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Performance Investigation of a Worm and Worm Wheel Apparatus in Engineering Mechanics Laboratory

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Abstract: ***A worm gear is used when a high speed reduction ratio is required between crossed axis shafts which do not intersect. The author aim is to investigate the performance of worm and worm wheel apparatus used to lift the heavy loads by applying small efforts in the engineering mechanics laboratory. The study is useful for investigators and designers in the conceptual stage of design phase.***
Keywords: Worm and worm wheel, Mechanical Advantage, Velocity Ratio, Efficiency

I. INTRODUCTION

Agitators, conveyors, crushers, cranes, elevators, feeders, small ball mills, mixers, cooling towers, Extruders, Packaging, Filters are the examples of worm gears.Hashiguchi et.al. [1] describes the unconventional friction. Kartal [2] written on concept of elastically similar flat-ended cylinders. Eriten et. al. [3] worked on the behavior of flat rough surfaces. Kostas et.al [4] written on the coefficient of friction between the inter particles. Chiew et .al [5] worked on friction model identification. Piatkowski et.al. [6] Worked on dynamic friction models. Kostas [7] gave a concept on mechanical inter particle loading apparatus. Dong et.al. [8] Prepared a wear reduction model. Deepak et. al. [9] presented the effect of roughness on coefficient of friction. Cura et. al. [10] worked on wear formulation approach. Saha et.al. [11] Demonstrated a modified friction model. Aita et.al. [12] Worked on nonlinear friction models. Putelat et. al. [13] demonstrated their work on frictional waves and Tsampras et al [14] written on experimental study of friction devices and rubber bearings. The author has also consulted a lot of other references including [15-28] for giving a finishing touch to the present work. The apparatus consists of a toothed wheel (known as worm wheel) carrying load drum is shown in Figure-1. A string is wound around the load drum to carry weight 'W' to be lifted. A horizontal spindle is provided with worm and this worm is engaged with the teeth of the worm wheel. To the end of the spindle, an effort pulley is attached. Another string passes round the effort pulley and at the end of which a scale pan is tied. The weights are placed in the pan to find the value of effort 'P'

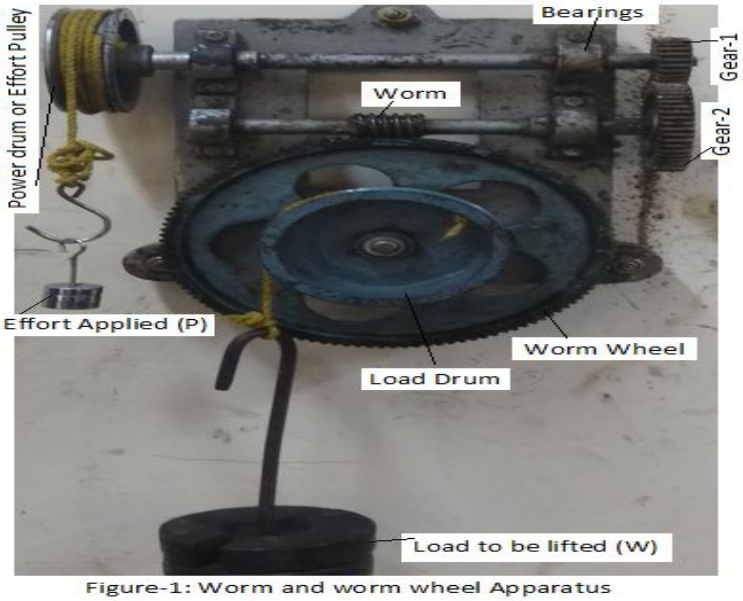

Figure-1: Worm and worm wheel Apparatus

A. Notations Used

In the present study, the notations and terminology used are as follows.
W = Load to be lifted,
Wf = Frictional load,
Wi = Ideal load,
P = Effort to be applied to lift load W,
Pi = Ideal effort,
Pf = Frictional effort,
D = Diameter of the effort pulley,
d = diameter of load drum,
M.A. = Mechanical Advantage = W/P,
x = Distance moved by effort P,
y = Distance moved by load W,
V.R. = Velocity Ratio = Distance moved by Effort / Distance moved by Load.
Now, considering one revolution of effort pulley,
(V.R.)True = Distance moved by Effort for one revolution of the effort pulley / Distance moved by Load vertically = πD TG/ πd = DTG /d ,
(V.R.)Exp = Distance moved by Effort / Distance moved by Load = x/y,
η = Efficiency = M.A. /V.R.,
(η)True = Efficiency (True) = M.A. / (V.R.)True,
(η)Exp = Efficiency (Experimentally) = M.A. /(V.R.)Exp.,
FL = Friction Loss = 1 – Efficiency (η),
(FL)True = Friction Loss = 1 – (η)True,
(FL)Exp = Friction Loss = 1 – (η)Exp,
T = Number of teeth on the worm wheel,
T1 = Number of teeth on the smaller gear,
T2 = Number of teeth on the larger gear,
G= Gear ratio= T2 / T1 ,

II. METHDOLOGY

A. Step1: Measure the circumference of both the pulley and the drum with the help of a string and meter rod or measure their diameters with outside calliper.
B. Step2: Wrap the string round the drum and attach a load W
C. Step3: wrap another string round the pulley and attach a pan with it
D. Step4: Add weights in the pan till the load just starts moving upwards.
E. Step5: Note down the weights in the effort pan
F. Step6: Calculate the M.A., V.R. and efficiency
G. Step7: Repeat the experiment with different load
H. Step8: Enter all the data in the M.S.Exel sheet and determine all the required values as shown in Table-1.

III. OBSERVATIONS

A. Diameter of the Effort pulley, D = 120 mm,
B. Diameter of the load drum , d = 138 mm,
C. Number of teeth on the worm wheel, T = 120,
D. Number of teeth on the smaller gear, T1 = 25,
E. Number of teeth on the larger gear, T2 = 50,
F. Gear ratio, G = T2 / T1 = 50 / 25 = 2,
G. (V.R.)Th = ΠDTG / Πd = D* T* G / d = 120 *120 * 2 / 138 = 208.7,

Table-1: Observations of Worm and Worm Wheel

S.N.	Load to be lifted W (N)	Effort applied P (N)	Distance moved by P x (mm)	Distance moved by W y (mm)	M.A.= W/P	(V.R.)Exp= (x/y)	(V.R.)Th= D* T * G/D	Pi = W/ (V.R.)Th (N)	Pf = P -Pi (N)	Wi = P * (V.R.)Th (N)	Wf = Wi -W (N)	Efficiency (η)Exp = M.A./(V.R.)Exp	(η)Th = M.A./(V.R.)Th	Friction FLTh = 1-(η)Th	Loss FLExp = 1-(η)Exp
1	40	2.5	377	1.5	16.0	251.3	208.7	0.19	2.31	521.8	481.8	6.4	7.7	92.3	93.6
2	60	3	377	1.6	20.0	235.6	208.7	0.29	2.71	626.1	566.1	8.5	9.6	90.4	91.5
3	80	3.5	377	1.7	22.9	221.8	208.7	0.38	3.12	730.5	650.5	10.3	11.0	89.0	89.7
4	100	4	377	1.8	25.0	209.4	208.7	0.48	3.52	834.8	734.8	11.9	12.0	88.0	88.1
5	120	4.5	377	1.8	26.7	209.4	208.7	0.57	3.93	939.2	819.2	12.7	12.8	87.2	87.3
6	140	5	377	1.8	28.0	209.4	208.7	0.67	4.33	1043.5	903.5	13.4	13.4	86.6	86.6
7	160	5.5	377	1.8	29.1	209.4	208.7	0.77	4.73	1147.9	987.9	13.9	13.9	86.1	86.1
8	180	6	377	1.8	30.0	209.4	208.7	0.86	5.14	1252.2	1072.2	14.3	14.4	85.6	85.7
9	200	6.5	377	1.8	30.8	209.4	208.7	0.96	5.54	1356.6	1156.6	14.7	14.7	85.3	85.3
10	220	7	377	1.8	31.4	209.4	208.7	1.05	5.95	1460.9	1240.9	15.0	15.1	84.9	85.0

IV. RESULT AND DISCUSSION

Mean M.A. = 25.98

(V.R.)Exp = distance moved by effort/ distance moved by load = x/y = 217.48,

(V.R.)Th = ΠDTG / Πd = D* T* G / d = 120 *120 * 2 / 138 = 208.7,

(η)True = Efficiency (True) = M.A. / (V.R.)True =12.45 %,

(FL)True = Friction Loss = 1 – (η)True = 87.6 %,

(FL)Exp = Friction Loss = 1 – (η)Exp = 88.1 %,

The detailed result analysis is summarized in Table-1. The relation between the effort applied (P) and load (W) to be lifted is shown in Figure-2. The relation between Mechanical Advantage (M.A.) and load to be lifted (W) is shown in Figure-3. Figure-4 illustrates the relationship between efficiency (η) and load (W).

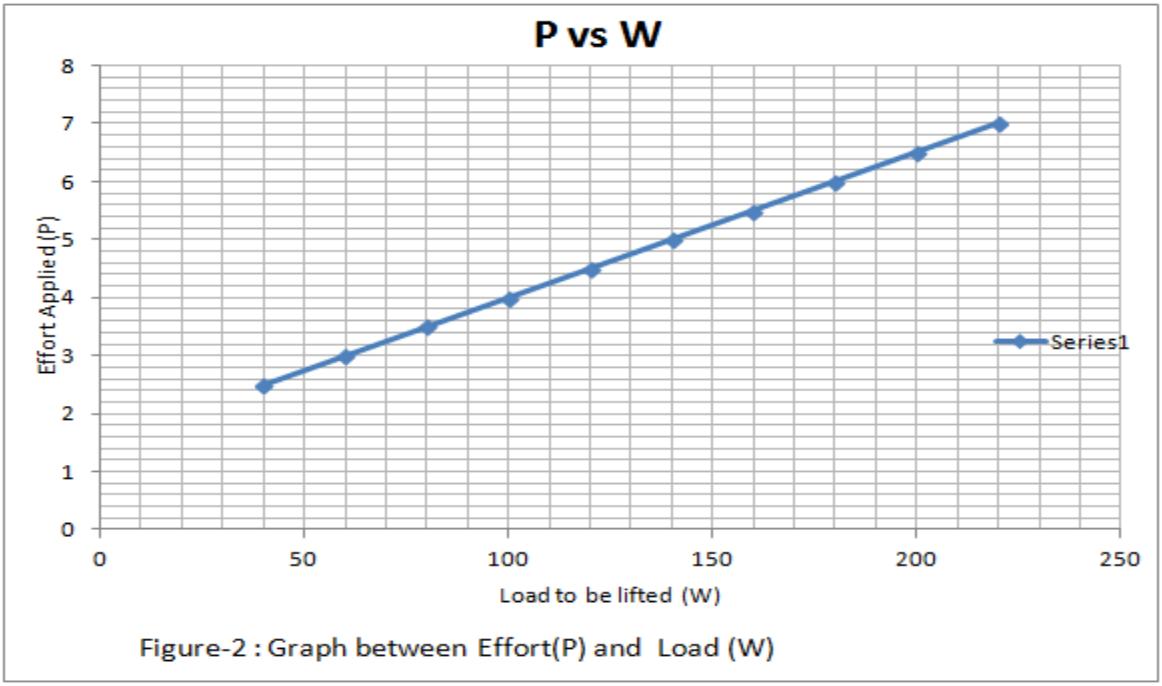

Figure-2 : Graph between Effort(P) and Load (W)

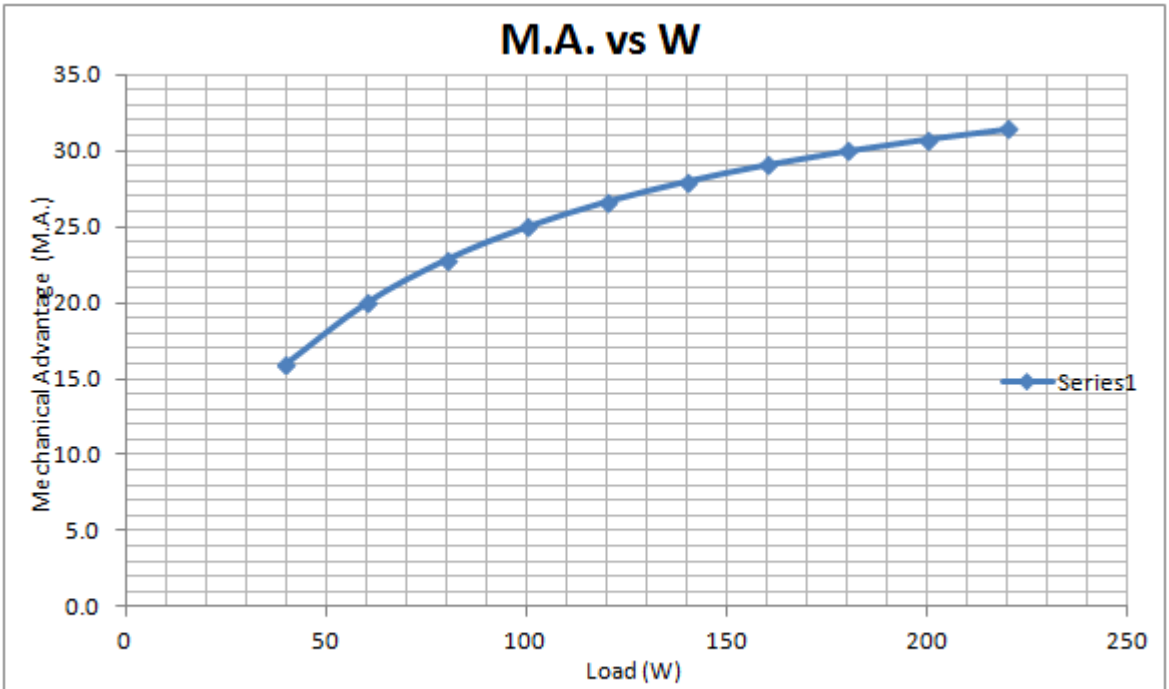

Figure-3: Graph between Mechanical Advantage(M.A.) and Load (W)

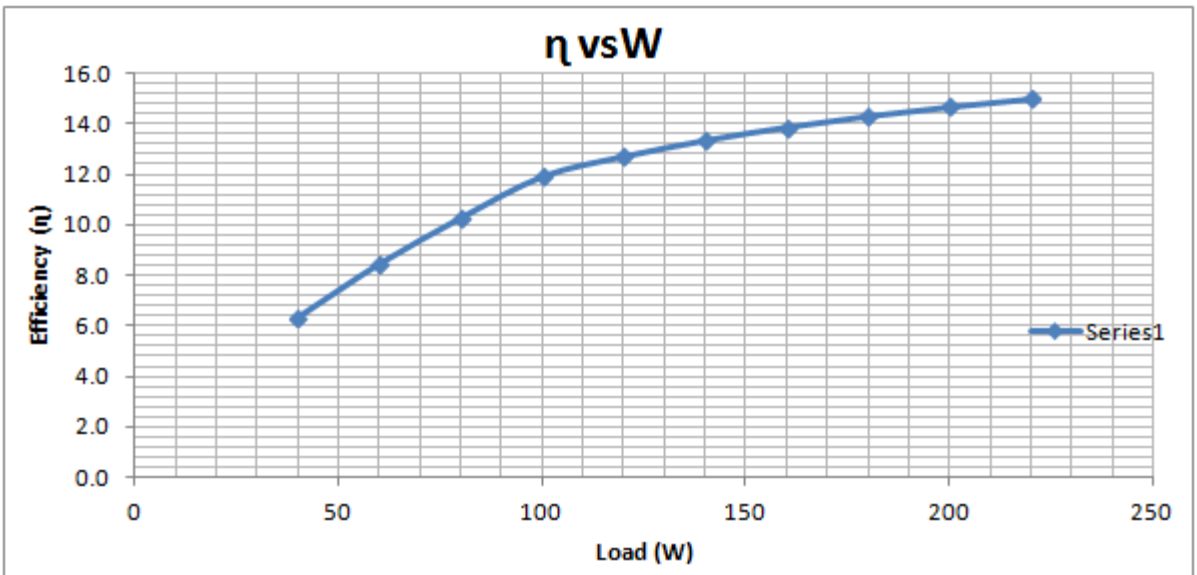

Figure-4: Graph between Efficiency (η) and Load (W)

V. CONCLUSIONS

We observe from Figure -2 that the effort (P) is directly proportional to the load to be lifted (W). Since the efficiency is greater less than 50 %, so, this equipment is irreversible. Figure-3 gives the relation between M.A. and W. we observe that after 200N, the value of M.A. becomes almost to be constant. We observe from Figure-5 that after 200 N of load, the efficiency of the equipment has a tendency to become almost constant.

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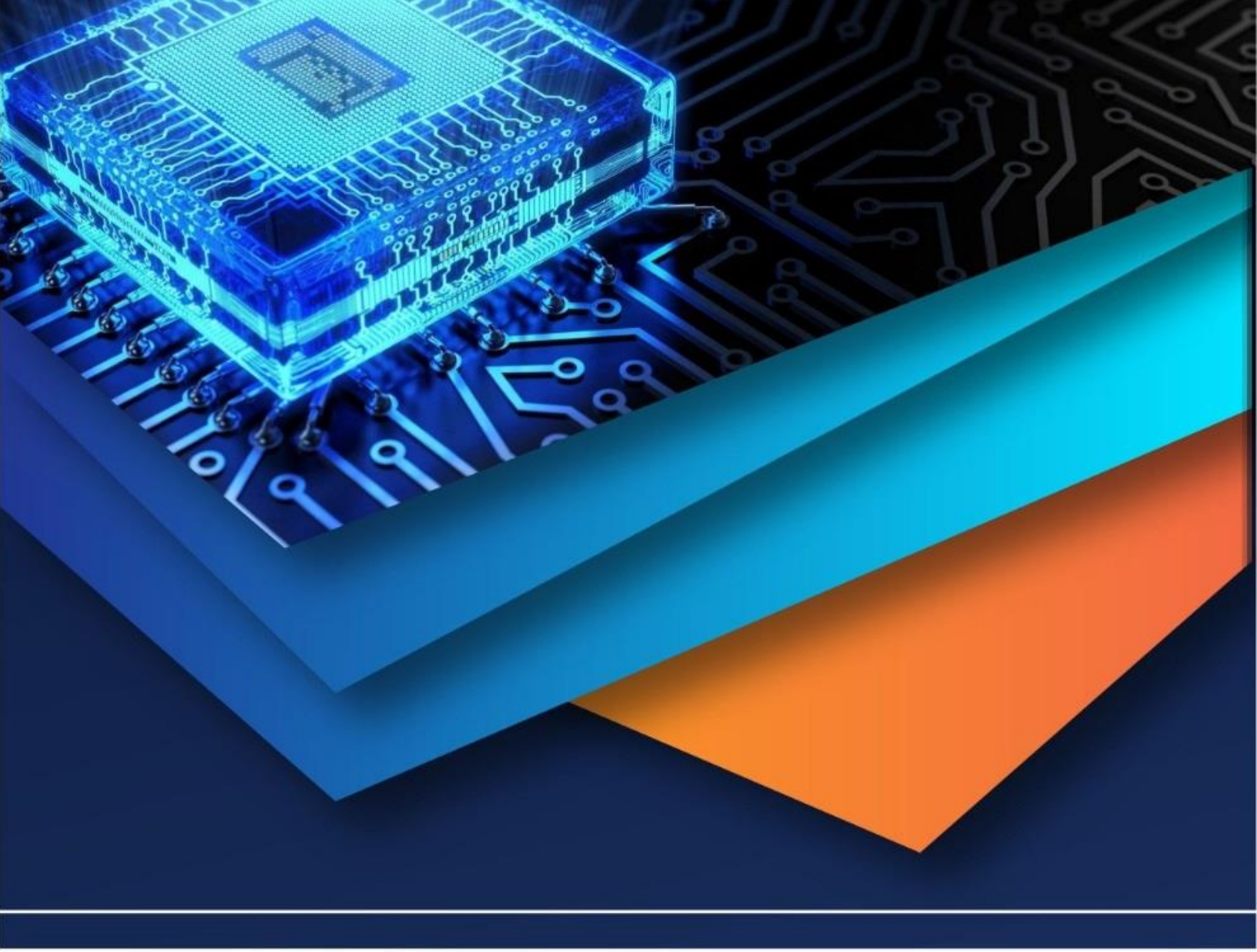

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