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Optimization Design of Vibrating Screen Damping Spring Based on Multi-objective Genetic Algorithm

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Abstract—The damping spring plays an important role in the design of the vibrating screen. In view of the problems existing in the design of the vibration damper, the multi-objective genetic algorithm is used to select the relevant design variables of the damping spring, and the objective function and the constraint conditions are established to obtain the optimal solution. Finally, the practicality of the algorithm is verified by practical application.

Keywords- ***Vibrating screen; vibration damper; multi objective genetic algorithm; optimum design***

I. INTRODUCTION

In recent years, the development direction of the vibrating screen in coal mining industry is gradually tending to light and high strength, and the stiffness and strength of the vibration screen is an important design index to ensure the efficiency of the vibration sieve, and is also a main content of the vibration analysis[1]. In order to strengthen the strength and reliability of the spring, the spring is generally used to increase the spring, but this will increase the quality of the spring, not only affect the vibration sieve vibration trajectory, but also lead to rising costs. In order to design a more practical damping spring, some related optimization algorithms have been used in the literature. For example [2], [3] used the fuzzy algorithm and particle swarm algorithm, but two references used the single objective optimization, and engineering practice often encounters in multiple criteria and multiple targets situation, also genetic algorithm with the traditional algorithm has a essential difference, genetic algorithm starting from the entire population, and the traditional optimization algorithm starting to a single point, so genetic algorithm don't need complementary information or knowledge, and has a higher search efficiency. Therefore, the multi objective genetic algorithm is used to optimize the design of the vibration damper spring to achieve a better effect.

II. THE CONCEPT OF MULTI OBJECTIVE OPTIMIZATION

The problem of Multi objective optimization design (Optimization Multi-objective) is a common situation in engineering practice, sometimes it is necessary to achieve the optimal problem of multiple targets in a given region. For example, vibration sieve spring, the general design of the cost of the minimum, the maximum safety factor, and the best vibration trajectory, but a parameter changes, the other parameters will be changed, resulting in conflict. This kind of optimization problem with more than one objective value is called the multi-objective optimization problem. The mathematical model of multi objective optimization is generally expressed by the following formula,

$$\begin{cases} V-\min f(x)=[f_1(x), f_2(x),..., f_n(x)]^T \\ s.t. x \in X \\ X \subseteq R^m \end{cases} \tag{1}$$

In the equation (1), ***V***-min said vector minimization, even Vector objective function in which each sub objective function is to minimize as much as possible.

III. MULYI OBJECTIVE OF GENETIC ALGORITHM BASED ON HYBID METHOD

With the research of multi-objective genetic algorithm, many scholars have put forward a variety of algorithms, such as the weight coefficient transformation method, the parallel selection method, the permutation method, the shared function method and so on. But each algorithm has some disadvantages, such as the parallel selection method can be divided into a variety of groups to search for a common search so that the search efficiency is reduced by [4]. In this paper, by using the hybrid method, the parallel selection method and the shared function method are combined, and the characteristics of the two algorithms are optimized. The basic idea of the hybrid method is that the main body of the selection operator uses the coordinate method, according to the number of sub objective functions of the multi-objective optimization problem, the whole population is divided into some sub groups, and then the corresponding generation of the next generation. Pareto optimal individual to retain, do not let it participate in the crossover, mutation operations, but it will be retained directly to the next generation. Finally, the sharing function method is used to deal with an individual X, in which the number of species and the degree of similarity in the vicinity of it can be measured, which is called the niche [5],

$$m_X = \sum_{Y \le n} s[d(X, \mathrm{Y})] \tag{2}$$

In the equation (2), s(d) is a shared function, which is a monotonically decreasing function of the distance between the individual and the D. D (X, Y) can be defined as individual X, Y between the Hamming distance. Niche technology is an effective method to avoid local convergence and premature convergence in genetic algorithm, and to maintain population diversity [6]. Each individual niche is computed, the niche of the small number of individuals can have more chance of being selected, so as to better genetic to the next generation, which is similar to a lesser degree of individual can have a better opportunity to be inherited to the next generation, increase the diversity of the population. Algorithm flow chart is shown in Figure 1.

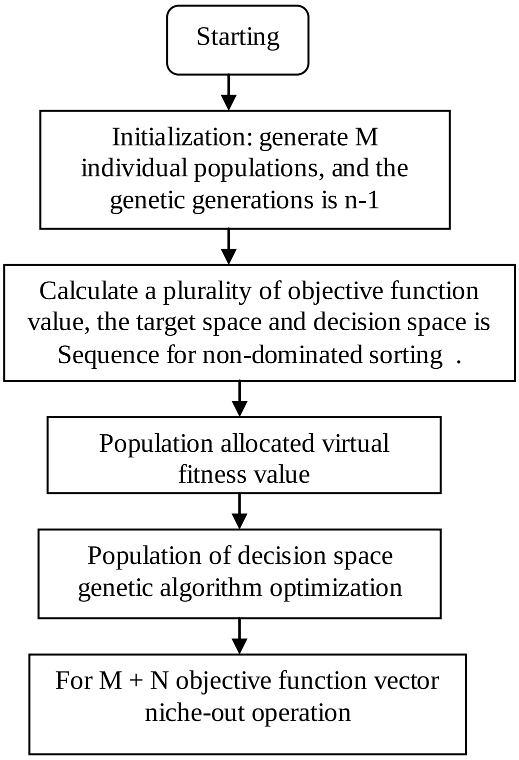

Figure 1. Algorithm flow chart

IV. PROOF OF ALGORITHM

In order to verify the feasibility of the hybrid genetic algorithm, this paper uses a multi-objective optimization example with two optimization objectives to verify the feasibility of the algorithm,

min f1=300/x+500/y+300/(100-x-y)

min f2=30(300/x-3)+12(500/y-5)+ (3-1)

(300/(100-x-y)-3)

X y, S.T. is an integer, and x+y<100

Among them, the optimal Pareto values obtained as shown in Figure 1, x, Y values shown in Figure 3, can be seen from Figure 1 because of the mixed method, using the niche technology, so the distribution of the optimal Pareto value is more uniform, figure 2 is the corresponding x, y value of the coordinate.

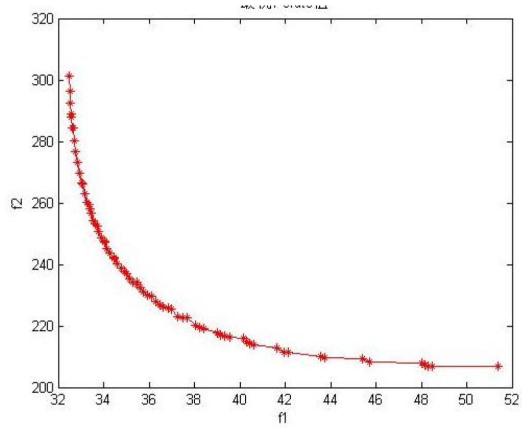

Figure 2. optimal Pareto value

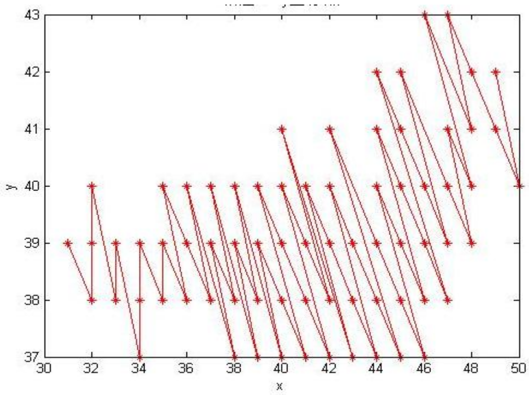

Figure 3. x, y value of the corresponding coordinates

V. APPLICATIONS

Cylindrical coil spring structure shown in Figure 4, the spring working load F = 680N, the working stroke h = 16.59mm, the operating frequency fr = 25Hz, requires N ≥106 life cycles. Spring materials used 50CrVA, allowable stress [τ] = 405MPa. Structural requirements shown in Table 2, check the relevant design manual know, spring is the material density ρ = 7.5 × 10-6Kg / mm3, the curvature of the spring coefficient K = 1.6 / C0.14, in this instance to the structure of the lightest weight, minimum spring free height and the natural frequencies of the three conditions for the highest design objectives,

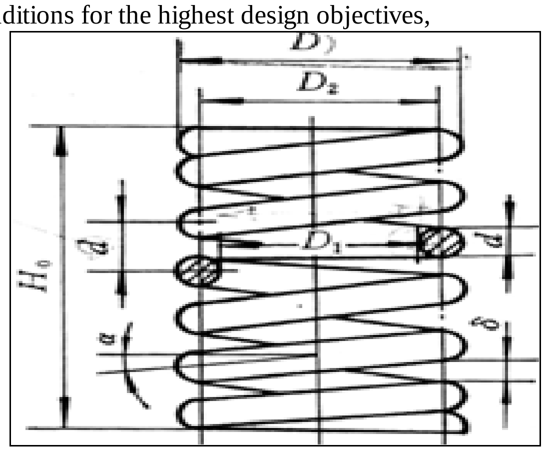

Figure 4. helical springs Chart

Table I Simulation parameters

Take spring wire diameter d, diameter D2 and n is the number of turns of work the three design parameters as design variables, equation as follows,

$$x=\begin{bmatrix}x_1\\x_2\\x_3\end{bmatrix}=\begin{bmatrix}d\\D_2\\n\end{bmatrix} \qquad (4\text{-}1)$$

Respectively structure the lightest weight, the minimum spring free height and the natural frequencies of the highest objective function, the formula is as follows,

$$\begin{cases} f_1(x)=1.8148\times10^{-4}x_1^2x_2(x_3+1.8)\\ f_2(x)=x_1(x_3+1.3)+18.25 \\ f_3(x)=f_r^{-1}=2.809\times10^{-6}x_2{}^2x_3/x_1\end{cases} \qquad (4\text{-}2)$$

Where, f1 (x) on behalf of a spring structural weight; f2 (x) on behalf of free height of the spring; f3 (x) on behalf of the natural frequencies of the spring. Finally, the establishment of constraints, constraints, the following equation. Of which the first five to performance constraints, after 6 as boundary conditions, it can be seen which is a 11 dimensional nonlinear constraints objective optimization design problem,

$$\begin{cases} g_1(x)=2.7706\times10^3x_2{}^{0.86}/x_1{}^{2.86}-405\le0\\ g_2(x)=6-x_2/x_1\le0\\ g_3(x)=(x_3+1.3)x_1+18.25-5.3x_2\le0\\ g_4(x)=250-3.56\times10^5x_1/(x_2{}^2x_3)\le0\\ g_5(x)=680-1.659\times10^5x_1{}^4/(x_2{}^3x_3)\le0\\ g_6(x)=2.5-x_1\le0\\ g_7(x)=x_1-9.5\le0\\ g_8(x)=30-x_1-x_2\le0\\ g_9(x)=x_1+x_2-60\le0\\ g_{10}(x)=3-x_3\le0\\ g_{11}(x)=x_3-6\le0\end{cases} \qquad (4\text{-}3)$$

Wherein, g1 (x) is the intensity of the constraint condition; g2 (x) is a spring index constraints; g3 (x) is a spring stability constraints; g4 (x) is a spring to prevent the resonance constraints; g5 (x) is a spring g6 (x) is a spring wire diameter lower;; stiffness constraints g7 (x) is a spring wire diameter upper limit; g8 (x) spring diameter limit; g9 (x) for the upper limit of the spring diameter; g10 (x) for the spring working g11 (x) for the spring working laps ceiling; the minimum number of laps. Optimized results are shown in Table 3 and Table 4. Figs. 5 and 6, respectively, over the plane Pareto point set and the objective function,

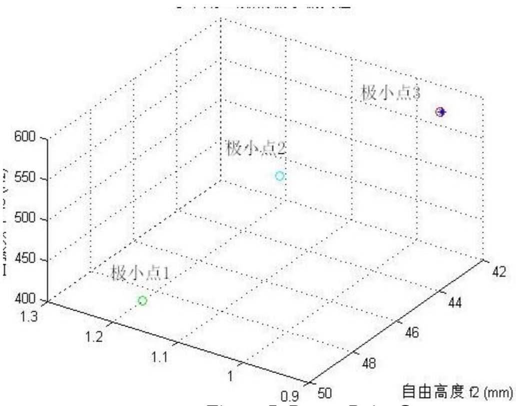

Figure 5. Pareto Point Set

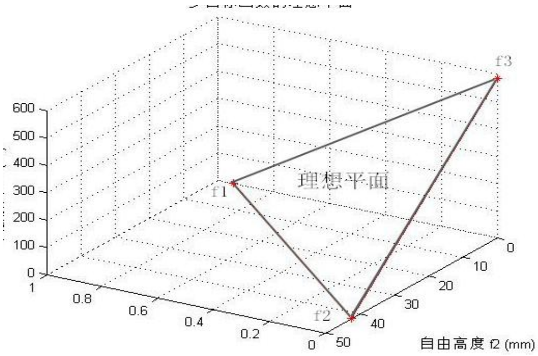

Figure 6. Over plane

VI. CONCLUSIONS

In this paper, the use of vibration sieve spring as an example, the use of multi-objective genetic algorithm to optimize the design of the spring, not only to improve the shortcomings of traditional design, but also to design parameters for a variety of choices. In this paper, the weight is light, the free height and the natural frequency are the design parameters, and the main parameters of the spring can be optimized according to the spring in different conditions, so as to improve the design efficiency, reduce the cost and so on.

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