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MODELING, DESIGN, DEVELOPMENT, TESTING & ANALYSIS OF DUAL WORM SELF LOCKING SYSTEM FOR IMPROVED TRANSMISSION EFFICIENCY & DECELERATION LOCKING PROPERTY

Mr. Naeem B. Tamboli,
T.K.I.E.T Warananagar, Shivaji University,
Kolhapur, India

Prof. Amol S.Todkar
Assistant Professor Department of Mechanical Engineering
T.K.I.E.T Warananagar Shivaji University, Kolhapur, India

ABSTRACT
In many cases wherever material handling equipment gear drives are used because of their efficient transmission of power. But disadvantage of this system are whenever power shut down occurs or may be mechanical failure occurs are input side of the system. If this situation occurs, guarantee of rotation of the shaft cannot be predicted. It can move in both the direction, either it can continue moving in same direction because of inertia or it may move in opposite direction because of gravity of the load. Moving in the reverse direction is also called as back driving [1]. To prevent back driving self locking gears can be provided, which doesn't move in opposite direction.
The project implemented aims at self locking property by usage of worm pair which are connected to each other in mesh pattern. The advantage of implemented system is simple and robust in construction. And we can achieve efficiency of around 90%, where as conventional system has efficiency of only 40%.

KEY WORDS: Worm Pair, Self locking, Transmission efficiency, back driving etc.

INTRODUCTION
This survey contributes to the design and development of mating worm pairs for their use in load lifting devices. The main property which is a worm gear system exhibit is its self-locking ability. We have also considered the system of worm pair due to its property of self-locking as that of worm and gear system. Due to this property worm pair can be used in various applications such as differential gear mechanism used in vehicles, self-locking system for load lifting, automatic dual ratio motion convertor, etc. Out of all these applications I have selected to work on worm pair self-locking system.
Author proposed the system for lifting the load which uses the pair of worms instead of conventional worm and gear system. The main intension behind development of this system is to improve the efficiency of the conventional system and also to improve the reliability and safety

of conventional system, the cost of manufacturing and space requirement is also important for the development of this system [2].

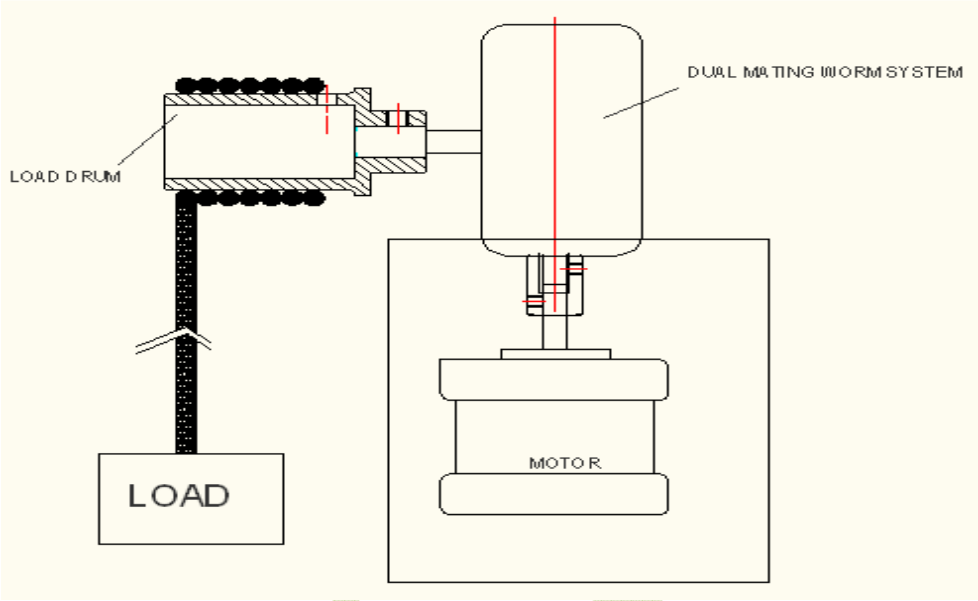


Fig. 1. Test Rig Set-up for Mating Worm Pair Self-Locking System

EXISTING SYSTEM

Self locking is made part of gear system, and drives the gear and has free rotation. Output gear can move in any direction but they are mounted on the same shaft as the input system they have inherent self locking capacity. This property of self locking attracts many researchers, who are designing the system based on this. The best advantage of worm gears is we can use self locking arrangement but usage of worm pair disadvantage efficiency of the system reduces only when they are made self locking.

Disadvantage of existing system:

1. Space requirement is larger.
2. Overload protection cannot be provided.
3. Cost of production is very high.
4. Efficiency of self locking system less than 40%, so the 60% power is wasted in friction. Due to high capacity of motor is required.

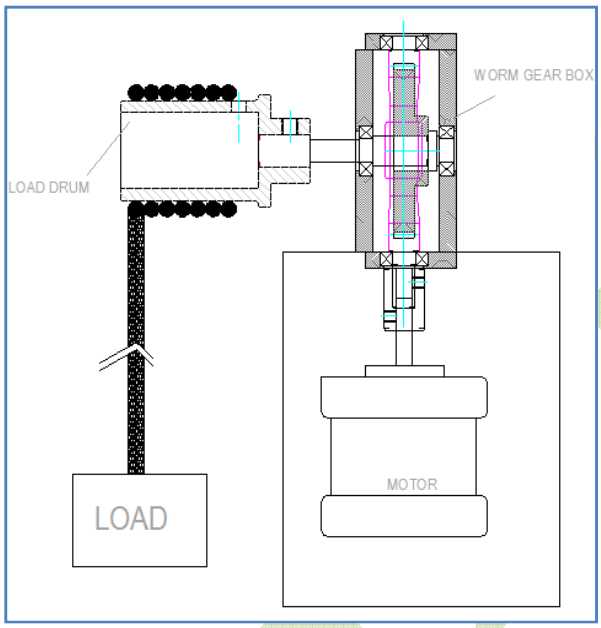


Fig.2. Conventional Worm-Gear box

Table 1. Result table for conventional system

Sr. No.	Load (N)	Effort (N)	Efficiency	Avg. Efficiency
1	14.715	0.73575	53.8503	
2	19.62	0.93195	56.68452	
3	24.525	1.2753	51.77913	
4	29.43	1.5696	50.48465	**52.78 %**
5	39.24	2.0601	51.286	
6	44.145	2.30535	51.55879	
7	49.05	2.4525	53.8503	

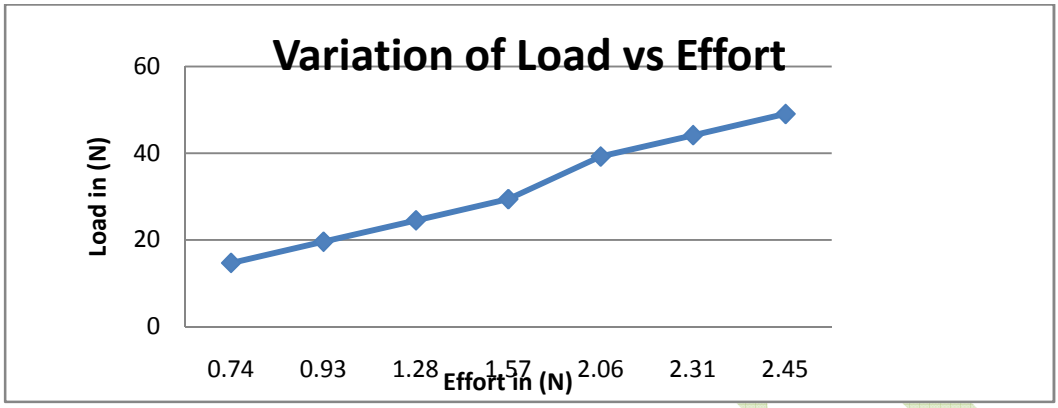


Fig. 3. Graph of conventional system (Load vs Effort)

Above figure shows the graphical representation of variation of load vs effort. We can see that as the load is increased the effort required to lift the load also get increased. That means the effort required to lift the load is directly proportional to the load to be lifted.

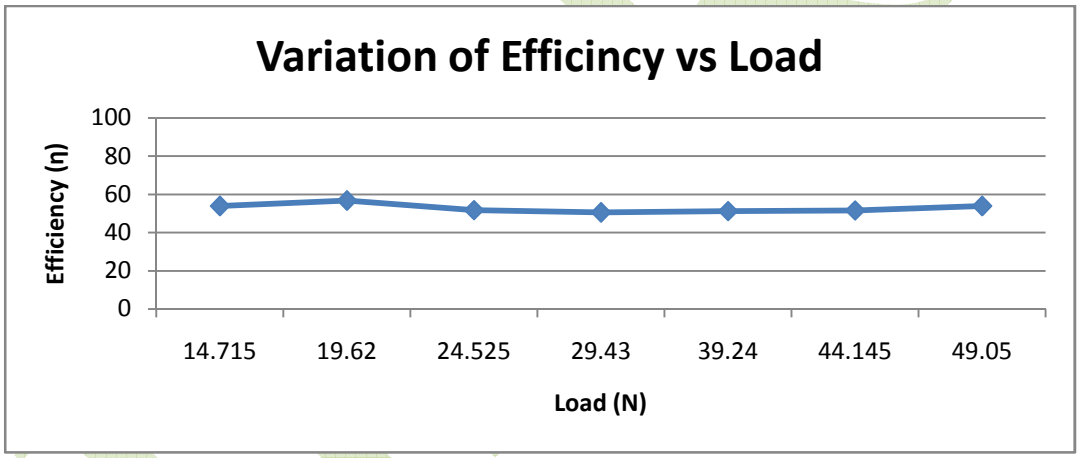


Fig. 4. Graph of conventional system (Efficiency vs Load)

Above figure shows the graphical representation of variation of efficiency of conventional worm gear system vs load. From above graph we can conclude that the efficiency of conventional worm and gear system lies between 50% to 60%. From result table it is concluded that the average efficiency of this system is 52.78%.

MODIFIED SYSTEM

Modified system is termed as mating worm self locking system. The proposed system combines two screws to produce a self locking properties [3]. It also has advantage of fast operation and application brake, whenever power shut down. In other words mating worm self locking system is same as worm pair system possessing self locking property with improved efficiency by 50%.

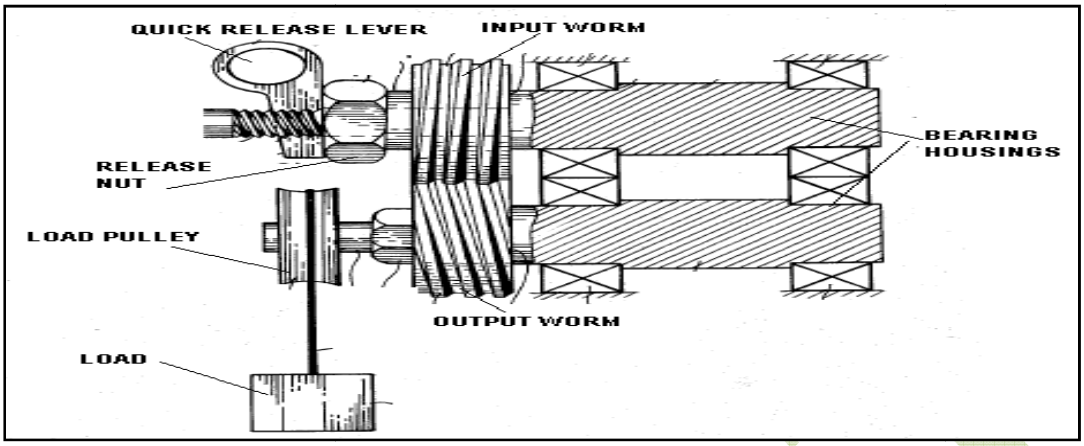


Fig. 5. Proposed -Mating Worm Pair System

EFFICIENCY OF WORM GEAR

The efficiency of the worm gear is determined by dividing the output Torque M2 with friction = μ by the output torque with zero losses i.e. μ = 0
First cancelling $[(M_1 . d_2 / d_1) / M_1 . d_2 / d_1)] = 1$
Denominator = $[(\cos \alpha_n / (\cos \alpha_n . \tan \gamma] = \cot \gamma$
$\eta = [(\cos \alpha_n - \mu \tan \gamma) / (\cos \alpha_n . \tan \gamma + \mu)] / \cot \gamma$
$= [(\cos \alpha_n - \mu .\tan \gamma) / (\cos \alpha_n + \mu .\cot \gamma)]$

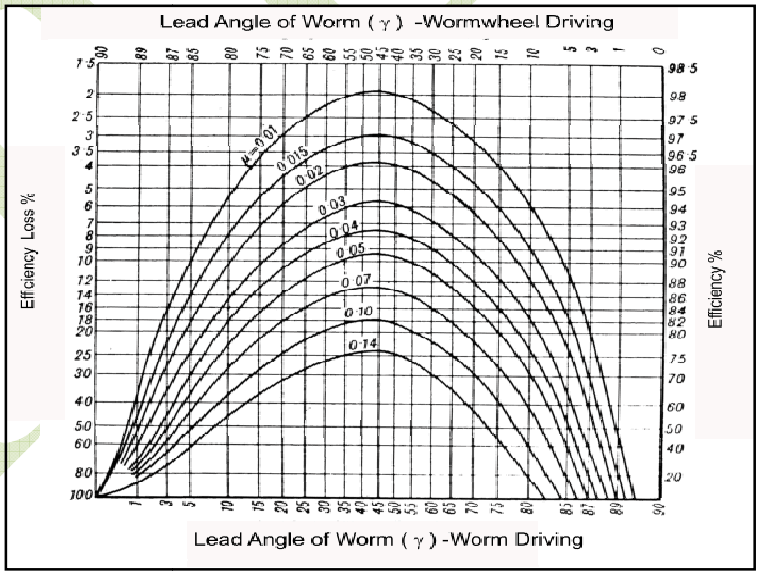


Fig.6. Graph showing worm gear efficiency related to gear lead angle (γ)

The efficiency of worm gear depends on the coefficient of friction and the lead angle. Below we can see the diagram representing the dependency of the efficiency and those two parameters. In order to obtain a worm gear with high efficiency it is recommended to use the lead angle in the range between 15° and 30°.

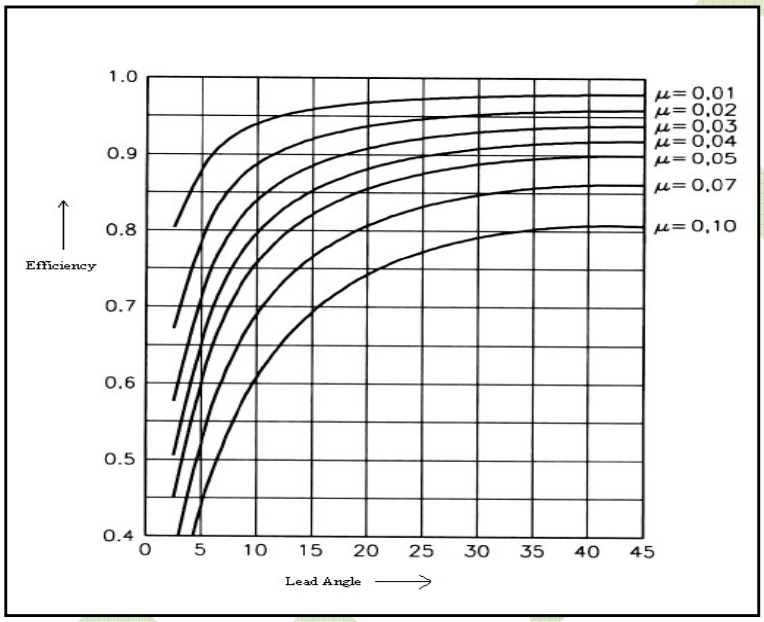


Fig .7. Graph showing worm gear self-locking efficiency

b) Self-Locking:

The graph shown in fig.5., gear wheel is driving intersection points at the curve. The line which is showing an zero efficiency indicates the graph of worm drive self locking. It simply means that gear wheel is not capable of driving the worm. The limit of self locking system will arise when worm lead angle (γ) equals a tan (μ). (2^o to 8^o).

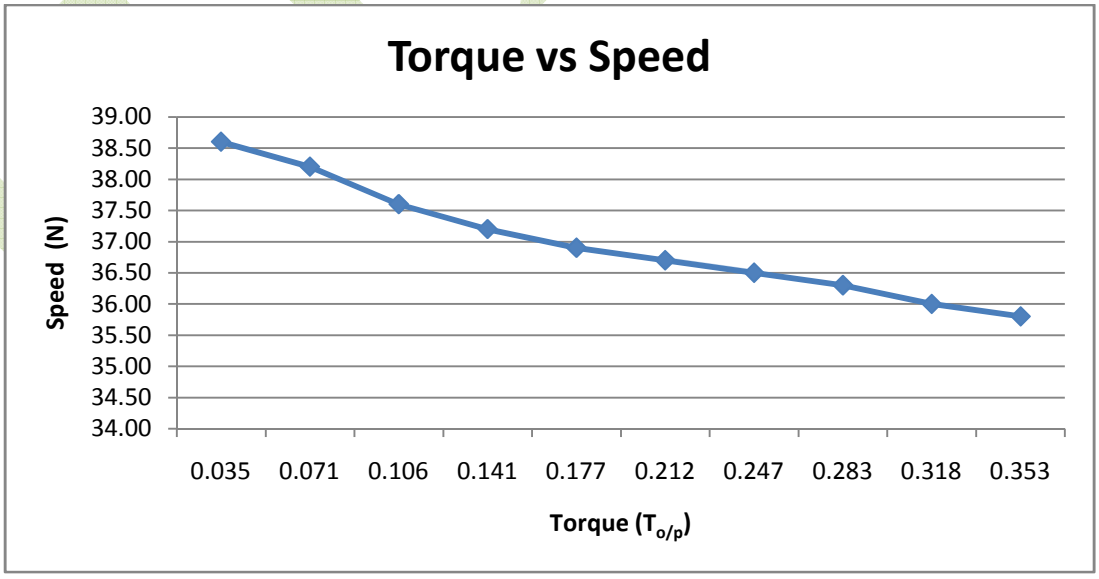
The proposed system (mating worm self locking system) associated with worm pair system is proposed with efficiency at 90%. While making this system every worm sheen is given different direction and with different pitch angle [4]. The selection of not only proper but also different pitch angles is very important while making self – locking system. The table no.1. shows coefficient of friction under different circumstances.

Table 1.1 Coefficient of friction

Circumstances	STARTING	RUNNING
Average quality of material & workmanship & average running conditions.	0.18	0.13

Table 2 Result table for mating worm pair system

Sr. No.	W in gm	Speed ($N_{o/p}$)	Torque ($T_{o/p}$)	Power ($P_{o/p}$)	Efficiency (η)	Avg Efficiency (η_{Avg})
1	100.00	38.60	0.035	0.143	83.79	
2	200.00	38.20	0.071	0.283	83.61	
3	300.00	37.60	0.106	0.417	82.98	
4	400.00	37.20	0.141	0.551	82.77	
5	500.00	36.90	0.177	0.683	83.07	
6	600.00	36.70	0.212	0.815	83.72	84.046
7	700.00	36.50	0.247	0.945	84.35	
8	800.00	36.30	0.283	1.074	84.85	
9	900.00	36.00	0.318	1.199	85.17	
10	1000.00	35.80	0.353	1.325	86.15	



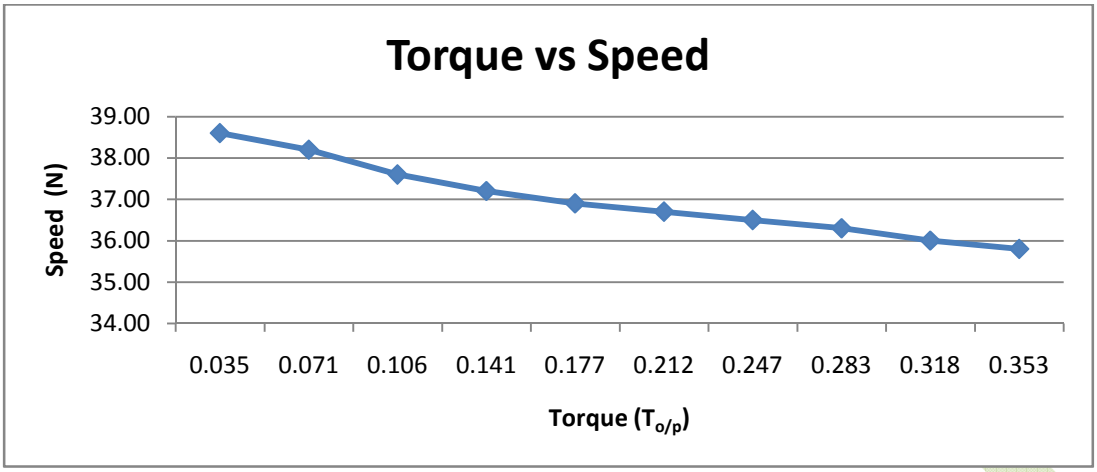


Fig.8. Graph of mating worm pair system (Torque vs Speed)

Above figure shows the graphical representation of variation of torque vs speed of the mating worm pair system. From above graph we can conclude that torque output of the system decreases as there is decrease in speed of the shaft. We can say that the torque output is inversely proportional to the speed of the shaft.

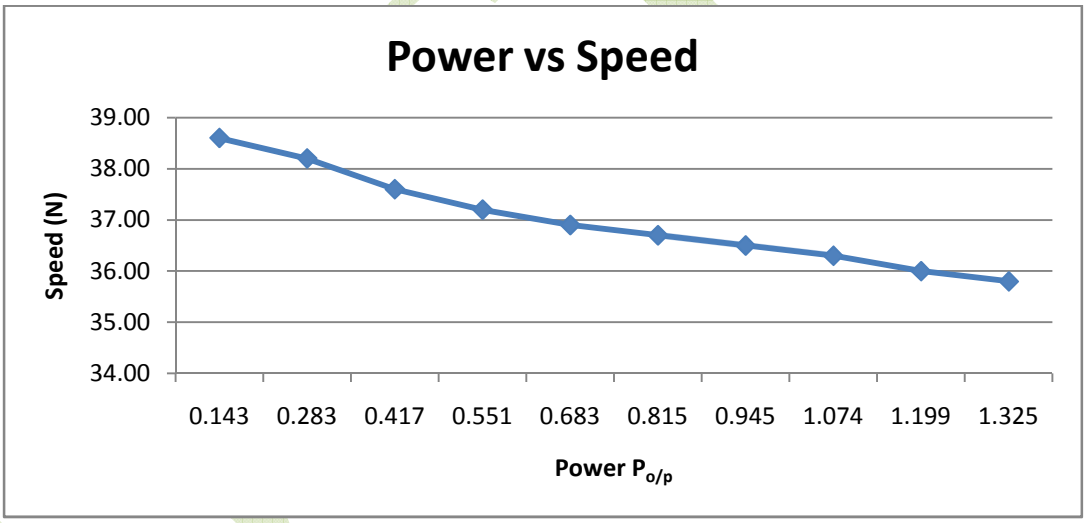


Fig. 9. Graph of mating worm pair system (Power vs Speed)

Above figure shows the graphical representation of variation of power output of the mating worm pair system vs speed of the system. From the graph we can conclude that the power output of the mating worm pair system decreases as the speed of the system increases. So from this we can say that the power output of the system is inversely proportional to speed of the system.

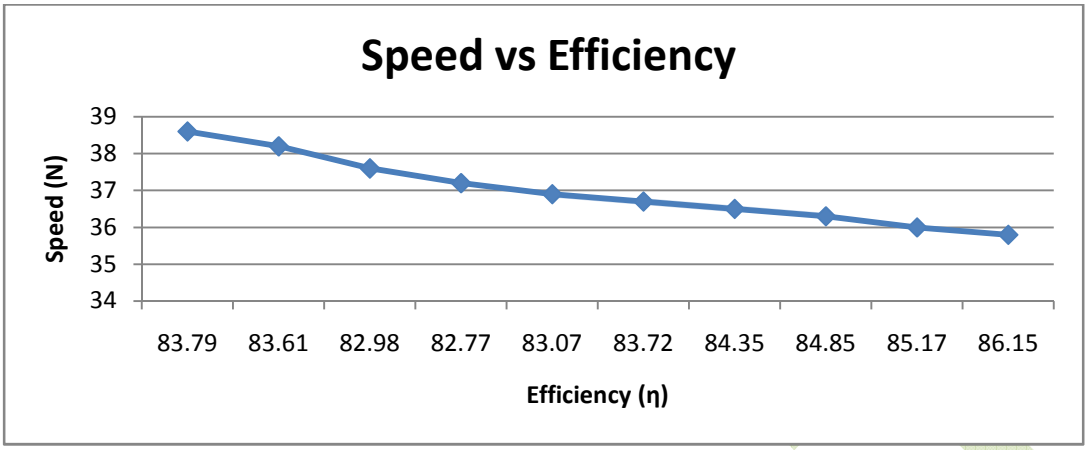


Fig. 10. Graph of mating worm pair system (Efficiency vs Speed)

Above figure shows the graphical representation of variation of efficiency of the mating worm pair system vs speed of the system. From above graph we can conclude that the efficiency of the system decreases as there is increase in speed of the system.

CONCLUSION

At the conclusion of above experiment, mating worm pair system also xhibits a self-locking ability as that of conventional worm gear system. Also the efficiency of the mating worm pair system is also greater than that of conventional worm gear system if they use in mesh fashion. If we can modify the warm gear for, helix angle, lead angle and other parameters. The replacement of conventional system i.e. existing system is possible with proposed system i.e. worm pair with self locking system also we can achieve maximum efficiency and less frictional losses.

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