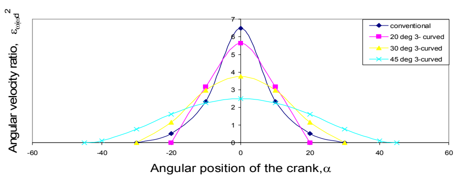


Fig.8. Comparison of Output Velocity of Conventional and 3-Curved Slot Geneva Wheel

In Fig.9 the angular acceleration ratio is plotted against angular position of the crank for different α_0 values. Fig.9 indicate that peak acceleration is reduced if α_0 is increased. If α_0 is 45^0, the peak acceleration is less than 16% of that of the conventional Geneva mechanism.

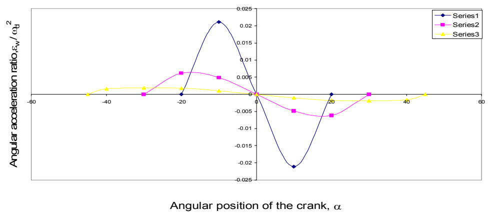


Fig.9. Comparison of Output Acceleration of Conventional and 3-Curved Slot Geneva Wheel

The output angular velocity of 4- slotted Geneva mechanism, when n=4 (θ_0=45^0) is shown in Fig. The angular velocity ratio is plotted against angular position of the crank for different α_0 values. The Fig.10 indicate that the peak angular velocity is reduced, if α_0 is increased.

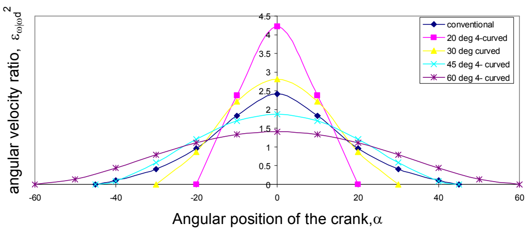


Fig.10. Comparison of Output Velocity of Conventional and 4-Curved Slot Geneva Wheel

In these angular acceleration ratio is plotted against angular position of the crank for different α_0 values. The Fig.11 indicates that peak angular acceleration is reduced if α_0 is increased.

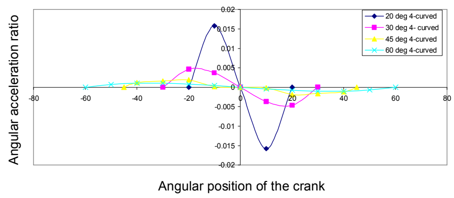


Fig.11. Comparison of Output Acceleration of Conventional and 4- Curved Slot Geneva Wheel

The peak angular velocity for different α_0 values is shown Fig.12, for n=3, The peak velocity is calculated by equation number 38, i.e. $\frac{(\omega_w)_{max}}{\omega_d} = \frac{15\theta_0}{8\alpha_0}$, when crank position α=0^0. This Fig indicates that the peak angular velocity is reduced if α_0 is increased.

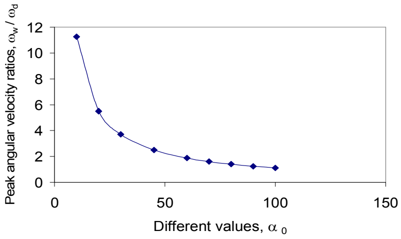


Fig.12.Comparison of peak angular velocity ratios for different values

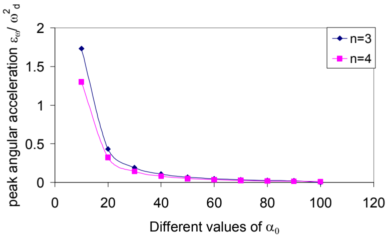


Fig.13. Comparison of peak angular accelerations for different α_0 values

The peak angular acceleration for different α_0 values is shown Fig.13, for n=3 and 4, where n is the number of slots. Equation number 39 calculates the peak velocity, i.e. $\frac{(\varepsilon_w)_{max}}{\omega_d^2} = +\frac{5\sqrt{3}\theta_0}{3\alpha_0^3}$, when crank position $\alpha = -\frac{\sqrt{3}\alpha_0}{3}$.

This Fig indicates that the peak angular acceleration is reduced if α_0 is increased.

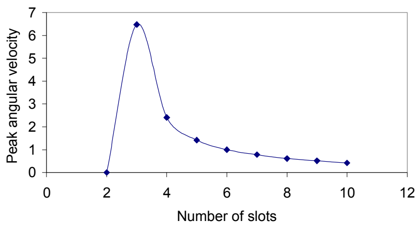


Fig.14. Peak angular velocity for different number of slots

The peak angular velocity for different, number of slots is shown in Fig 14, for conventional Geneva mechanism. It indicates that, the peak angular velocity is decreased if numbers of slots are increased.

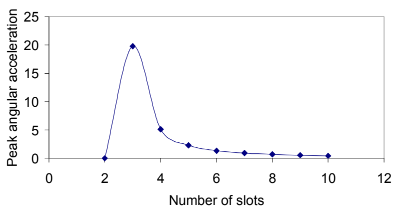


Fig.15. Peak angular acceleration for different number of slots

The peak angular acceleration for different, number of slots is shown in Fig 15, for conventional Geneva mechanism. It indicates that, the peak angular acceleration is decreased if number of slots is increased

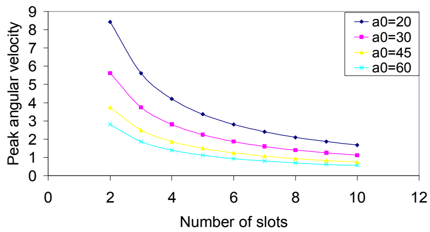


Fig.16. Peak angular velocity for different number of slots for different α_0 values

Fig.16 shows that the peak angular velocity decreases with increase in number of slots and α_0.

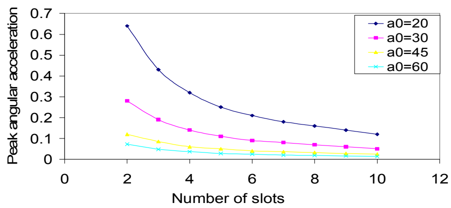


Fig.17. Peak angular acceleration for different number of slots for different α_0 values

Fig.17 shows that the peak angular acceleration with increase in number of slots and α_0.

CONCLUSIONS

The Geneva mechanism with curved slots represents a major improvement in the kinematic characteristics of the mechanism. The non-zero initial and final accelerations are eliminated. The motion starts and ends smoothly with zero acceleration. The peak value of the output velocity and acceleration is considerably reduced. An additional advantage of the new Geneva mechanism is that the motion to dwell time ratio can be freely selected, with in limits, by suitably choosing the value of α_0.

The kinematic characteristics of the curved slotted Geneva mechanism are superior to those of the conventional Geneva with straight slots. This new mechanism is simple and reliable. The only problem is that the shape of the curved slot often exhibits loops or sharp cusps, which render the slot unacceptable for practical purposes. The introduction of an offset eliminates this problem, by selecting a suitable offset value, the shape of the curved slot becomes eminently suitable for practical purposes. The offset does not affect the kinematic characteristics of the mechanism. The output angular velocity, the angular acceleration of the wheel does not change while the introduction of the offset.

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REFERENCES

[1] R.G.Fenton, "Geneva Mechanisms Connected in Series", Transaction of ASME, Journal of Engineering for Industry, pp. 603-607, 1975.

[2] R.G.Fenton and Wu Zhenbiao, "Kinematic analysis of flexible Geneva mechanisms", Transactions of the CSME, Vol.12, No.2, pp. 115-118, 1988.

[3] K.H.Hunt and N.Fink and J.Nayar, "Linkage Geneva Mechanisms. ADesign study in Mechanism Geometry", Proc. Insts. Mech Engrs, Vol 174, No.21, pp. 643-656, 1960.

[4] T.W.Lee, "Optimization of High speed Geneva Mechanisms", Transaction of the ASME, Journal of Mechanical Design, Vol.103, pp. 621-630, 1981.

[5] Robert.W.Ellms, "Pneumatic Geneva mechanism", Machine Design, pp.195-198,1952.

[6] R.G.Fenton , "Geneva mechanisms", Machine Design, pp.177-182, 1965.

[7] Akihiro Takanashi, "Effect of Tolerance and clearance in the Geneva Mechanism", Bulletin of the JSME, Vol.16, No.101, pp. 758-1766, 1973.

[8] J-J.Lee and C-C.Cho, "Improving kinematic and structural performance of Geneva mechanisms using the optimal control method", proc. Inst mech. Engrs, Vol.216, part c Journal of Mechanical Engineering Science, pp. 761-774, 2002.

[9] Richard M. Phelan, "Fundamentals of Mechanical design", 2nd edition, Mc.Graw- Hill publishers and Co.