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Cam based Infinitely Variable Transmission Theoretic Modelling

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Abstract Infinitely variable transmission (IVT) is a system which delivers the ratio between two turning elements to a continuous (non-discrete) variation (including zero). This article uses Solidworks software to build and simulate a cam-based IVT system. There are two identical units in the system under examination. Each unit comprises a cam with an oscillating slot connection that swings on a hinge and can be vertically shifted by changing the transmission rate. This modifier can be a power screw or a hydraulic ram. In addition, a grooved wheel and followers or an actuator are included in the system units. The raised wheels swing rotating movement, such that they are coupled by a single-way clutch to the output shaft (ratchet) to move the output shaft one way.

During the performance research, cam shapes are considered and examined inside the mechanism. a mixture of the unchanging speed and 1-5 polynomial shapes, used for the current investigation and tailored for

The results produced from the simulation generally reveal the theoretical results expected in accordance with the layout of the current IVT system. For all parts in these units, the findings imply a uniform velocity while each unit is powered. In this investigation, nevertheless, the ratchets used cause remarkable fluctuations in the angular speed of the output axis. Further research is therefore urgently needed in the choice and investigation of more efficient ratchets.

1. Introduction.

IVT is the system which enables for infinite variable transmission (stepless). IVT varies from CVT because it produces zero transmission proportion. The IVT model differs from the CVT system. The ability to change the transmission ratio under performance allows the IVT to choose the most appropriate one. The final outcome, along with the steady, fluid variation of the ratio, enables the smooth, constant flow in the machines that employ the IVT technology. The specific values range from 40/km to 300/km. CVT is used in wind turbines Mangialardi and Mantriota (1993) [1] due of the variation in air velocity. The generator's speed remains constant, independent of the wind speed. Lang (2000) [2] and Bertini (2014) [3] Clichés are frequently overused in day-to-day speech. electrification rather than conventional means (CVT-V-belt) Srivastava (2009) [4]. It is the cheap, brevity of its elements, and its speed ratios that have brought it down in price. a mathematical model (and the outcomes of that model) were able to produce power transfer that was more efficient than with a CVT, notably in cars. Lee (2004) [5] and Verbelen (2018) [6], created a Complete -Toroidal IVT transmitter

IOP Conf. Series: Earth and Environmental Science **961** (2022) 012091 doi:10.1088/1755-1315/961/1/012091

and examined it completely in order to look for uses for the technology. With pressures, the capacity increased. Raja Ramanujam states: [7] Innovated with the CVT (Continuously Variable Transmission), a transmission that does not use friction as a means of transmitting power. Aliukov et al. (2017) [8] and Aliukov et al. (2018) [9] presented a CVT-type transmitter device and compared it to a mathematical model. while Benitez and Madrigal (2004) [10] The following results provide significant evidence of a CVT-type transmission device being realistically implemented and an established mathematical model that correlates theoretical and simulation results in this device. Lahr and Hong (2006) [11] Suitable for storing plenty of media and avoiding mechanical losses. This design implemented a four-part IVT type model (2 planetary gear sets, wrenches, free wheels) with the following parts (which is two different types of planetary gear sets, one type of wrenches, and two different types of free wheels) in addition to the development of the mathematical model which matched the theoretical results with the operation.

the design for an IVT transmission device is complete, as well as the formulation of a mathematical model and the outcome is that the exit axis rotational speed is steady compared to the rest of the types. with a simulation model for a transmission and power transmission in the manner proposed by Amjad M. Abood in the year 2010[12]) (IVT). visualized as graphs and equations (constant outputs in the case of stability of the inputs). use input to process, then output These elements have a lot in common with dynamic considerations. A quote from Abbas Olyaei (2019[13])

provided a theoretical analysis of an endlessly variable cam-based transmission system (A.Al-Hamood , et al. 2018 [14]) and (A.Al-Hamood , et al. 2020 [15]) (IVT). In this research, we provide a different approach to analyzing this IVT system with the use of Matlab software.

2 .System of IVT.

As illustrated in figure (1), the IVT mechanism under examination includes principally of the reviewing pieces, each:

1-A cam-following device attached to the system's input axis.

2-.An oscillating slot connects the reciprocal motion from the cam follower to the follower for the groove wheel. The slot connection is attached to a hinge which delivers vertical motion via a power vibration.

3-.Grooved mechanism of wheel follower. The grooved wheel is a cam-following mechanism, but it has a profile that is bigger than 2 α and may cover an angular displacement. The figure shows this.(1)

4-wrench connected to the outlet shaft by the Groove wheel. This ratchet's job is to ensure that during oscillatory movement of the grooved wheel the output axis rotates in single direction.

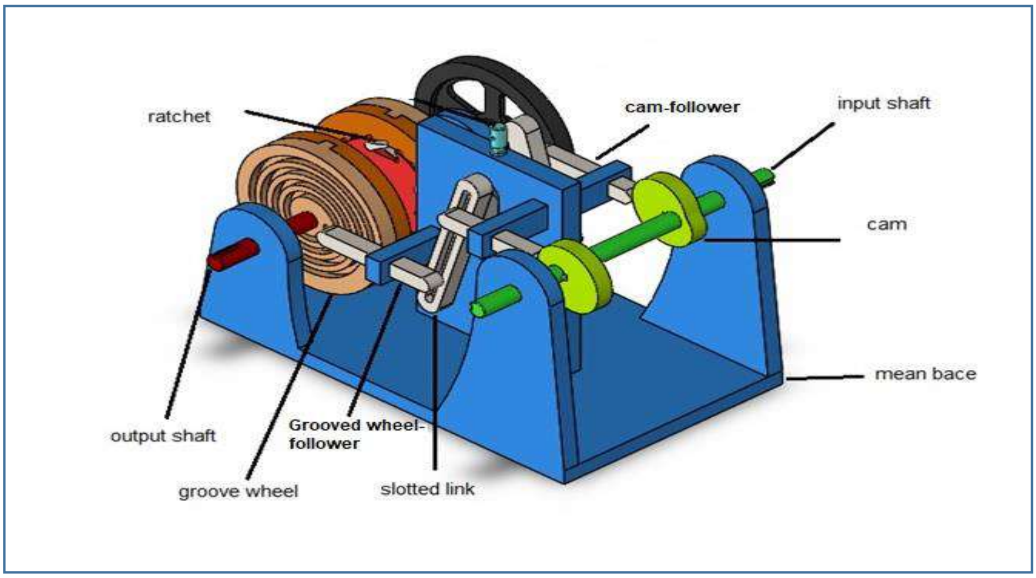

Figure 1 wrench connected to the outlet shaft by the oscillatory

3. mechanism procedure

The procedure of the IVT mechanism starts from the revolving speed of the input axis. This input revolving movement (of the input axis and the cam) is changed to replying rectilinear movement of the follower that that is linked to the cam

The cam-follower movement turns into oscillatory revolving movement of the slot linkage. As shown in figure (1), the slot linkage. is instilled to a adjustable position spindle that lead to adjustable transmission fraction. The location of the spindle can be controlled by mechanical system or a motorized coupled to a power screw.

linear replying movement is found again from the follower groove wheel which is linked to the slot linkage in one sideways and the grooved wheel on the other sideways. Accordingly, the grooved wheel gained a oscillatory revolving movement. The amount of angular displacement in (groove wheel) depends on the location of the spindle of the slot linkage. the oscillatory movement of the grooved wheel is changed to one-way angular movement of the output axis by the wrench.

The energetic stroke for apiece component is denoted via the cam external stroke which is described upward. .in order to achieve the round of apiece component, return stroke is completed using a rotating spring that is close-fitting to the slot linkage., the chief purpose of this spring is to keep the connection among the cam and the follower.

To variation the transmission percentage in the IVT mechanism, a power screw was used to offer a variation in the location of the spindle of the slot linkage. this gives a series of output angular speed for a definite rate of input angular speed. Mathematically, this mechanism offers zero transmission percentage within its continuous range and that is make this mechanism classified as an infinitely variable transmission mechanism.

4. Theoretical simulation of IVT.

This project was used to model the theory of the IVT system with the 2013 Matlabe Software version. The cinematic analysis is conducted in this work for all aspects of the IVT mechanism. It was determined the rectilinear and rotary displacement, speed and acceleration. During simulation theoretical, the geometric strategy of all aspects of the mechanism is accepted out. In the analysis for this survey it is vital to select and create the cam profile and the grooving wheel shape. Matlab software is a simulation software with a great potential. That is why the analysis and simulation of the study take this into account. Moreover, in addition to several foreign colleges that rely on it in their work, this program is utilized by more than a million engineers around the world.
A constant output angular speed for homogeneous input is required for every transmission system. This allows the cam to offer the working stroke of every unit constant speed. It is not convenient to employ a single speed profile for the return stroke. This is related to the problem of sharp borders that results in an infinite acceleration value. This in practice means that in the connection region among the cam and its supporter very high value is generated by contact forces. So that a fifth polynomial purpose for the cam shape is selected in order to deal with this difficulty. This is displayed in figure (2).
The continuous speed shape in this graphic includes the angle $(0-\pi)$ and the polynomial angle arc $(\pi-2\pi)$.

In theory, a follower with a tip-edge linked to the cam above is listed in a table on the displacement, speed and acceleration equations (1).

Theoretic kinematic calculations characterizing the movement of a tip -edge follower attached to the cam employed in this investigation are shown in Table (1). The follower stroke is denoted by the letter H.

Table (1).

Angle of cam turning (θ)	placement	Speed	Acceleration
[0- π]	$x_{i=r_b+c_i\,\theta_i}$	$v_i = c_i\,\omega_i$	0
[π- 2π]	$a_o + a_1\theta_2 + a_2\theta_2^2 + a_3\theta_2^3 + a_4\theta_2^4 + a_5\theta_2^5$	$0a_o + 1a_1 + 2a_2\theta_2 + 3a_3\theta_2^2 + 4a_4\theta_2^3 + 5a_5\theta_2^4$	$0a_o + 0a_1 + 2a_2 + 6a_3\theta_2 + 12a_4\theta_2^2 + 20a_5\theta_2^3$

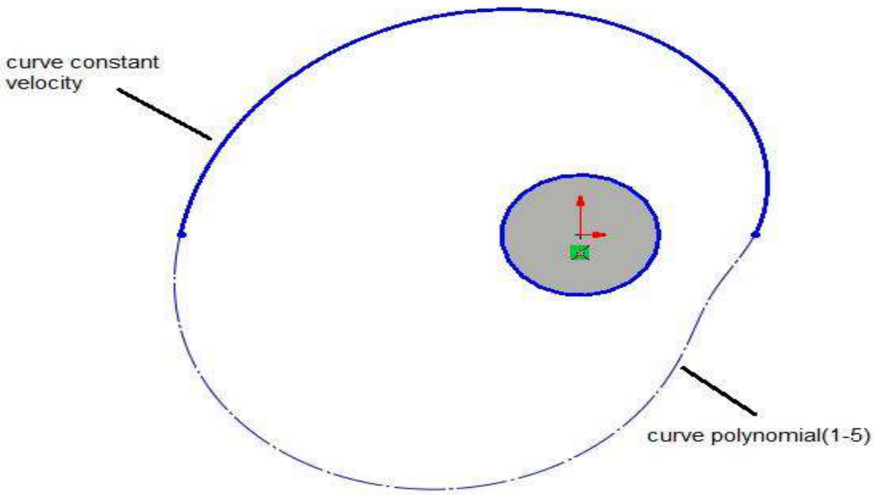

Figure (2): The cam profile

IOP Conf. Series: Earth and Environmental Science **961** (2022) 012091 doi:10.1088/1755-1315/961/1/012091

The previously reported grooved wheel is illustrated (3). This wheel operates as a cam also with ability to create a arc of more than 2π. The groove wheel built with a uniform speed profile is shown in Figure (3). (similar to the uniform velocity employed in the cam). The shape includes a range of 8π to introduce a big transmission ratio. It can be found.

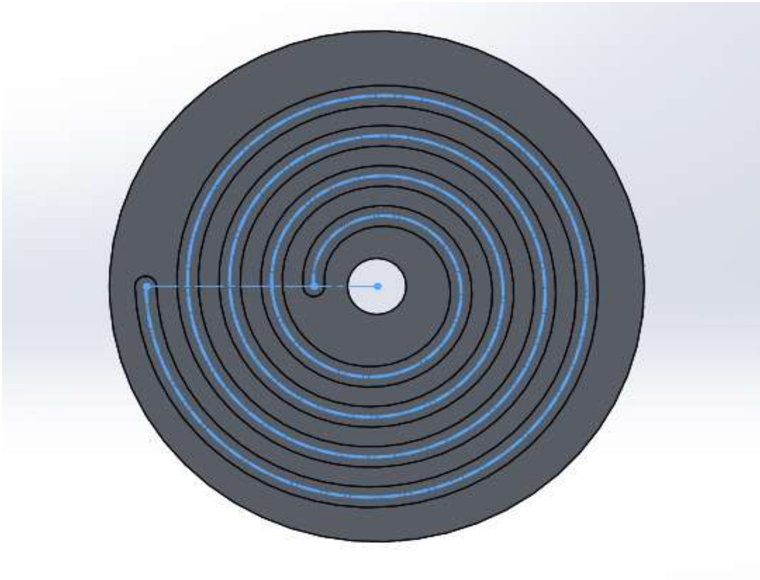

Figure (3): Grooved Wheel

5.Result

The results of this study are acquired using the model constructed using matlabe software, as stated previous parts, from cinematic simulation of IVT system.

Figure (4) displays a speed of rotation of 500 Rpm of the entrance shaft of the rectilinear displacement, speed and acceleration of the cam-follower. Figure (4a) showing the displacement with time, reveals that the curve is virtually smooth and continuous over a period of more than one cycle (described in table 2).

The following linear speed displays in Figure (4b), and the two portions of the cam profile can be clearly seen in this Figure (the uniform speed and the polynomial 1-5). The active stroke should be stressed as a uniform velocity stroke. The negative number for this stroke presented in the graphic is because of the axis of the model matlabe. This graphic indicates how important it is to have two units for each mechanism where the other section should work through its constantly uniform speed component during the return stroke of this unit (polynomial 1-5).

This curve is the time derived from the velocity profile as indicated in this figure and is depicted in Figure (4c) (4b). The null-value component represents the same speed pattern. From this curve, it is evident that it is nice and there is no rapid change.

IOP Conf. Series: Earth and Environmental Science **961** (2022) 012091 doi:10.1088/1755-1315/961/1/012091

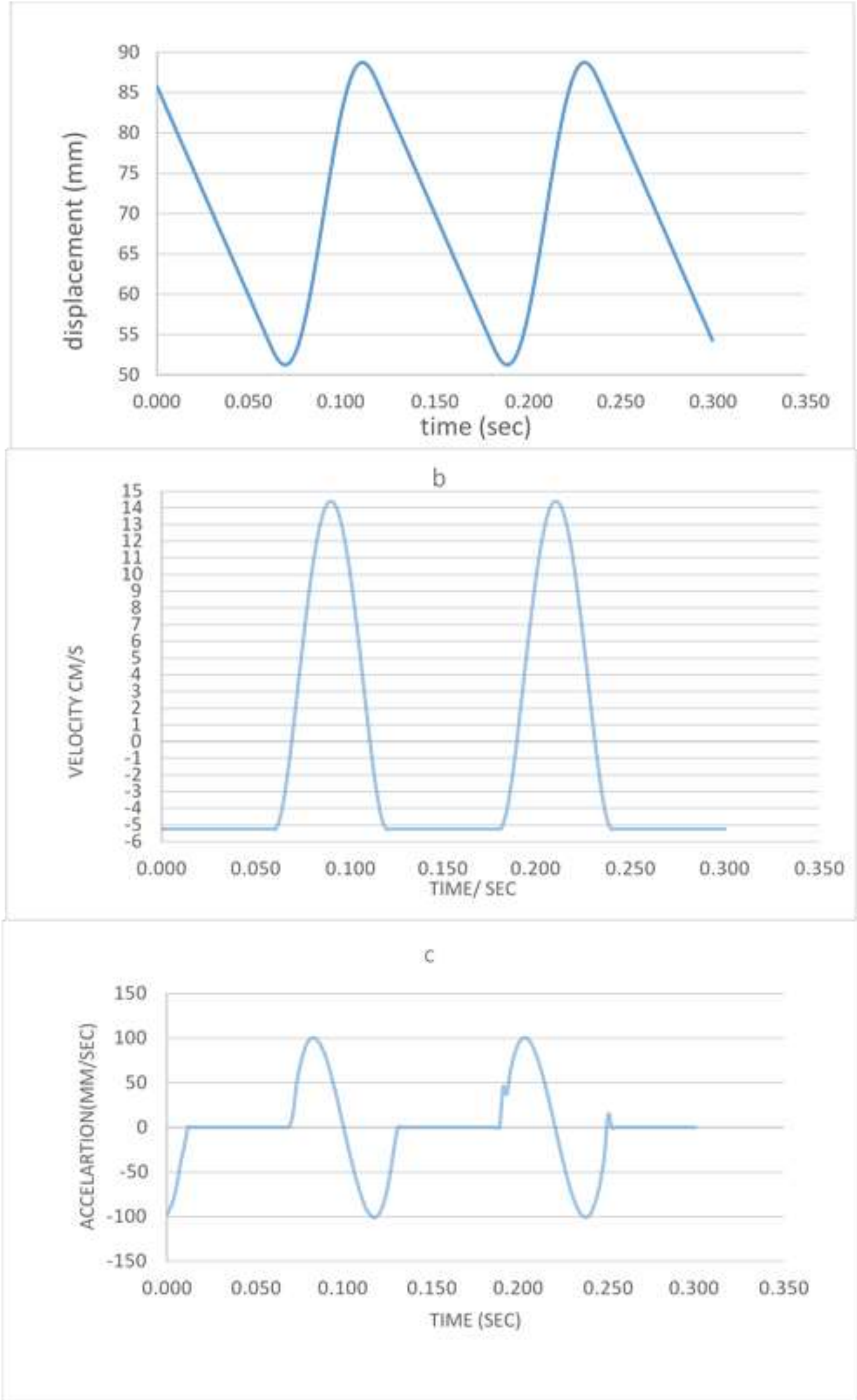

Figure 4: Displacement, velocity, and acceleration of the cam follower.

The speed of the two followers of the two units is shown in Figure (5). This figure shows that a single speed stroke (about 0.5 mm/s) takes place during all operating period, when the other supplier has a return stroke. This is an active stroke.

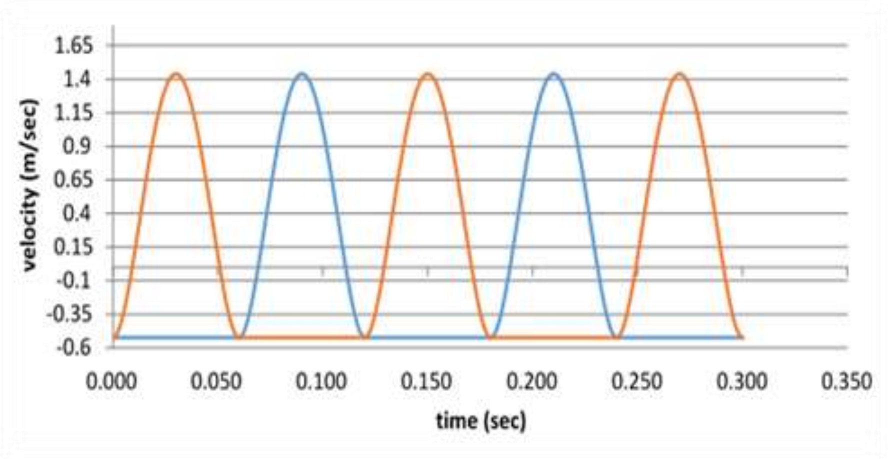

Figure 5: Linear velocity of the cam followers for both units

The angular speed of the two-slot links of the 2 groups is shown in Figure (6). The figure shows that the cycles displayed do not include a consistent speed part. This is because of the change of angle during operation of the slotted link.

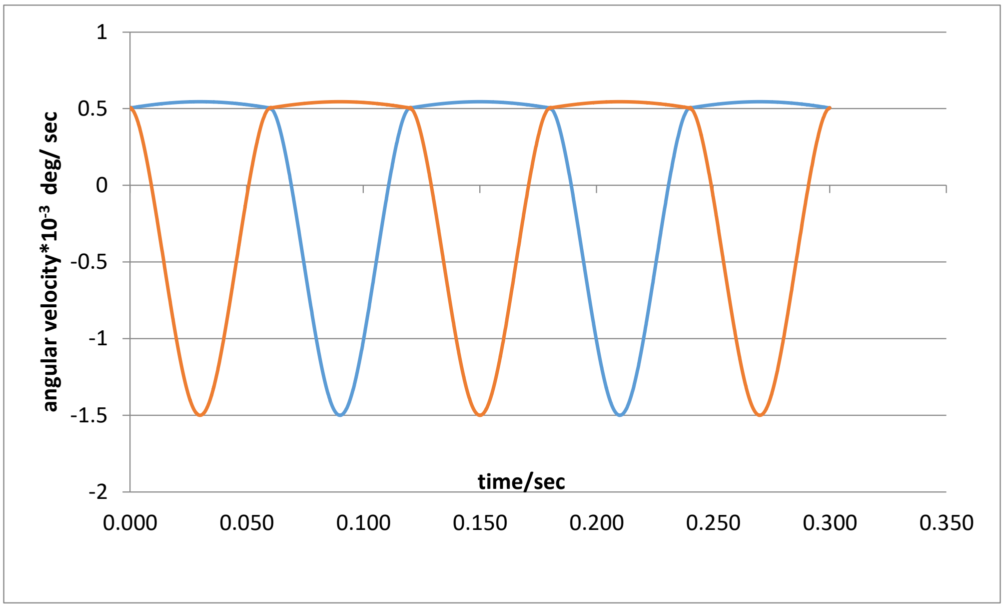

Figure (6): Angular speed of slot links of together components.

The linear speed of the double rain-fed followers is shown in Figure (7). This graphic is similar but has negative values to Figure (4). The grooved followers of the wheel transfer in the direction reverse of the cam followers. It should be mentioned that the slotted link pivot for the data is fixed at the midpoint of their allowed vertical position, with negative values.

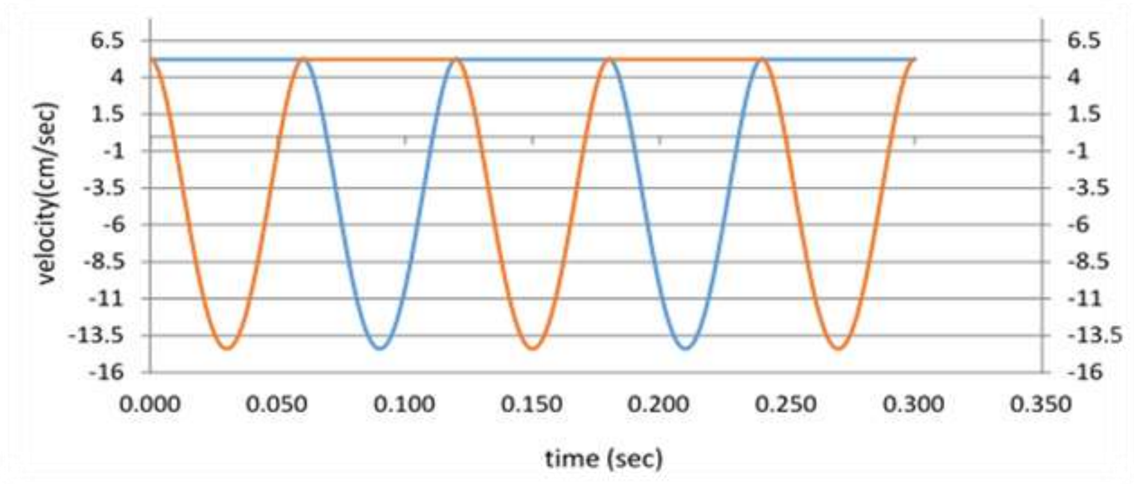

Figure 7: Linear velocity of the two grooved wheel followers.

The angular speed of both the groove wheels is shown in Figure (8) during operation of the system. This graphic shows that the system produces a standard angular output speed for uniform input. The angular velocity of every wheel oscillates in two directions opposed to this figure. This is why the groovy wheel is connected to the shaft using ratchets. These ratchets can be moved solely to the output axis at a uniform speed.

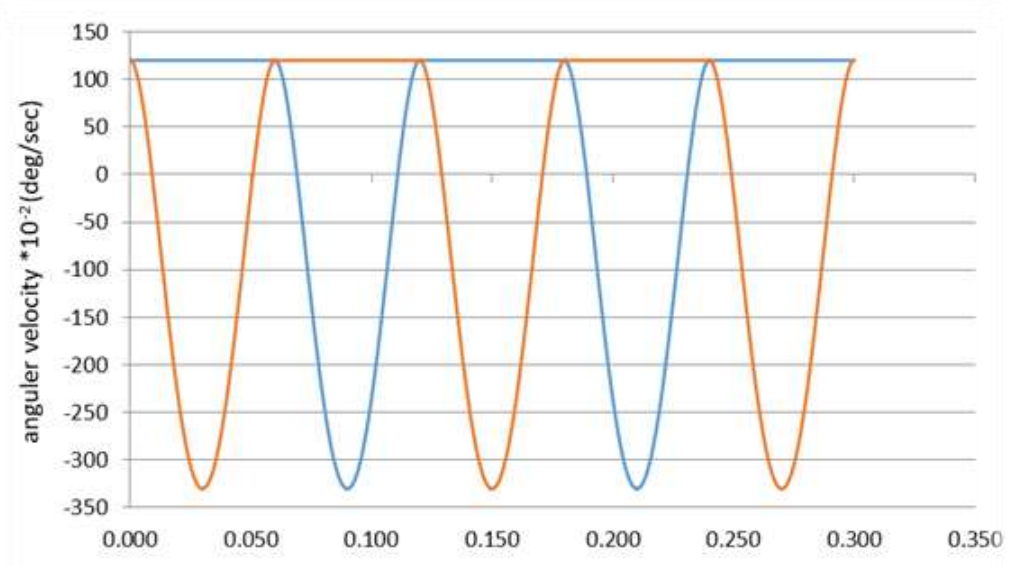

Figure 8: Angular velocity of grooved wheels during system operation.

Figure (9) illustrates the angular speed output of the output axis when the grooved wheels are connected via the ratchets to the axis. The figure demonstrates that the angular speed of the output is almost consistent at the conclusion of the raised wheel peed period with tiny fluctuating values. The particular sort of ratchet utilized in this investigation can lead to this behavior. To upgrade or replace the ratchets in future work with another type.

6. Conclusion.

The major objective of the existing work was to numerically animation the cinematics of a variable transmission system created on camshafts. Matlab Software version 2013 generated and run the model.

The study showed that the system movies may efficiently modeled and simulated using the program of MATLAB. The kind and characteristics of the cam profile have been demonstrated as the important aspect in the design of IVT mechanisms. The animation therefore implies that a blend of a uniform speed shape with the 1-5 polynomial profile achieves the cam-follower smoothness and continues trends in displacement, speed and acceleration. The other components of the IVT mechanism therefore exhibit a same trend during their operation.

The findings of this study confirmed the notion that two identical units, which often function, can provide efficient system operation in these systems. The units in this study were orientated for the working stroke without overlap, future overlap studies would be interesting.

The designing of the groove wheel geometry is another important result. The simulation showed that a unchanging speed shape should be useful to achieve unchanging output angular speeds for a unchanging input. Furthermore, the amount of the overall angle of the groove profile governs the system's biggest transmission fraction.

Finally, the ratchets used in the IVT system cause a substantial variation in the output angular speed, according to this study. As a result, greater research into the choice and administration of more effective wrenches is strongly advised.

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