

Flywheel Weight Reduction through Genetic Algorithm

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ABSTRACT: Enhancement is a method through which better outcomes are gotten in specific situations. The present work manages weight minimization of flywheel.

Flywheels have vast number of multivariable and non-straight conditions/in correspondences. Henceforth customary advancement procedures can't be connected in these cases. Conventional advancement strategies have a probability for the answers for get caught into nearby minima. Likewise the calculation produced for one sort of issue may not be appropriate for another kind of issue. In this proposition, a non customary advancement procedure, to be specific Genetic Algorithm is utilized. Ideal outline of fly wheel is settled utilizing Genetic Algorithm. From the outcomes acquired, it is watched that the ideal measurements and weight got by GA are closer and they are greatly improved than the qualities got by Consol-Opt cad

Flywheel utilized as a part of a punching press, which is having more number of outline factors and consequently the issue is more intricate.

By applying Genetic Algorithm to fly wheel, the ideal measurements least weight were gotten.

KEYWORDS: Flywheel, Genetic Algorithm.

I. INTRODUCTION

Plan improvement can be characterized, as the way toward finding the greatest or least of a few parameters, which might be known as the target capacity and it should likewise fulfil a specific arrangement of determined necessities called requirements. Numerous strategies have been created and are being used for outline advancement. Every one of these strategies utilizes scientific programming methods for arrangements.

Many designing advancement issues contain different ideal arrangements, among which at least one might be without a doubt the base or most extreme arrangements. These total ideal arrangements are known as worldwide ideal arrangements and other ideal arrangements are known as nearby ideal arrangements. In a perfect world, it is smarter to look in the worldwide ideal arrangements since they compare to without a doubt the ideal target work esteem. None of the conventional calculations are ensured to locate the worldwide ideal arrangement, yet hereditary calculations are found to have a superior worldwide point of view than the customary techniques

II. OPTIMAL PROBLEM FORMULATION

It is difficult to apply a solitary plan technique for all building outline issues. The goals in an outline issue and the related plan parameters differ from item to item. Diverse systems are to be utilized as a part of various issues. The motivation behind the definition system is to make a numerical model of the ideal plan issue, which at that point can be unravelled utilizing an improvement calculation. An advancement calculation acknowledges an improvement issue just in a specific arrangement. Figure

Exemplar Based method proposed by Criminisietal. [2] used a best exemplar patch to propagate target patch including missing pixels. This technique uses an approach which combine structure propagation with texture synthesis and hence produced very good results. In [3], the authors decompose the image into sum of two functions and then reconstruct

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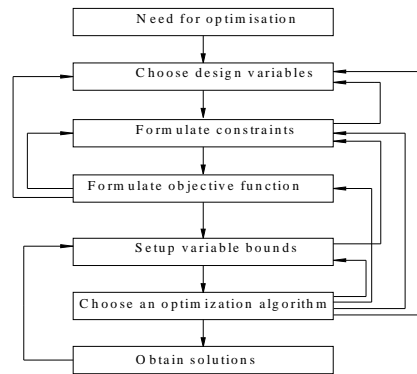


fig 3.1 Flow chart for general optimal design procedure

2.1) Design factors and Constraints

The plan of an enhancement issue starts with distinguishing the fundamental outline factors, which are principally changed amid the improvement procedure. An outline issue as a rule includes many plan parameters, of which some are exceedingly touchy to the best possible working of the outline. These parameters are called plan factors in the speech of improvement systems. Other plan parameters normally stay settled or shift in connection to the outline factors.

The requirements speak to some-utilitarian connections among the outline factors and other plan parameters fulfilling certain physical marvel and certain asset constraints. Some of these contemplations require that the outline stay in static or dynamic balance. In numerous mechanical building issues, the requirements are planned to fulfill stress and diversion restrictions. Frequently, a part should be outlined such that it can be set inside a settled lodging, there by confining size of the segment.

2.2) Objective capacity and Variable limits

The last undertaking of the definition technique is to set the base and the most extreme limits on each plan variable. Certain Optimization calculations don't require this data. In these issues, the imperatives totally encompass the practical locale. Different issues require this data so as to restrict the inquiry calculation to these limits. By and large, all N outline factors are confined to lie within the base and the most extreme limits as takes after:

$$X_i(L) \leq X_i \leq X_i(U) \quad \text{for } i = 1, 2, \dots, N.$$

In any given issue the assurance of the factors limits $X_i(L)$ and $X_i(U)$ might be troublesome. One approach to cure this circumstance is to make a figure about the ideal arrangement and set the base and most extreme limits so the ideal arrangement exists in these two limits.

III. OPTIMIZATION PROBLEM FORMAT

The optimization problem can be mathematically written in a special format, known as nonlinear programming format. Denoting the design variables as a column vector $X = (x_1, x_2, \dots, x_N)^T$, the objective function as a scalar quantity $f(X)$, J, inequality constraints as $g_j(X) \geq 0$, and k equality constraints and $h_k(X) = 0$;

Mathematical representation of the nonlinear programming problem:

Minimize $f(X)$

Subject to $g_j(X) \geq 0, j = 1, 2, \dots, J; h_k(X) = 0, k = 1, 2, \dots, K;$

$$X_i^{(L)} \leq X_i \leq X_i^{(U)}, i = 1, 2, \dots, N;$$

The constraints must be written in a way so that the right side of the inequality or equality sign is zero.

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3.1) Working Principle

When the simple Genetic Algorithms is implemented it is usually done in a manner that involves the following operators such as fitness proportionate, reproduction, crossover and mutation. The Genetic Algorithm begins with an initial population of size is equal to 10 (zeroth generation) of strings which consists of binary coding selected at random. Thereafter convert the binary coding in to decimal value and calculate the actual values of design variables within their range by using mapping rule. Next calculates the value of objective function by substituting the design variables and thereafter violation coefficient (C) and the corresponding modified objective function is obtained.

This modified objective function is used to calculate the fitness values of each individual string and also calculate the average fitness value. First, the reproduction operator makes a match of two individual strings for mating, and then crossover site is selected at random within the string length and position values are swapped between the same strings.

Finally the mutation is applied to the randomly selected strings. It is the random flipping of the bits or gene that is changing a zero to one and vice versa, so that the first cycle of operation is completed which is called as iteration. This iteration is termed as generation in genetic Algorithms. This new generation creates a second population (i.e. generation -1).

IV. OPTIMAL DESIGN OF FLYWHEEL.

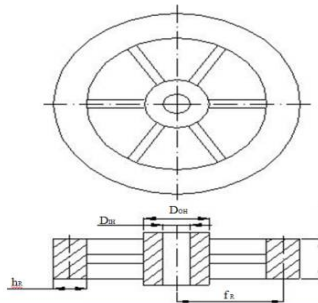


Fig.3. Flywheel in Punch press.

4.1 Introduction

It is widely used as an energy storage mechanism in today's world. It is economic because the growing costs and potential scarcity of energy have increased the importance of energy storage as a conservation measure and is technological because improvements in materials

Therefore the simplified objective function is make flywheel energy storage more attractive. A punch press is one of those mechanical systems in which a flywheel is used not only for power conservation but also as a mechanical filtering element in a circuit through which power is flowing. In fact, energy is stored in a flywheel by speeding it up and is delivered to it by slowing it down. It also acts as a smoothing or equalizing element. Therefore a flywheel plays an important role in the performance of the punch press.

4.2 Objective Function

The objective function is to minimize the weight of the flywheel (W_F) which is the sum of the weights of rim (W_R), hub (W_H) and spokes (W_S).

$$f = W_F = W_R + W_H + s.W_s$$

The objective function is simplified by considering the weight of hub and spokes to be one-eighth of the weight of the rim concentrated at the mean radius of the rim.

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$$W_H + s.W_s = 1/8 W_R$$

Therefore the simplified objective function is

$$W_F = 9/8 W_R = 9/8 (2 \pi \gamma_f r_R h_R b_R) g_c$$

4.3) Constraints

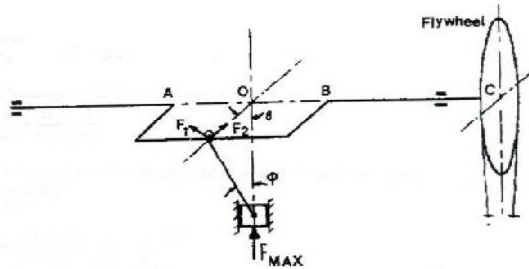
4.3.1)Weight Relation (g₁)

The weight of the hub and spokes are one eight of the rim weight.

$$(D_{OH}^2 - D_{IH}^2) b_H + 1/2 k_s d_s^2 (D_{IR} - D_{OH}) = r_R h_R b_R$$

$$\text{Where } D_{IR} = 2 r_R - h_R$$

4.3.2) Shaft Stress (g₂)



At point C, only tensional stress due to punching is taken into account. Presumably this stress is much larger than any other stress present at point C, with proper overload factor. The torque producing this stress is given by $T = F_1 R$

$$\text{Where } F_1 = F_{\max} \sin \theta \left[\frac{1 + \cos \theta}{\left(\left(\frac{1}{R} \right)^2 - \sin^2 \theta \right)^{0.5}} \right]$$

$$F_{\max} = \pi d t_p \text{Sup } n_{OL}$$

Notice that point C is in fact under partial (half-cycle) torsional stress due to punching. Therefore the mean (τ_m) and alternating

(τ_a) shear stresses are considered a

$$\tau_m = \tau_a = 1/2 \tau_{\max}$$

$$\text{Where } \tau_{\max} = 16 T_m / (\pi D_{IH}^3)$$

$$T_m = T/2$$

$$\text{Since } \tau_m = \tau_a, S_{us} > S_{ys}$$

This constraint may be written in the following form after simplification

$$D_{IH} \geq K_2$$

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$$\text{Where } K_2 = \left(\frac{4TS_f}{\pi} \left(\frac{1}{S_{US}} + \frac{1}{S_{NS}} \right) \right)^{\frac{1}{3}}$$

4.3.3) Key Stress (g3)

$$\tau_{k \max} = \frac{F}{A}$$

$$\text{Where } F = \frac{2T}{D_{IH}} \text{ and } A = b_H t_k$$

$$\tau_{ak} = \tau_{mk} = \frac{1}{2 \tau_{k \max}}$$

$$\text{Thus } \frac{\tau_{ak}}{S_{ns}} + \frac{\tau_{mk}}{S_{us}} \leq \frac{1}{S_{fkey}}$$

This constraint may be written in the following form after simplification

$$D_{IH} \geq K_2$$

$$\text{Where } K_3 = \frac{TS_{fkey}}{t_k} \left(\frac{1}{S_{us}} + \frac{1}{S_{ns}} \right)$$

4.3.4) Energy of Flywheel (g4):

In order to find the energy of the flywheel, first find the total energy which is used per stroke. The kinetic energy (K.E) of a body rotating about a

$$\text{fixed center is } K.E = \frac{1}{2} I \omega^2$$

Since there is velocity change due to punching, the expression for change of energy is

$$\Delta K.E = \frac{1}{2} I (\omega_{\max}^2 - \omega_{\min}^2)$$

This may be rewritten as

$$\Delta K.E = \frac{I V_{ave}^2 C_f}{I_R^2}$$

$$\text{Where } C_f = \frac{V_{\max} - V_{\min}}{V_{ave}},$$

$$V_{ave} = \frac{V_{\max} + V_{\min}}{2}$$

$$\text{And } I = \frac{W_f r_R^2}{g_c}, \quad V = r_R \omega$$

Thus the energy constraint is

$$\Delta KE \geq E_f$$

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This can be written in the following for

$$K_4 r_R^{-3} h_R^{-1} b_R^{-1} \leq 1, \quad \text{Where}$$

$$K_4 = \frac{E_r}{9\pi\gamma_f C_f \frac{1}{4g_c} \left(\frac{2\pi N}{60}\right)^2}$$

4.3.5)Rim stresses (g5)

The rim stresses have been developed due to combined effect of hoop tension and bending stresses. The rim is subject to high bending stresses. The maximum combined stress at the rim of the flywheel having six spokes is given

$$\text{by } S_R = \gamma_f V^2 \left[0.75 + \frac{4.935 r_R}{S^2 h_R} \right]$$

$$\text{Where } V = \omega_1 \cdot r_R \quad \text{and} \quad \omega_1 = \frac{2\pi N}{60}$$

$$D_{OR} = 2r_R + h_R$$

$$\text{Therefore } S_R \leq S_{uf} / S_{tR}$$

4.3.6) Spokes Stresses (g6)

In the design of spokes, it is assumed that cantilever action is predominant. The bending moment due to punching at the hub of the arms is taken to be

$$M = \frac{T(D_{OR} - D_{OH})}{s D_{OR}}$$

For which the bending stress is $S_1 = M/Z$ where

$$Z = \frac{\pi k_s d_s^3}{32}$$

It is safe to assume that each arm is in tension due to one-half of the centrifugal force of that portion of the rim which it supports.

$$S_2 = \frac{3}{4} \gamma_f V^2, \quad \text{Where } V = r_R \omega$$

$$\text{Therefore } S_1 + S_2 \leq \frac{S_{uf}}{S_{fs}}$$

4.3.7. Stability (g7)

The hub length of the flywheel is usually taken greater than the shaft diameter for stability reasons. $D_{IH} > b_H$

4.3.8. Optimal Design Model

Mathematical model for optimal design of flywheel is summarized as Minimize

$$W_F = \frac{9}{8} (2\pi\gamma_f r_R h_R b_R) g_c$$

Subjected to

$$g_1: (D_{OH}^2 - D_{IH}^2) b_H + \frac{1}{2} k_s d_s^2 (2r_R - h_R - D_{OH}) - r_R h_R b_R = 0$$

$$g_2: \frac{K_2}{D_{IH}} \leq 1, \quad g_3: \frac{K_3}{D_{IH} b_H} \leq 1$$

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$$g_4: \frac{K_4}{r_R^3 h_R b_R} \leq 1, \quad g_5: S_R \leq \frac{S_{uf}}{S_{fR}}$$

$$g_6: S_1 + S_2 \leq \frac{S_{uf}}{S_{fs}}, \quad g_7: \frac{D_{IH}}{b_H} \leq 1$$

The design variables $r_R, h_R, b_R, D_{OH}, D_{IH}, b_H$ and d_s

The minimum weight of Flywheel obtained by GA is reduced by 4.5 %, when compared to the weight obtained by Consol - Opt cad solution.

V. RESULTS AND DISCUSSIONS

Optimal design of flywheel has been discussed by using Consol-Optcad and optimization capability of Genetic Algorithms (GA).

Seven design variables and seven constraints are considered in the flywheel problem. The results obtained for flywheel are shown in table A. It was observed that the optimum dimensions and minimum weight obtained by GA are better than the values obtained by the Consol- Opt cad method.

METHOD	r_R (mm)	h_R (mm)	b_R (mm)	D_{OH} (mm)	D_{IH} (mm)	B_H (mm)	D_S (mm)	W (N)
CONSOL OPT CAD	864	152	133	370	190	216	170	8815
G.A	864	152	127	353	228	150	159	8419

VI. CONCLUSION

A viable strategy for choosing the ideal outline of fly wheel utilizing Genetic Algorithm an effective non – customary improvement technique is proposed. It is discovered that, rather than punishment parameter for change of obliged enhancement issue to unconstrained streamlining issue, the utilization of infringement parameter facilitates the issue detailing. Further, it is watched that Genetic Algorithm gives better outcomes as its look is for worldwide ideal as against the neighborhood ideal in customary hunt techniques. Hereditary Algorithm can deal with multivariable and non direct conditions. Hereditary calculation can apply for complex building issues. It is inferred that by applying Genetic Algorithm, the ideal plan parameters, least weight for fly wheel are acquired.

The productivity of Genetic Algorithm procedure exhibited in this investigation recommends its prompt application to other plan enhancement issues.

REFERENCES

1. Dr.Shapour Azarm, 1996, "Flywheel optimization via consol-optcad", University of Maryland, USA.
2. S.Vijayarangan & V.Alagappan ,I.Rjandran 1999 "design optimization of leaf spring using genetic algorithms" journal of IE(I) , vol 70pp : 135-139.
3. Dr.Shapour Azarm, 1996 "helical compression spring optimization via consol-optcad" University of Maryland, USA.
4. David E.goldberg . 1989 "Genetic algorithm in search optimization a machine learning" Addison –Wesely publishing company Singapore.
5. Singiresu.S.rao ,1984 "optimization theory and application" Wisely Easten , New Delhi.
6. Kalyanmoy Deb.1995 "optimization for engineering design algorithm and examples" prentice-hall of India private limited.