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Design optimization of Plain Journal Bearing to Minimize the Power loss using Genetic algorithm

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Abstract-** A hydrodynamic journal bearing optimization of design variables is a very complex task. The typical and time consuming nature the present study genetic algorithm is to utilize to optimally design a plain journal bearing and to develop the best bearing configurations to minimize power loss. A genetic algorithm with suitable number of design variables, population, crossover and mutation probabilities is formulated. The power loss equation and a fitness based selection method is utilized. In this study bearing radial clearance, oil viscosity is considered as design input variable. The proposed algorithm shows better results than available in literature with very rapid convergence.
***Keywords-** power loss, genetic algorithm, optimization, hydrodynamic journal bearing*

I. INTRODUCTION

Tribology is the branch of science which deals the surfaces, that are rub together or we can say that it is a scientific and systematic method to deal with interacting surfaces so that characteristics of the system can be improved. Tower [1] who was a railroad engineer at that time has done a series of experiments on lubrication so that he could minimize friction to control the wear, for this he drilled a hole in a bearing so that lubricant (oil) can be poured through it, when shaft starts rotating he observes that the oil is coming out of that hole, to prevent this he put a plug on that hole. At the same time Petroff [2] was interested in calculating friction in journal bearings. For this he conducted some experiments and came out with some relationship between frictional force and operating parameters of bearing. However, he didn't notice that the oil film also generates the pressure which was given by tower hence he should be given the credit for enhancing the concept of hydrodynamic fluid film lubrication. With the help of these developments, Reynolds [3] formulated the concept of formation of hydrodynamic fluid film lubrication in journal bearings and developed Reynolds equation for hydrodynamic lubrication. Reynolds equation also explained that hydrodynamic pressure which is generated between shaft and bearing is due to converging wedge shaped film, viscosity of oil and surface motion. Sommerfield [4] obtained the analytical expression for pressure distribution, load carrying capacity, frictional force etc. by integrating the Reynolds equation. These equations form a basis later to design different types of bearings which was later used in different machineries. Successful operation with increased efficiency and higher power requirement in modern high-speed shaft-bearing systems is very much dependent upon behavior of the bearings which support the shaft shown in figure 1. The bearings provide damping, which is adequate for many rotating system designs, and their stiffness properties affect the stability of the shaft-bearing system. The power loss performance objective is an important element in the design and optimization of hydrodynamic bearings. For this study, power loss reduction is a primary goal in the design of plain journal bearings. The shorthand that bearing analysts use with regards to journal bearings can be confusing and is certainly inconsistent from one analysis program to another. The terminology used in this project is shown diagrammatically in figure 1.

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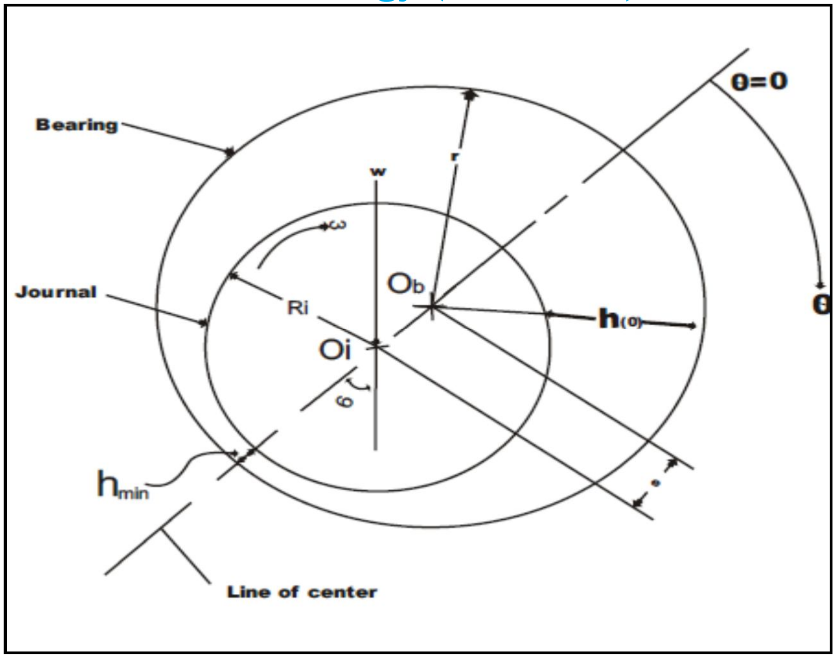

Fig. 1 Geometry of hydrodynamic journal bearing

II. METHODOLOGY

A. Optimization

Optimization is a procedure of finding and comparing feasible solutions until no better solution can be found. Evolutionary algorithms (EA's) are often well-suited for optimization problems involving several, often conflicting objectives [5]. It is a process that finds the best or optimal solution for a problem [6]. All optimization problems can be summarized to revolve around these three factors:

1) An objective function: which is to be minimized or maximized.
2) A set of variables: which affect the considered objective function / problem.
3) A set of constraints: which allow the unknowns to take on certain values but exclude others.

B. Optimization using Genetic Algorithm [7]

Genetic algorithms, developed by John Holland and his collaborators in the 1960s and 1970s, are a model or abstraction of biological evolution based on Charles Darwin's theory of natural selection. Holland was the first to use crossover, recombination, mutation and selection in the study of adaptive and artificial systems. These genetic operators are the essential components of genetic algorithms as a problem-solving strategy. Since then, many variants of genetic algorithms have been developed and applied to a wide range of optimization problems, from graph coloring to pattern recognition, from discrete systems (such as the travelling salesman problem) to continuous systems (e.g., the efficient design of airfoil in aerospace engineering), and from financial markets to multi-objective engineering optimization.

C. Generalized steps of optimization using genetic algorithm [8]

Step 1: Determine the number of chromosomes, generation, and mutation rate and crossover rate value.
Step 2: Generate chromosome-chromosome number of the population, and the initialization value of the genes chromosome-chromosome with a random value
Step 3: Process steps 4-7 until the number of generations is met.
Step 4: Evaluation of fitness value of chromosomes by calculating objective function.
Step 5: Chromosomes selection.
Step 6: Crossover.
Step 7: Mutation.
Step 8: New Chromosomes (Offspring).

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Step 9: Solution (Best Chromosomes).

This can be shown with the help of a simplified flowchart also as given below:

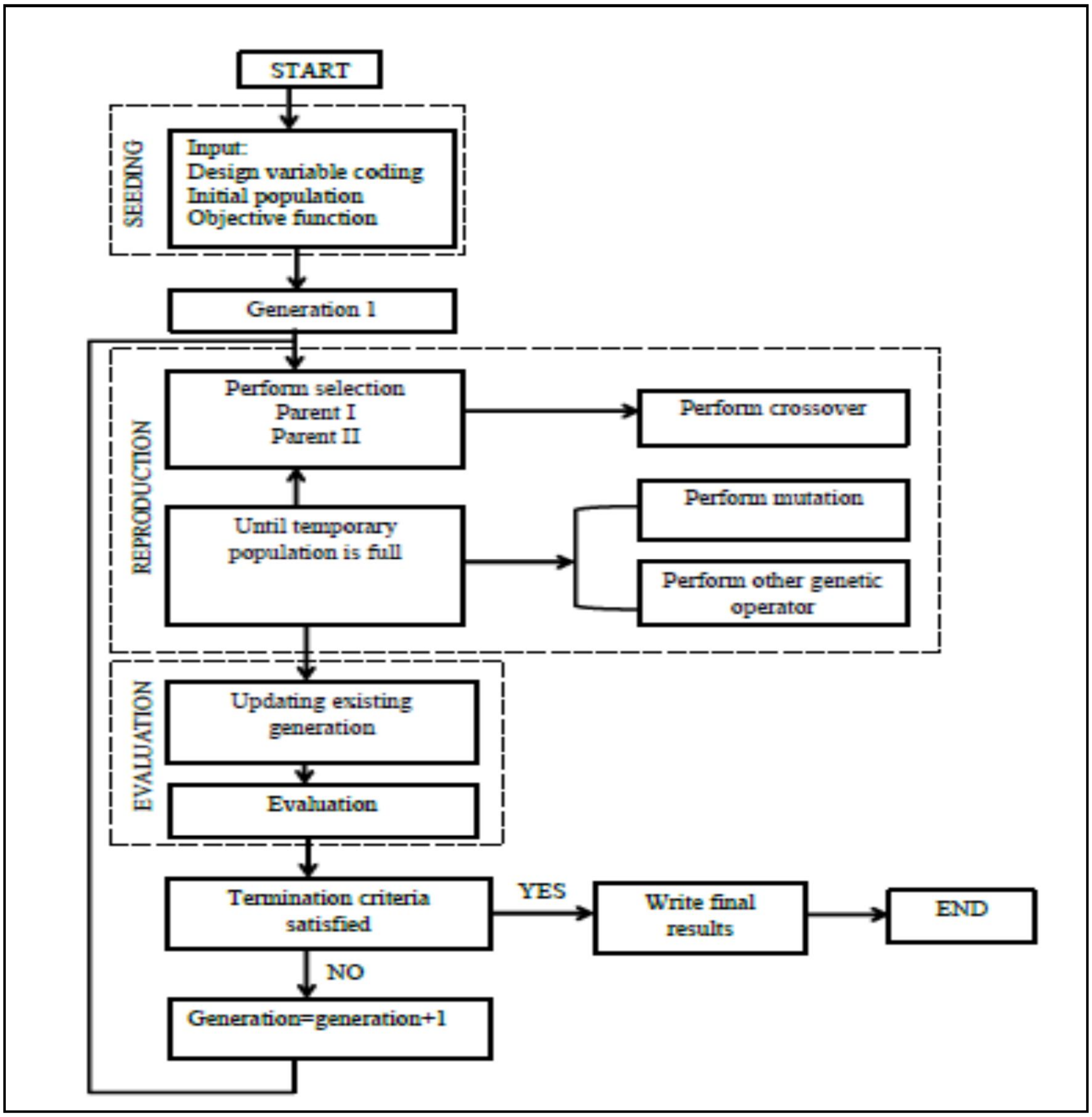

Fig. 2 Flow chart for the proposed Genetic algorithm

III. CONSTRUCTION OF DESIGN VARIABLES AND THE GENETIC ALGORITHM

Hirani, H. et. al. [9] used genetic algorithm for axiomatic design of journal bearing. In order to validate the proposed objective function the values of variables (utilized by Hirani, H. et. al. [9]) were put into the proposed objective function. This provided the values of power loss which were in the range of the result obtained by the abovementioned group of investigators. This objective function is needed to be minimized to obtain minimum value of power loss in journal bearings under proposed constraints.

Objective: To minimize the power loss of journal bearing given by proposed function

$$F = \frac{2\pi^3 \mu D^3 N_s^2 L}{C}$$

Subjected to: $1 \leq \mu \leq 16$, $35 \leq C \geq 70$

μ = Oil viscosity of lubricant (mPa)

C= Radial clearance (μm)

D = diameter of journal = 0.1m

N_s = journal speed = 50rps

L = length of bearing = 0.3m

Optimization Technique: Genetic Algorithm

Selection: Fitness value based selection method

Initial Population: 20

Probability of crossover: 0.7

Probability of mutation: 0.01

IV. RESULT AND DISCUSSION

As mentioned in proposed methodology, the genetic algorithm was executed with the help of computer program generated in MATLAB and fitness value based selection method is applied. In this aforementioned problem, two types of optimization will be calculated. In the first type, two parameters of journal bearing have been selected based on the reference paper methodology. Genetic Algorithm in MATLAB has been implemented for the two variable problems in order to find the optimal value of power loss. A fitness value based selection method was adopted by considering 25 generations.

Fig. 4.1 shown convergence diagram for any specific genetic algorithm depicts the generartion wise fittest genes and corresponding fitness values of those fittest genes. An algorithm is said to have been converged if no fitter genes are being obtained or the genes in the last few generations all have almost similar fitness. Convergence depends upon termination criteria set by optimizer. For example if the same fitness is being obtained for last 'n' generations then the algorithm might be said to be converged.

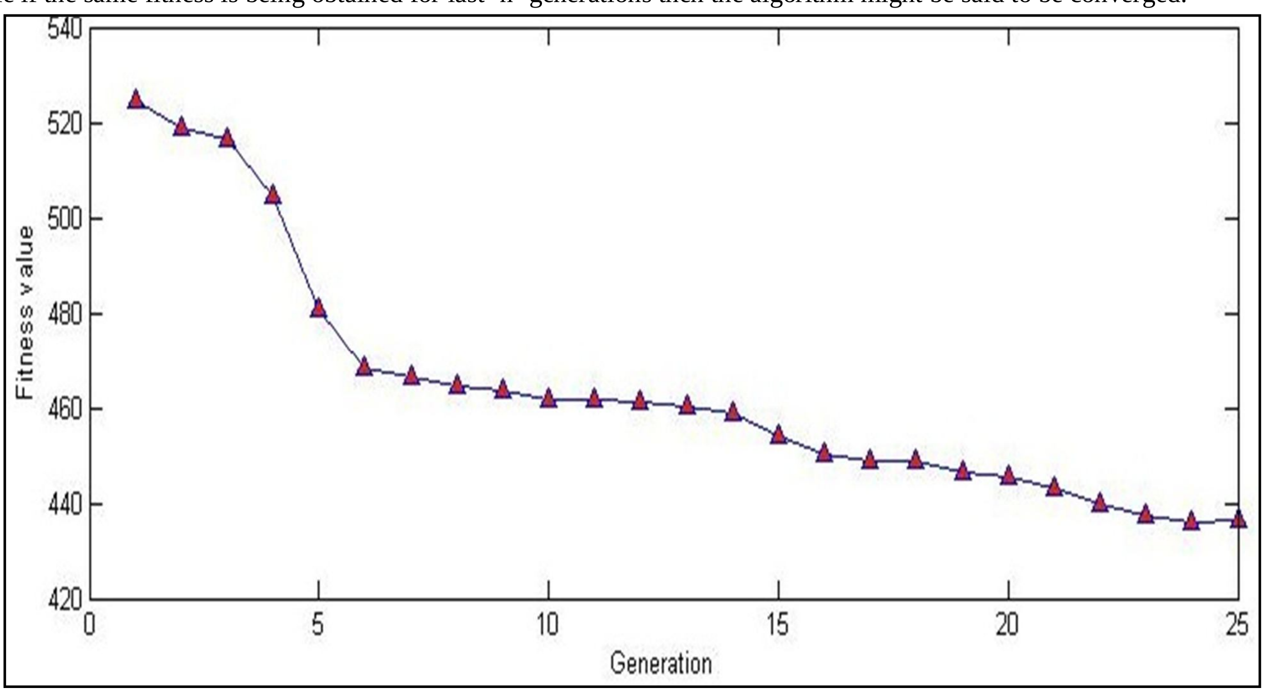

Fig. 4.1 Convergence diagram for two variable optimization (minimization of power loss)

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Figure 4.2 shows the generation wise variation of power loss on first design variable is oil viscosity of lubricant and also Figure 4.3 shows the generation wise variation of power loss on second design variable radial clearance of two variable optimization problem of minimizing the power loss.

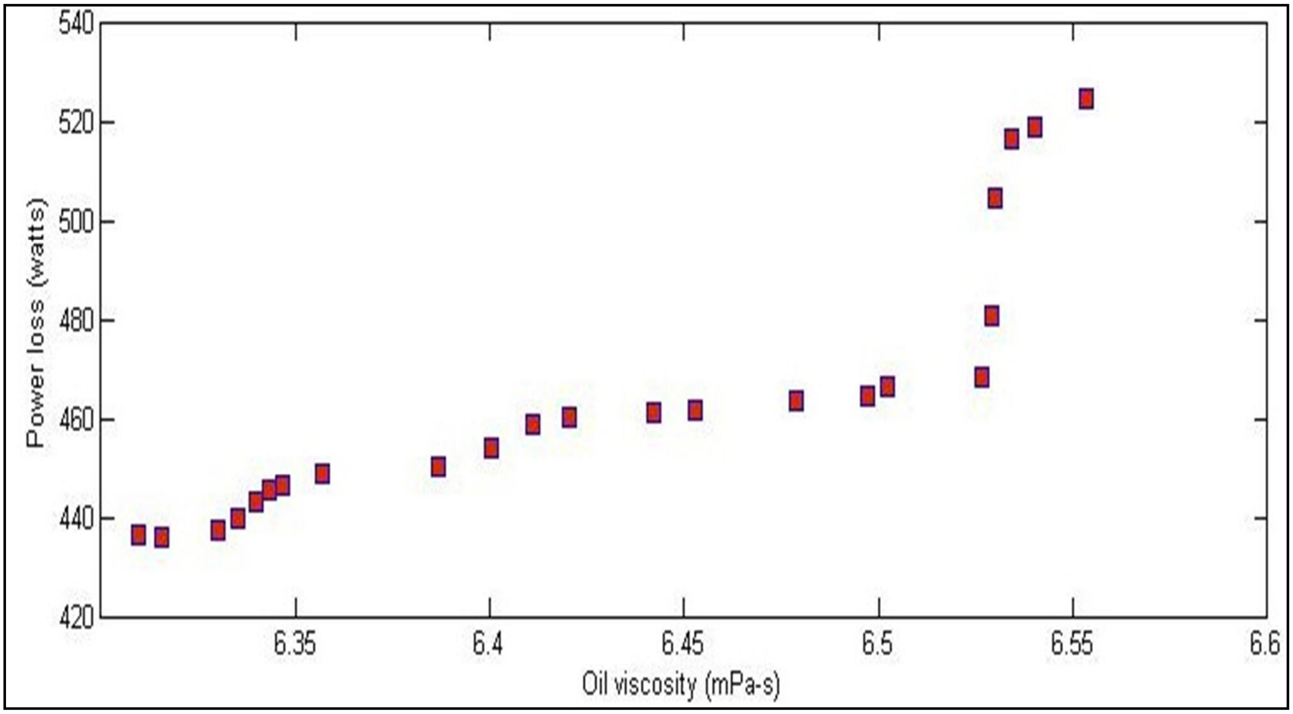

Fig. 4.2 Dependence of power loss on oil viscosity design variable for two variables optimization

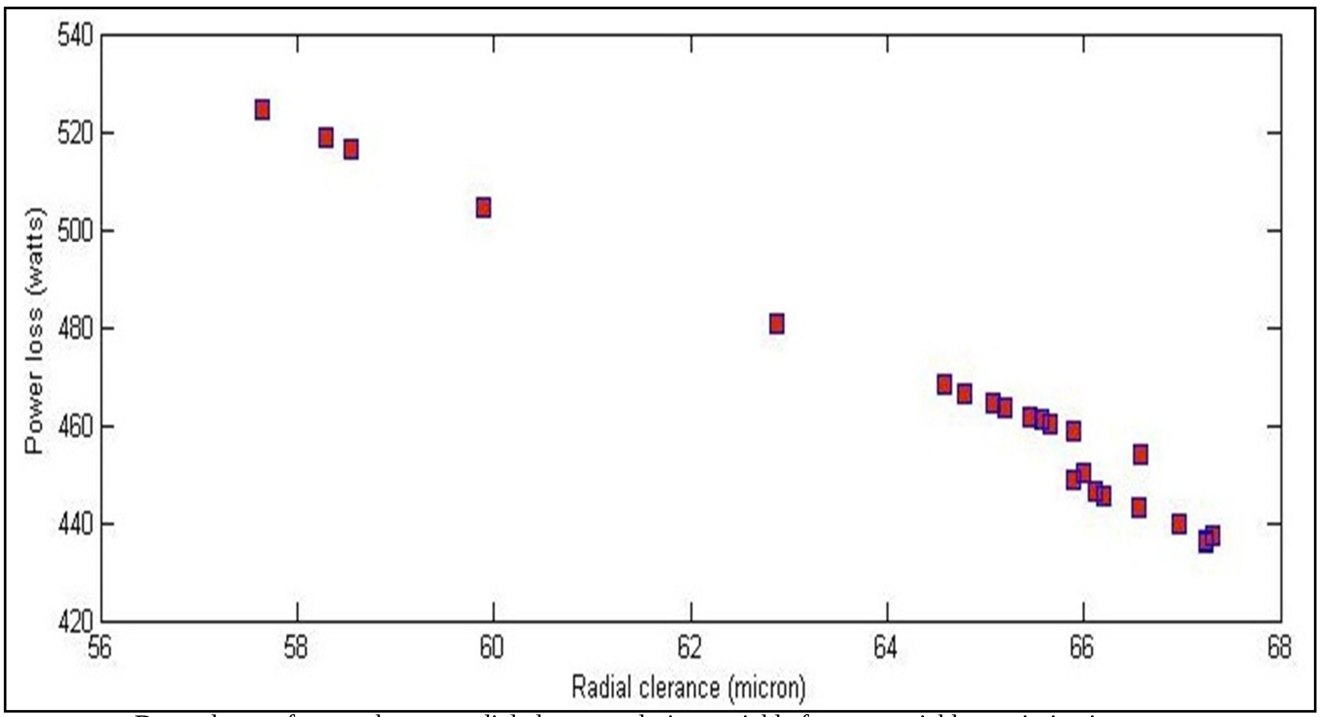

Fig. 4.3 Dependence of power loss on radial clearance design variable for two variables optimization

Fig 4.4 depicts genealogy for two variable optimization problems. Genealogy plots the genealogy of individuals. Lines from one generation to the next are color-coded as follows. Red lines indicate mutation children. Blue lines indicate crossover children. Black lines indicate elite individuals.

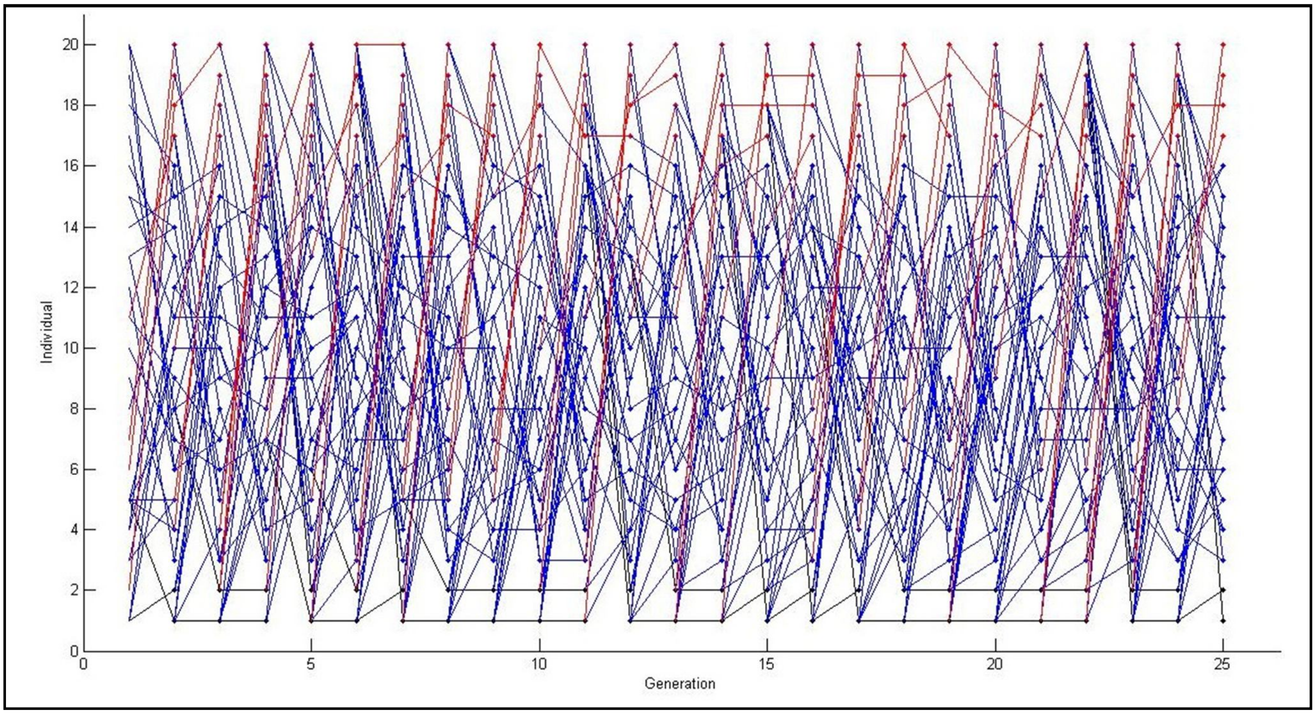

Fig. 4.4 Genealogy for two variable optimization (Minimization of power loss)

V. CONCLUSION

The present work shows the implementation of the genetic algorithm and the feasibility of this technique considering a hydrodynamic plain journal bearing in essence of developing the bearing configurations that optimize minimum power loss objective. The overall results obtained in this study are superior to those from a gradient-based optimization method. Instead of using a starting point from which progress is made toward the identification of the values of the design variables that optimize the objective function.

A. The result of two variable optimization for minimization of power loss of journal bearing taken two parameter such like oil viscosity μ and radial clearance C in range of (1 to 16 mPa-s) and (35 to 70 μm) as a design variables and all other parameter constant. Hence a fitness value based optimization method in 25 generation of suitable crossover and mutation probability a set of design variables [6.3096/ 67.2380] are generated and giving the minimum power loss for this variable is 436.4432 W.

B. A specific genetic algorithm fit for designing such a hydrodynamic journal bearing formulated in this thesis whose key components were utilization of minimization of power loss developed in hydrodynamic journal bearing with fitness value based selection technique as selection criterion and special randomized crossover and mutation technique.

REFERENCES

[1] Tower, B., “First and second report on friction experiments (friction of lubricated bearings)”, Proceeding Institute, Mechanical Engineers, London, UK, pp. 659 and pp. 58-70, (1883).
[2] Petroff, N., “Friction in machines and the effect of lubrication (in Russian)”, Inzh., Zh., St. Petersburg, vol. 1-4(71), pp. 227, 377, 535, (1883).
[3] Reynolds, O., “On the theory of lubrication and its application to Mr. Beauchamp Tower’s experiments, including an experimental determination of the viscosity of olive oil”, Philosophical, Transaction, Royal Society, pp. 177, 157-234, (1886).
[4] Sommerfeld, A., “Zur Hydrodynamischen Theorie der Schmiermittelreibung”, Z. Angrew. Math., Phys., pp. 50, 97-155, (1904).
[5] Deb K.M., Zitzler E. and Thiele, L., “Comparison of Multi objective Evolutionary Algorithms: Empirical Results”, Massachusetts Institute of Technology Evolutionary Computation, vol. 8 (2), pp. 173-195, (2000).
[6] Zitzler, E. and Thiele, L., “Multi objective Evolutionary Algorithms-A Comparative Case Study and the Strength Pareto Approach”, IEEE Transactions on evolutionary computation, vol. 3(4), pp. 257-271, (1999).
[7] Farzad, A. Sadjadi, “Comparison of fitness scaling functions in genetic algorithms with applications to optical processing”, Proceedings of SPIE, vol. 5557, pp. 356-364, (2004).
[8] Popov, A., “Genetic algorithms for optimization-Application in controller design problems”, TU Sofia, Hamburg, pp. 3-21, (2003).
[9] Hirani, H. and Suh, N.P., “Journal Bearing Design Using Multi Objective Genetic Algorithm and Axiomatic Design Approaches”, J. Tribology International,

vol. 38, pp. 481–491, (2005).

[10] Boedo, S. and Eshkabilov, S. L. "Optimal shape design of steadily loaded journal bearings using genetic algorithms", STLE Tribology Transaction, vol. 46(1), pp. 134-143, (2003).

[11] Saruhan, H., Rouch, K.E., and Roso, C.A., "Design optimization of fixed pad journal bearing for rotor system using a genetic algorithm approach", International Symposium on Stability Control of Rotating Machinery, ISCORMA-1, Lake Tahoe, Nevada, (2001).

[12] Goldberg, D.E., "Optimal initial population size for binary-coded genetic algorithms", TCGA Report No.85001, Tuscaloosa, AL, (1985).