International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.2, Issue.1, Jan-Feb 2012 pp-504-508 ISSN: 2249-6645

Optimizing Efficiency of Square Threaded Mechanical Screw Jack by Varying Helix Angle

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ABSTRACT
This paper deals with Optimization of efficiency of square threaded mechanical screw jack with respect to different helix angle .mathematical model has been done to quantify the effect of varying helix angles. It is concluded that efficiency become large and optimum at helix angle 3.6952936^0 for 10000 Kg screw jack.

***Keywords* - Optimization, Mechanical screw jack, square thread, helix angle, mathematical modeling.**

I. INTRODUCTION
Screw jack is a portable device use to raise or lower the load. The movement of nut on the screw jack is similar to the movement of a weight on an inclined plane, since when one thread is developed, it is an inclined plane as shown in figure 1 and nut taking place of the weight. The base of the inclined plane will be equal to πd_m.

α = Helix angle & p = pitch threads
Then $\tan \alpha = P/\pi d_m$

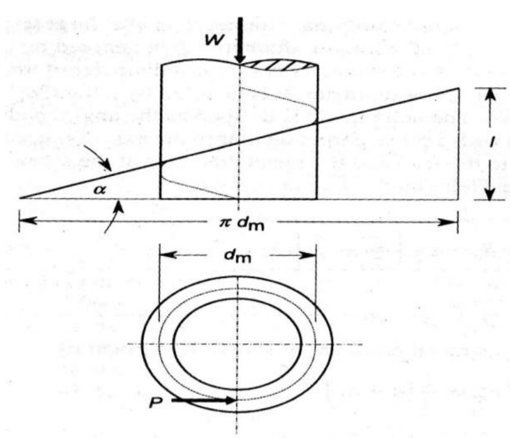

Figure 1: Inclined plane

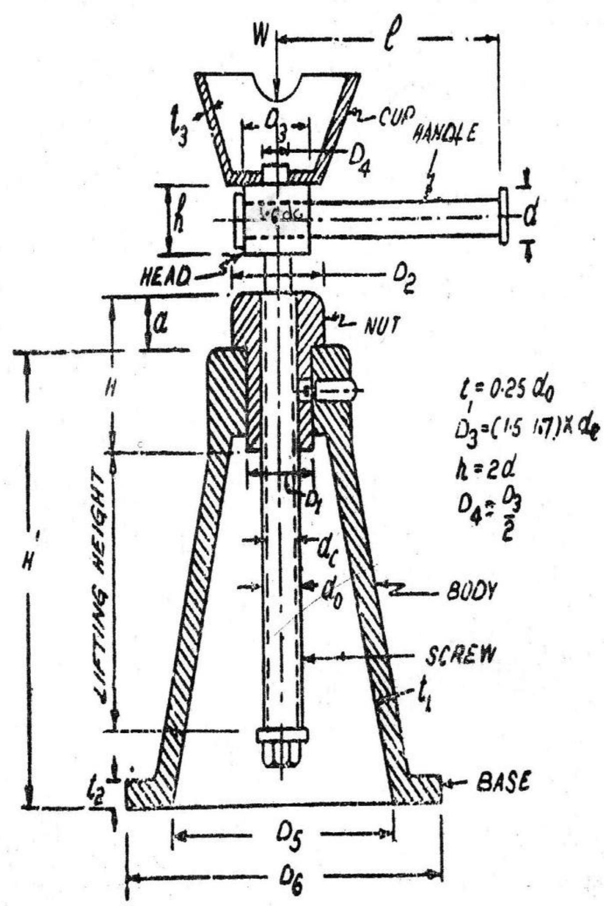

Figure 2: screw jack.

For multi start screws P is replaced by lead 'l'. The square threads are mainly used in screw jacks. Optimization is the act of obtaining the best result under given circumstances. The ultimate goal of optimization is to either minimize the undesired effect or maximize the desired benefit. Optimization can be defined as the process of finding the conditions that gives the maximum or minimum value of a function. The optimum design for mechanical elements should be conducted on the basis of most significant quantity to be minimized or maximized. The optimization is done either to maximize desirable effect or to minimize the undesirable effect [13]. In the earlier study B.R.Singh & Onkar Singh a prototype of air turbine was developed & its functionality was ensuring by testing it [1]. R.K. Jain & B.D. Gupta have conducted study on experimental investigation on the rotary furnaces. They have done modeling & simulation of energy (fuel) consumption of L.O.O. fired rotary furnace. [2] The multilayer feed forward modeling method (with two hidden layers) of artificial neural network continued in MATLAB Software is used for modeling & simulation of energy (fuel) consumption. Claudiu Valantin, Hozumi Goto Hisanori Abiru have optimized screw worm jack by imposing constraints on it. It was optimized for maximum efficiency & minimum overall size [3]. Mastaka Yashimura described a total system optimization method from conceptual design stage to final product realization [4]. N.S. Yalvoi & A.M. kats applied complex approach to the optimal design of machine building production to optimize essentially all structure parameter [5]. Sunil Jha and Manoj Modi have made use of dimensional analysis to investing the effect of electrical & physical parameter on the material removal rate & surface roughness of a die sinking (PMEDM) for hole drilling application. A new mathematical modeling been developed by using dimensional analysis to study the effect of various process parameters like duty cycle, voltage, and powder concentration etc. on material removal rate (MRR) and surface roughness. The model has been validated using the experimental values [6] S. Charles P. Venugopal & R. Bright Reginold Raja conducted tests by varying different cutting parameters and effect of built up base nose size and frank wear analyzed by using design of experiments. Mathematically models were developed to quantify this effect [7]. Hem Chandra Reddy, and Krishna Reddy have given a mathematical flow model which has been developed to study the performance of helical capillary tubes which simulated a situation closer to that existing in practice [8]. B. R. Singh and Omkar Singh optimize the output of vane type air turbine. To different injection angles. Mathematical model than to quantity the effect of varying injection angle, expansion due to isobaric, adiabatic, expansion and steady flow work of high pressure air he concluded that power output becomes large and optimum at injection angle 60^0 to 75^0 and decreases their after [9]. This methodology has been used in the project singh B.R. & onkar singh have carried out parametric evaluation of vane angle on the performance of Novel air turbine.

TABLE 1
PARAMETERS ON WHICH EFFICIENCY DEPENDS

Symbol	Parameter
dc	Core diameter of screw.
do	Outer diameter of screw.
dm=do+dc/2	Mean diameter of screw.
Pb	Bearing pressure.
N	No of threads.
$\Phi = \tan^{-1}\mu$	Friction angle.
$\mu = \tan\Phi$	Coefficient of friction between nut & screaw.
$\alpha = \tan^{-1}(P/\pi dm)$	Helix angle.
T= W*dm/2*tan(α+Φ)	Torque to be raised or lowered.
ή	Efficiency
P	Pitch of threads

2. MATHEMATICAL MODELLING

The movement of the nut on screw is similar to the movements of a nut on the inclined plane man machine plane as shown in fig & nut taking the place of weight. The base of inclined plane will be replaced by = πd_m, α- Helix angle & p= pitch of the threads.

$\tan\alpha = p/\pi d_m$ ---------**1**

$d_m = (d_o+d_c)/2$ ---------**2**

The torque to be transmitted is given by

T= w*dm/2*tan (α+Φ) ------------**3**

Considering the wear of nut,

$W = \pi/4*(do^2 - dc^2)*P_b*n$ ---------**4**

The efficiency of screw jack to lift the load is given by

Efficiency ή = tanα /tan (α+Φ) --------**5**

Tan (α+Φ) =tanα/ή -------------**6**

Substituting equation (4) & (6) in eq. (3)

$T = \pi/4*(do^2 - dc^2)*P_b*n*dm/2*\tan\alpha/ή$.

T = π/4*(do-dc) *(do+dc) *Pb* n* dm/2 *P/πdm /n.

= P*dm*Pb*n*P/4ή

ή = P*dm*Pb*n*P/4T. ---------**7**

$T = Pb*P^2*dm*n/4ή$-------------**8**

$T = \pi/4*(do^2 - dc^2)*P_b*n*dm/2*\tan(\alpha+\Phi)$.

$= \pi/4*(do^2 - dc^2)*P_b*n*dm/2*\tan\alpha/ή$.

Tanα = 2Tή/(π*[(dodc)/2]*(do+dc)/2*Pb*n*dm)

Tanα = 2Tή/(π*P/2*dm*Pb*n*P)

Tanα = 4Tή/(π*Pb*dm^2*n*P)

α = tan^{-1}[4Tή/ (π*Pb*dm^2*n*P)--------**9**

TABLE II
FOR 10000 KG LOAD

T (kg)	Friction angleΦ^0	Helix angle α^0	dc	do	Pitch	No of threads	% ή	Critical load (Wcr) kg
4504.0848	11.309932	3.123846	32	38	6	25	26.22	21548.121
4623.81	11.309932	3.6952936	31	38	7	20	27.42	20675.41
5739.6757	11.309932	3.3122712	40	48	8	12	22.07	35797.218
5938.994	11.309932	3.1685559	42	50	8	12	22.30	39584.094
6138.3697	11.309932	3.0367887	44	52	8	11	20.64	43616.904

3. RESULT AND DISCUSSION

Based on the various input parameter listed in table-1 & mathematical model, the effect of helix angles on various parameter studied efficiency, critical load, core diameter , outer diameter, torque to be transmitted, no. of thread & pitch of threads. Friction angle of screw jack is 11.309232^0, coefficient of friction μ=0.20 for whole study & bearing pressure were kept constant throughout the study.

[A] Helix Angle Vs. Critical load

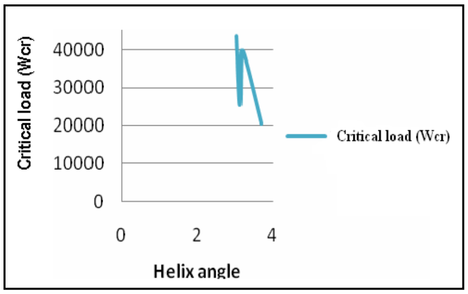

Figure 3: Helix angle vs. Critical load

As the helix angle increases critical load decreases. The minimum critical load at α is 3.6952936.

[B] Helix angle vs. no of threads.

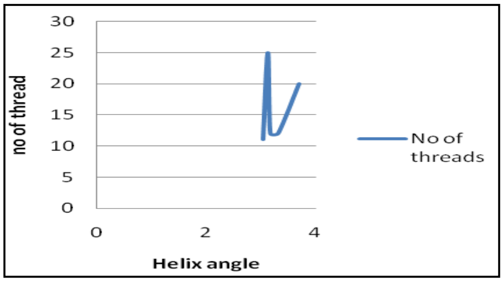

Figure 4: Helix angle vs. no. of threads

As the helix angle increases no of threads increases to some extent or helix angle decreases as no of threads decrease.

[C] Helix angle vs. efficiency.

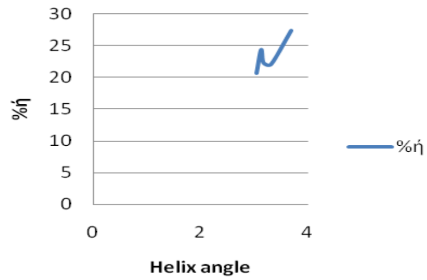

Figure 5: Helix angle vs. efficiency

As the helix angle increases the efficiency increases. But after certain value the efficiency also decreases. The efficiency is maximum for helix angle 3.6952036^0.

[D] Helix angle vs. turning moment.

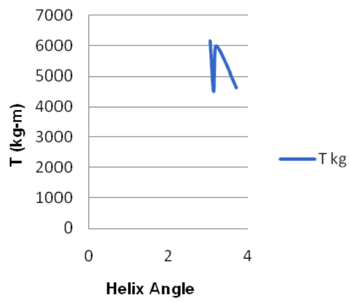

Figure 5: Helix angle vs. Turning moment

As helix angle increases the turning moment also reduces. The turning moment is maximum at 3.0367887^0.

[E] Helix angle vs. outer diameter.

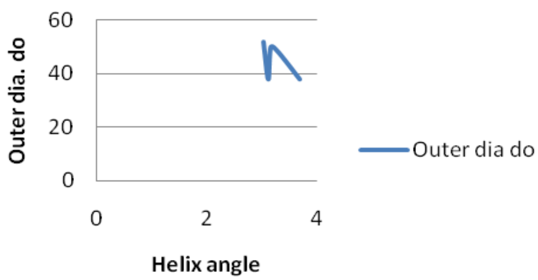

Figure 6: Helix angle vs. outer dia.

As the helix angle increases the outer dia. decreases.

[F] Helix angle vs. core dia. (dc)

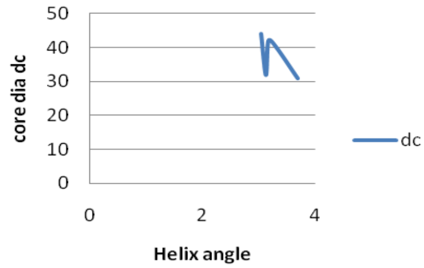

Figure 7: Helix angle vs. Core Dia (dc)

As the helix angle increases core diameter decreases.

[G] Helix angle vs pitch.

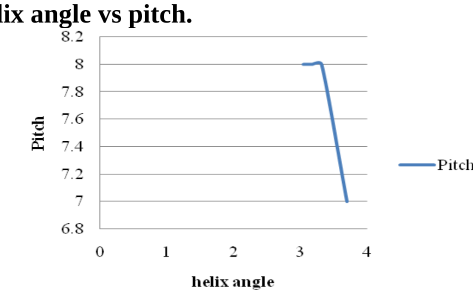

Figure 7: Helix angle vs. Pitch

As the helix angle increase pitch does not change it remains constant. It changes slightly.

CONCLUSION

Based on the input parameter & result obtain the following conclusion are drawn in references with the efficiency of square thread mechanical screw jack for 10000 Kg.

(i) As the helix angle increases the efficiency increases up to certain limit after which it decreases.

(ii) As helix angle increases the critical load decreases.

(iii) As helix angle increases the no of threads decreases.

(iv) As helix angle increases the turning moment reduces.

(v) As helix angle increases the outer diameter decreases.

(vi) As helix angle increases the core diameter decreases.

(vii) As helix angle increases the pitch does not change it remains constant up to certain value & then it reduces.

Thus from above study it is noticed that the jack efficiency becomes large and optimum when helix angle is 3.6952936^0 when the coefficient of friction is 0.20 and bearing pressure between nut & screw is 150 kg/cm^2.

NOMENCLATURE

dc : Core diameter of screw or minor diameter of screw.

do : Outer diameter or major

diameter of screw.

dm = (do+dc)/2 :Mean diameter of the screw.

Pb : Bearing Pressure bet^n nut & screw.

n : Number of threads.

$\Phi = \tan^{-1}\mu$: friction angle.

$\mu = \tan\Phi$: Coefficient of between nut & screw.

$\alpha = \tan^{-1}(P/\pi dm)$.Friction angle.

T = W*dm/2*tan ($\alpha+\Phi$): Torque to be applied.

W: Load to be lowered.

ή = Efficiency of screw jack.

P : Pitch of threads.

fyc : Yield stress in compression.

fyt : Yield stress in tension.

fys : Yield stress in Shear.

D1: Diameter of nut ay bottom.

D2: Diameter of nut ay top.

H : Height of nut.

Wcr : critical load in kg.

d : Diameter of lever.

l : length of lever.

fb : Bending stress.

t_1 : Thickness of body at top.

h = 2d

t_2 : Thickness of body at bottom.

t_3 : Thickness of cup.

D5 : Inside diameter of body.

D6 : Outside diameter of body.

Wdes = βW =1.3W: Design load.

REFERENCES

[1] Singh B.R. and Singh Onkar, 2008, " Development of a Vaned type novel Air Turbine", International Journal of Mechanical Engineering Science (The manuscript was received on 21st December 2007 and was accepted after revision for publication on 3rd June 2008), International Journal of IMehE 222 Part C, pp 1419-1426.

[2] R. K. Jain and B. D. Gupta, "Optimization and Simulation of Energy (Fuel) Consumption of L.D.O. Fired Rotary Furnace Using Back Propatation Algorithm", International Journal of Mechanical Engineering, IJME, July – December 2009, 2, pp 177 - 184.

[3] Claudiu Valentin Suciu, Hozumi Goto, Hisanori Abiru, "Modeling and Simulation of a Screw-Worm Gear Mathematical Transmission to Achieve its Optimal Design Under Imposed Constraints", ICPPW, pp. 160-165, 2009 International Conference on Parallel Processing workshops, 2009.

[4] Masataka Yoshimura, "System Design Optimization for Product Manufacturing", Concurrent Engineering 2007; 15; 329.

[5] N.S. Yalovoi and A. M. Kats, "Complex Optimal Design of Centrifugal Pumps", Chemical and Petrochemical Engineering, Vol. 35, Nos. 11-12, 1999.

[6] Sunil Jha and Manoj Modi, "Modeling and Analysis of Powder Mixed Electric Discharge Machining", International Journal of Mechanical Engineering. IJME July – December 2009, 2, pp 219 – 223.

[7] S. Charls, P. Venugopal and R. Bright Reginold Raja, " Analysis and Modeling of Built up Base Nose Size and its Effects on Tool Flank Wear When Turning Steels", International Journal of Mechanical Engineering. IJME July – December 2009, 2, pp 69 – 74.

[8] Hemchandra Reddy, K. & Krishna Reddy, V, "Numerical Studies on Helical Non Adiabatic Capillary Tube", International Journal of Mechanical Engineering. IJME January – June 2009, 2, pp 37 – 41.

[9] Singh B.R. and Singh Onkar, "Optimization of Power Output of a Vaned Type Novel Turbine with Respect to Different Injection Angles", International Journal of Mechanical Engineering. IJME July – December 2009, 2 PP 205-211.

[10] Singh B.R. and Singh Onkar, 2008, "Parametric Evaluation of Vane Angle on Performance of Novel Air Turbine", Journal of Science, Engineering & Management, SITM, December 2008, 2, PP 7-18.

[11] V. B. Bhandari 2006, "Introduction to Machine Design", Tata McGraw-Hill Publishing Company Limited, New Delhi, India, ISBN – 0 – 07 – 043449 – 2.

[12] Joseph E Shigley, Charls R Misckhke, Richar G. Budynas, Kith J. Nisbett, "Mechanical Engineering Design", Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008, ISBN 13: 978-0 – 07 – 066861 – 4, ISBN 10: 0 – 07 – 066861 – 2

[13] Ray C. Johnson, "Optimum Design of Mechanical Elements", A Willey – Interscience Publication John Wiley & Sons Inc. New York, ISBN - 0 – 0471 – 03894 – 6, [pp 1, 2, 3,178 -188, 193 – 196.] .

[14] Shingresu Rao, "Engineering optimization (theory and practice)", New Edge International Publishers Pvt. Ltd. New Delhi 1996.

[15] P.C.Sharma and D. K. Agrawal, "Machine Design", Katson Publishing House, B. D. Kataria & sons, Opp. Clock Tower, Ludhiana, Punjab.