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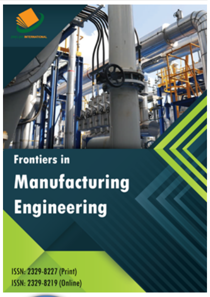

A HYBRID GENETIC ALGORITHM TO SOLVE MULTI-OBJECTIVE FUZZY FLEXIBLE JOB SHOP SCHEDULING PROBLEM

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ABSTRACT

In this paper, a hybrid genetic algorithm is introduced to overcome the toughest combinatorial optimization problem, the fuzzy-flexible job-shop scheduling. In consideration of the multi-product-and- small-batch production characteristic in aerospace equipments manufacturers, a framework based on hybrid genetic algorithm aimed at minimizing the max makespan and tardiness of workpieces is built to solve the fuzzy flexible job shop scheduling problem. The logistic chaotic mapping model and heuristic rules are introduced in this hybrid genetic algorithm which separates the mutation operation from crossover operation in order to prevent the local optimum happening. This algorithm employs the single point crossover method which protecting the order of procedures to ensure the convergence precision. Meanwhile, experiments are designed to demonstrate the efficiency and feasibility of the Improved Chaotic Genetic Algorithm.

KEYWORDS

Job shop scheduling, multi-objective, genetic algorithm, logistic chaotic mapping model

1. INTRODUCTION

Johnson first proposed the classical Johnson rules to solve n jobs and 2 machines scheduling problem in 1954, establishing the foundation of classical scheduling theory. Since then, lots of scholars pay attention to scheduling problems, especially in the manufacture area. Job Shop Scheduling Problem (JSSP) is one of the most intensive combinatorial optimization problems, which is a typical NP-hard problem. There exists a lot of uncertain factors in scheduling process, with the feature of discreteness, dynamism, multi-variable and constrains, making it the bottleneck problem in the actual production.

The classical JSP consists of scheduling a set of jobs on a set of machines, subject to the constraint that each job has a specified processing order throughout. So, different scheduling rules, heuristic and meta- heuristic algorithms are used to solve JSSP.A genetic algorithm and a scatter search procedure to solve the JSSP is presented by a researcher [1]. According to a researcher, a universal model, which can solve all the problem of SMS (Single Machine Scheduling), PMS (Parallel Machine Scheduling) and FSS (Flow Shop Scheduling), using multi-object Simulated Annealing (SA) [2]. Based on a research, a neural network model focused on detailed scheduling to alternate simulation modeling approach which is costly and time-consuming [3].

The models of classical JSSP mostly assume that all of the processing parameters are known exactly before which is obviously not a realistic approach in manufacturing industry, such as durations, due dates, etc. However, the processing time is uncertain and choosing machine is flexible in real word. Therefore, the actual scheduling problem is a FFJSSP (Fuzzy Flexible Job Shop Scheduling Problem) which releases constrains during the process. Many papers have been published recently. Study showed combine GA (Genetic Algorithm) and VND (Variable Neighborhood Descent) to form a hybrid search algorithm, trying to solve FJSSP (Flexible Job Shop Scheduling Problem) [4]. In literature, an algorithm integrated different strategies is proposed, which is applied in generating the initial population, selecting the individuals and reproducing new individuals [5].

Nevertheless, the combination of flexible and fuzzy JSSP is rarely observed. In this paper, LCS (logistic Chaotic Sequence) is introduced into GA to improve crossover and mutation operation. Considering about the machine tool selection flexibility, a fuzzy flexible job shop scheduling model is constructed with TFN (Triangular Fuzzy Number) to characterize the processing time.

This paper is organized as follows. In section 2, the fuzzy flexible job shop scheduling problem model is described. Section 3 presents an improved hybrid algorithm combined standard GA, LCS with heuristic rules. The simulation tests are illustrated and analyzed in section 4. Finally, a conclusion and directions for future study is covered in Section 5.

2. PROBLEM DESCRIPTION

The N*m FFJSSP can be described as n jobs ($J_1, J_2, \ldots, J_n$) processed on m machines (M_1, M_2,..., M_m), and each job J_i contains h_i sequenced procedure. The *j*-th working procedure of *i*-th job is denoted as O_{ij} which can be processed on a set of machines M_{ij} and O_{ij} should be assigned to one of these machines. If O_{ij} can be processed on any machine of group M, that is, $M_{ij} = M$, we call it total flexible JSSP, otherwise partial flexible JSSP.

Let a triangle fuzzy number $A_{ijk} = (d^1_{ijk}, d^2_{ijk}, d^3_{ijk})$ represents processing time of procedure O_{ij} on machine M_k. The triangular membership function can be expressed as:

$$u_{ijk}(x) = \begin{cases} 0, & x \leq d^1_{ijk} \\ \dfrac{x - d^1_{ijk}}{d^2_{ijk} - d^1_{ijk}}, & d^1_{ijk} < x \leq d^2_{ijk} \\ \dfrac{d^3_{ijk} - x}{d^3_{ijk} - d^2_{ijk}}, & d^2_{ijk} < x \leq d^3_{ijk} \\ 0, & x > d^3_{ijk} \end{cases} \quad (1)$$

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Wherein d^1 denotes the shortest processing time; means the most possible processing time

Figure 2: Force analysis for rollover.

3. FORCE ANALYSES FOR TEST-BED

3.1 Force Analyses of Rollover

As shown in Figure 2, suspension deformation of the vehicle in the stationary state can be ignored. When the overturning flip angle of test-bed is a, Gravity G can be divided into the force G1 parallel to the platform and the force G2 perpendicular to the platform, skid plate on the wheel force is F, friction force is f, the wheelbase is L, the vertical height form the center of gravity to the main platform is H1, wheel radius is *r*.

Rollover process is analyst as follows:

With the critical state when the outer wheel is just off the ground and the inner wheel as the bearing point, the overturning moment is equal to the moment of stability, as $G_1H_1 = G_2 \times \frac{L}{2} + F \times r$, the vehicle is in the state of equilibrium.

When the angle a increases further, $G_1 = G \sin\alpha$ larger, $G_2 = G \cos\alpha$ smaller, the overturning moment is higher than that of the stable torque, as $G_1H_1 > G_2 \times \frac{L}{2} + F \times r$, vehicle is going to rollover.

3.2 Force Analyses of the Main Platform Placed Horizontal

As Figure 3. shown is the test-bed section at the roll angle of 0°, the main technical parameters are as follows: the rollover test bench turning platform size (length and width) is 14000 mm 3500 mm, maximum load weight is 40 (not including the quality of platform), maximum turning angle is 50°, rated working pressure for hydraulic system P=10 MPA, the inner diameter of cylinder D=250mm. Considering the pressure loss of resistance, piping and components of sliding parts, the value of loss coefficient β is 0.8.

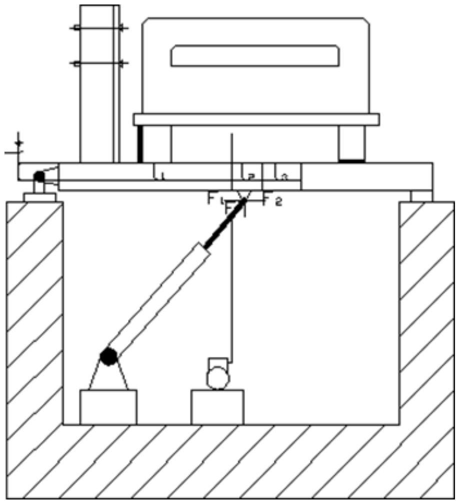

Figure 3: The test-bed section at the roll angle of 0°.

In Figure 3, L1 is the horizontal distance form rollover test-bed center to center of the rotating stand, 2090 mm; L2 is the horizontal distance from the centroid of rollover test-bed to the cylinder rotating bracket, 370 mm; L3 is the vertical distance from rollover table to the rotating support center, 450 mm; L4 is the vertical distance from the centroid of rollover test-bed, to cylinder rotation support =40°; θ =110 mm.

The maximum weight main platform table can bear is 40 *t*, the weight of table is 10 *t*, the total quality M=50 *t*, so vertical lift force cylinder required is:

$$Ml_1 = F_N \sin 40°(l_1 + l_2) + F_N \cos 40°$$

$$F_N = \frac{Ml_1}{\sin 40°(l_1 + l_2) + \cos 40° l_3} = 529\ KN$$

3.3 Force Analyses at Roll Angle of 50 °

As shown in Figure 4 is the force analysis at the roll angle of 50°.

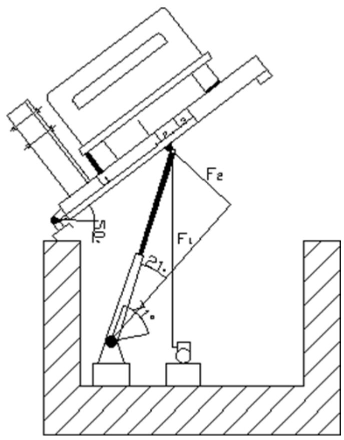

Figure 4: The force analysis at the roll angle of 50°.

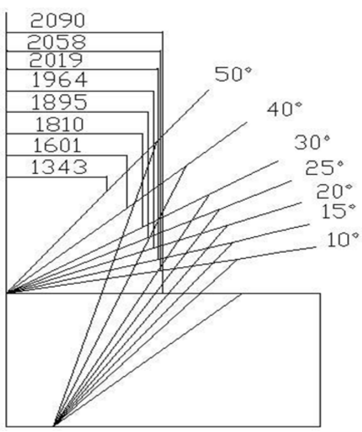

Figure 5: The force analyses at the roll angle of from 0 to 50°.

As shown in Figure 4, when the main platform turning 50 degrees, vertical lift force cylinder required F_J is:

$$M\sin 40°l_1 - M\cos 40°l_4 = F_J\sin21°(l_1+l_2) + F_J\cos21°l$$

$$F_J = \frac{M\sin 40°l_1 - M\cos 40°l_4}{\sin 21°(l_1+l_2) + \cos 21°l_3} = 460\ KN$$

With Calculation we know that when the main platform table turns 50 degrees, the thrust each cylinder required is 230 KN, smaller than the cylinder thrust, and in this state, when the 40t is the main platform of vehicle load, the table can be turned over 50 deg.

The maximum stroke of cylinder get by drawing method l is: $l = l_{max}$-l_{min} = 1445 mm.

In the type, l_{max} is full extension length of cylinder, l_{max} =3720 mm; l_{min} is full time-lapse length of cylinder, l_{min} =2275 mm.

3.4 Force Analyses at Roll Angle of 0 ° -50 °

The force analyses at the roll angle of from 0 to 50° is shown as Figure 5, when the main flat surface turn about 15°, the maximum bearing capacity of cylinder is about 545 KN.

4. CONCLUSIONS

Rollover test is the most effective method to test the side tilt angle of stability of the heavy-duty vehicle and the height of center of mass. To solve this problem, this paper puts forward a design of heavy vehicle rollover test research of heavy vehicle rollover through the system, which lays the foundation for the research of vehicle, rollover warning algorithm and the control system. For poor rollover stability of heavy vehicles, a rollover test-bed is designed to measure the stable roll angle, the test-bed is applicable to all types vehicles that quality ≤50000 kg, wheelbase ≤10 m, track≤ 2.7 m to do rollover test. Force analysis on the rollover test-bed was taken in different roll angle, which get the lift thrust and maximum thrust stand for test-bed. Through the experimental stress analysis, it provides the basis for the design of hydraulic system and the section of hydraulic cylinder and hydraulic pump.

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REFERENCES

[1] Zhao, Z.G. 2012. Heavy vehicles rollover warning technology condition and research progress, Communications Science and Technology Heilongjiang, (1), 93-94.

[2] Zhao, Z.G., Wang, D.D. 2013. Research status and development trend of side tumbing pre-warning vehicle, Journal of Hebei University of Science and Technology, 34, (2), 108-112.

[3] Linda, J., Matteson, A. 2008. Trucks involved in fatal accidents fact book 2006, The University of Michigan Transportation Research Institute, Ann Arbor.

[4] Yu, Z.X., Zong, C.F., He, L. 2009. Algorithms of anti-rollover control for heavy vehicle based on TTR warning, Journal of Jilin University: Engineering and Technology Edition, 39, (2), 258-261.

[5] Chen, B., Peng, H. 2001. Differential-Braking-Based Rollover Prevention for Sport Utility Vehicles with Human-in-the-loop Evaluations, Vehicle System Dynamics, 36, (4), 359-389.

[6] Shen, M., Wang, Y.S., Li, Z.G. 2009. A research on the rollover risk of motor vehicles based on simulation analysis, Automotive Engineering, 31, (12), 1173-1176.

[7] Liu, P.J. 1999. Analysis, detection and early warning control of dynamic rollover of heavy freight vehicles, Montreal: School of Mechanical engineering, Concordia University.

[8] Wang, J., Yu, G.Z., Zhang, W., Ding, N.G. 2010. Real time rollover prediction for vehicle based on principles of sliding mode and fuzzy inference system, Transactions of the Chinese Society for Agriculture Machinery, 41, (6), 1-6.

[9] Wang, A.B., Tang, W., Zhao, Y.X. 2013. Vehicle rollover prevention Strategy based on suspension distortion perception, Science and Technology Information, (26), 70-72.

[10] Li, Z.G., Shen, M., Zou, M., Zhang, J.H., Hu, J.Y., Ma, C.S. 2010. Multi-body dynamics simulations for mini-bus rollover tendency during sharp turns, Journal of Tsinghua University (Science and Technology), 50, (8), 1286-1289.

[11] Zhu, T.J., Zong, C.F., Wu, B.H., Sun, Z.J. 2011. Rollover Warning System of Heavy Duty Vehicle Based on Improved TTR Algorithm, Journal of Mechanical Engineering, 47, (104), 88-94.

[12] Jin, Z.L., Zhang, H.S., Ma, C.Z. 2012. Research on dynamic rollover warning system for SUV, Transducer and Microsystem Technologies, 31, (9), 32-35.

[13] Zong, C.F., Wang, C. 2011. Driving Intention Recognition Based on Double-layer HMM, Automotive Engineering, 33, (8), 701-706.

[14] Xia, J.J., Chang, L., Hu, X.M. 2010. Active control on the side tumbling of heavy vehicle based on model forecast, Transactions of the Chinese Society of Agricultural Engineering, 26, (9), 176-180.

[15] GB/T14172-2009. Test methods for static rollover stability of vehicle.