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Investigation Of Start-Up Torque Of Plain Journal Bearing And Design Optimization Using Genetic Algorithm To Minimize The Power Loss

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Abstract: *The main focus of this work is optimization of design variable in a hydrodynamic journal bearing. The purpose of this study of genetic algorithm is to optimally design a plain journal bearing to improve machines performance and to minimize power loss in start- up friction torque. A genetic algorithm is a process of natural selection and used to generate high-quality solution to optimized through mutation, Crossover and selection. The power loss in start-up friction torque equation fitness based selection method is used.This study considered bearing oil viscosity and radial clearance as design input variable. Genetic algorithm proposed for better result in this work using MATLAB.Theoptimized results plotted in a graph of the algorithm under consideration.*

Keywords *-Genetic Algorithm, Hydrodynamic Journal Bearing, Optimization, Power loss.*

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I. Introduction

This chapter is more to recognize the basic understanding of knowledge about study. The topic of tribology is the branch of science which deals the surface that is rubs together and successful operation with minimize start-up friction torque and minimize power losses. In hydrodynamic bearing has been the subject of several published studies. A brief review of paper on this topic is presented here. Hirani H. and Suh N. P. [2] was axiomatic design to provide inside of objective function and design variables. Such as radial clearance length to diameter ratio, oil viscosity and groove geometry and supply pressure and thus results minimize oil flow and power loss. Bouyer. J. and fillon M. [8] due to increasing interest in energy savings, the start-up friction coefficient is a very useful parameter for engineers, who design hydrodynamic bearing. They studies can be found in experimental measurement of the friction torque on hydrodynamic plain journal bearing during start- up. But they are concerned with air bearings and just numerical models. And they studies are more general and they deal with the transient thermal behavior in journal bearing and thrust bearings. And they studies friction coefficient during running and given a constant rotational speed. In order to understand the mechanism occurring during the transition between mixed lubrication and hydrodynamic lubrication, several studies have been conducted over the past three years. They also provide an overview of the best results of these studies and draw general conclusions on the behavior of a plain journal bearing during start-up.

The first part of the result focuses on the measurement of bearing torque during start-up with varying specific pressure (load divided by the projected area). Thus, the friction coefficients at start-up (deduced from measurements) is obtained for four different bearings. Varying feeding conditions, radial clearance and length. The second part of the results consists of observations relating to the strick-slip phenomenon which occurs during this transient period. Finally, a study dealing with bearing characteristics influencing the friction coefficient (surface roughness and bearing materials) is presented. Saruhan H. [5] was found the complexity and time consuming nature of the design process of hydrodynamic bearings wanted the development of a new methodology. And for the good results use of the genetic algorithm in the optimal design of a three lobe preloaded fluid film bearing. The developing the bearing configurations that optimize power loss along with other design criteria namely stability parameter, film temperature, fluid film thickness, and film pressure. Hermawanto D. [9] explains genetic algorithm for novice in this filed. Also explains philosophy of genetic algorithm and its flowchart are described. Solving step by step numerical computation of genetic algorithm for simply mathematical equality problem will be briefly explained. Genetic algorithm developed by Goldberg was inspired by Darwin's theory of evolution which states the survival of an organism is affected by rule "the strongest species that survives of an organism can be maintained through the process of mutation, crossover and

reproduction. Darwin's concept of evolution is then adapted to computational algorithm to find solution problem called objective function in natural fashion. A solution generated by genetic algorithm is called a chromosome is composed from genes and its value can be solved. These chromosomes will undergo a process called fitness function to measure the solution generated by genetic algorithm with problem. The producing new chromosomes named offspring. In a generation, a few chromosome in the population that will maintain for next generation will be selected based on Darwinian evolution rule, the chromosome which has higher fitness value will have greater arability of being selected again in the next generation. The chromosomes value will converges to a certain value which is the best solution for the problem after several generations.

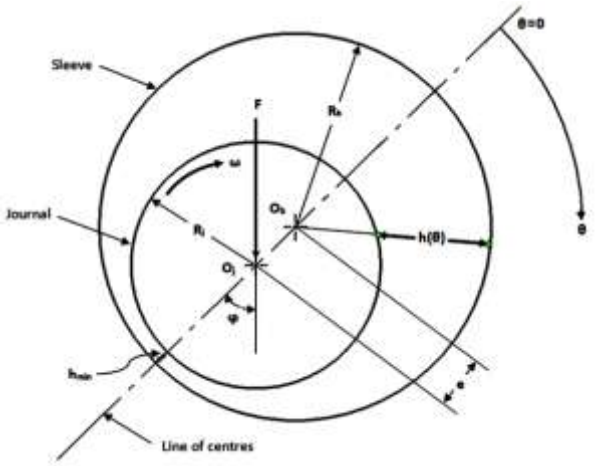

Fig: 1.1 Geometry of hydrodynamic journal bearing

II. Methodology

Optimization using genetic algorithm

Optimization process genetic algorithm developed by John Holland and his collaborators in the 1960s and 1970s is a model. Charles Darwin's theory of natural selection in biological evolution based process. Holland was the first to use mutation, recombination, crossover and selection in the study of artificial systems.

In this paper, we propose a generic, start-up friction torque in plain journal bearing for solving constrained optimization problem using genetic algorithm.

Generalized steps of optimization using genetic algorithm, [9].

Step1: Determine the number of chromosomes, mutation rate, crossover rate value and generation.

Step2: Generate chromosome - chromosome number of the population and the initialization value of the genes chromosome with a random value.

Step3: Process step 4-7 until the number of generation is met.

Step4: Calculating objective function Evaluation of fitness value of chromosomes.

Step5: Chromosomes selection.

Step6: Crossover.

Step7: Mutation.

Step8: New Chromosomes (offspring).

Step9: Solution.

Optimization

Optimization is the process achieving the best possible results under given circumstances. In construction, maintenance, design, engineers have to take good decisions. Optimization process decisions are either to minimize effort or to maximize benefit. Optimization is the process of finding the conditions that give the minimum or the maximum value of a function. Thus, optimization can be taken to be minimization.

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Optimization process that finds the best or optimal solution for a problem. All optimization problems can be summarized to revolve around these three factors:

1. An objective function process: 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 unknown to take on certain values but exclude others.

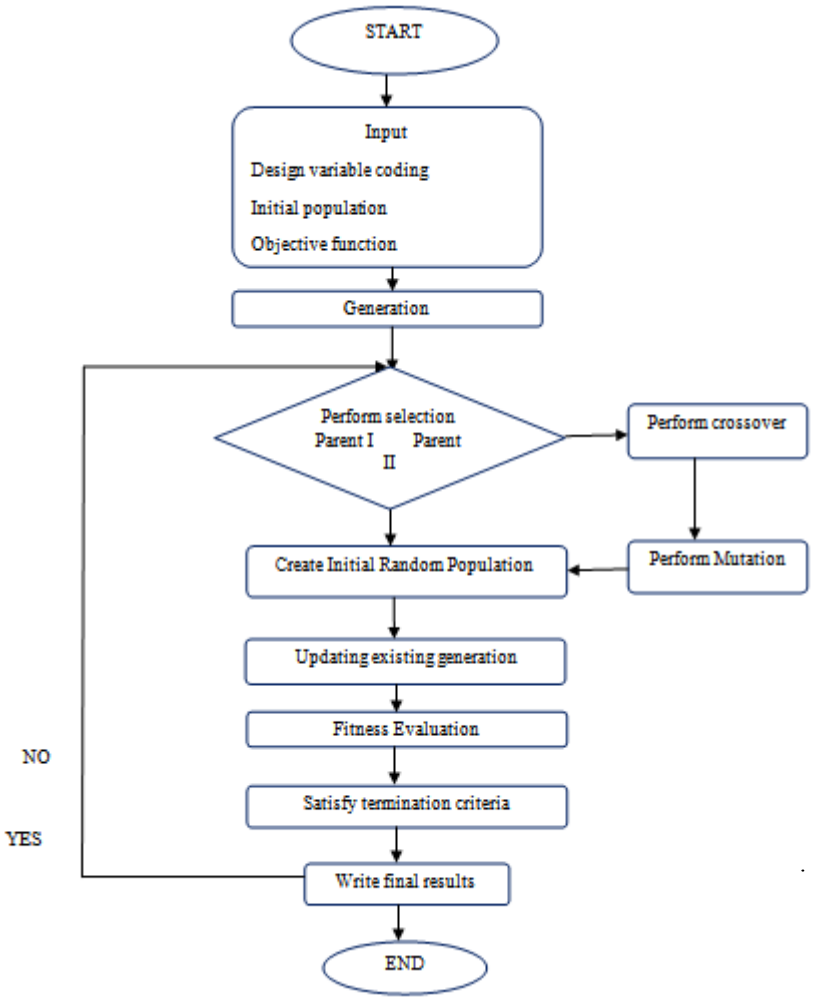

Figure 2.1 Flow chart for the proposed genetic algorithm

III. Optimization Formulation Using Genetic Algorithm

Design variable

There is a strong relationship in design objective and design criteria functions. These variable are the main factor in determine the design problem. In this design problem, various variables are including oil viscosity, radial clearance and Diameter of plain journal bearing, journal speed and length of journal bearing.

$$X(i) = \begin{cases} \text{Oil viscosity} \\ \text{Radial clearance} \\ \text{Jounal bearing} \\ \text{journal speed} \\ \text{journal length} \end{cases}$$

Objective function

In this paper used genetic algorithm for axiomatic design of plain journal bearing in start-up. In order to validate the proposed objective function the value of variable (utilized by Hirani H. et. al [2]) were put into the objective function. This provide the value of friction torque and minimize the power losses which were in the range of the result obtained by the above – mentioned group of investigators. This objective function is needed to be minimized to obtain minimum value of start-up friction torque in plain journal bearing under proposed constraints.

Objective: to minimize the friction torque of journal bearing given by proposed function and reduce the power losses.

$$T_f = \frac{4\pi^2 r^3 l \mu n}{c}$$

Subjected to: $1 \leq \mu \geq 16$, $35 \leq C \geq 70$ [2].

The optimization for a two variable problem genetic algorithm optimization technique and selection used fitness value based selection method used. In this optimization process initial population is 20. And probability of crossover is 0.7 and probability of mutation is 0.1. In this optimization process input value define in table 1.

Table 4.1 List of inputs

Input variable	Definition	Range	Units
μ	Oil viscosity	1 -16	mPa-s
C	Radial clearance	35- 70	μm
D	Diameter of journal	0.1	m
n	Journal speed	50	rps
l	Length of bearing	0.3	m

IV. Results And Discussion

In this paper proposed methodology genetic algorithms in MATLAB software used in two variable problems and minimizes the value of start-up friction torque and minimize the power loss.

Fig.4.1 the Optimization presents in the current graph a fully hydrodynamic operation of journal bearing. In this graph 52 generation value of friction clearance is 67.72 and oil viscosity (μ) is 1. And two variable optimization and population size 20, crossover probability 0.7. This figure represents fitness value of best. Worst and mean scores of optimization two variable problems. And minimization of start-up friction torque.

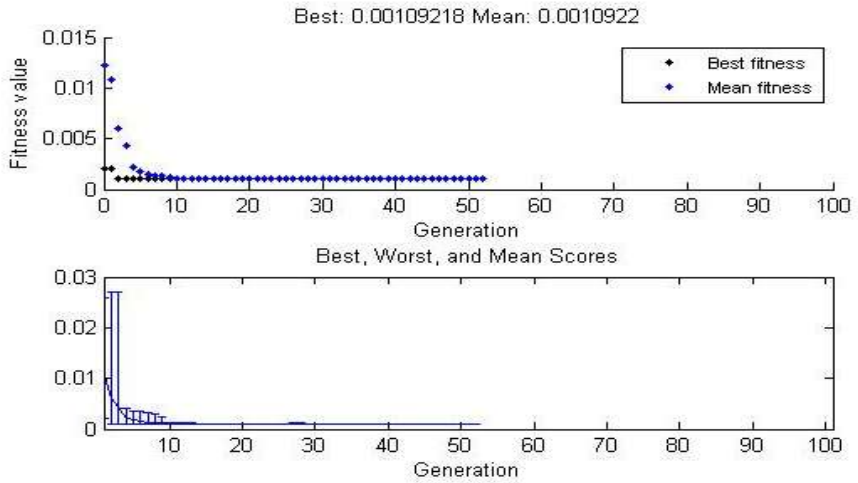

Fig 4.1 Convergence diagram for fitness value (minimize start-up friction torque) for two variable optimization (population size 20, Crossover probability 0.7)

Fig 4.2 in this optimization process use of genetic algorithm show the Genealogy for two variable optimization (minimize start-up friction torque) genealogy plots the genealogy graph of individuals. And in this graph red lines describe the mutation children and blue lines indicate crossover the children and black lines indicate the elite individuals in the optimization genetic algorithm process.

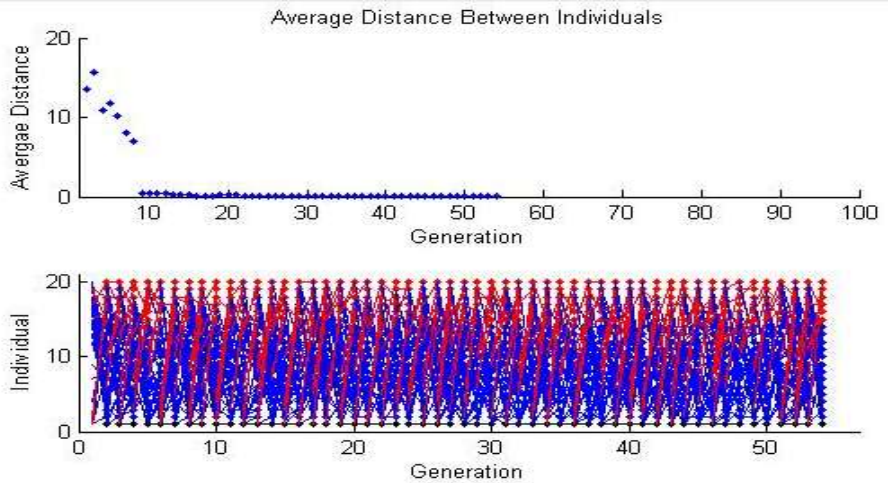

Fig 4.2 Genealogy for two variable optimization (minimize start-up friction torque)

Fig 4.3 Convergence diagram of genetic algorithm for best, worst, and mean scores fitness function (minimization of stat-up friction torque) for two variable clearance and viscosity. In this graph value of clearance is 69.999 and oil viscosity is 1. This is the best result for optimization minimizes start-up friction torque. For best result clearance value is high and minimizes the friction torque.

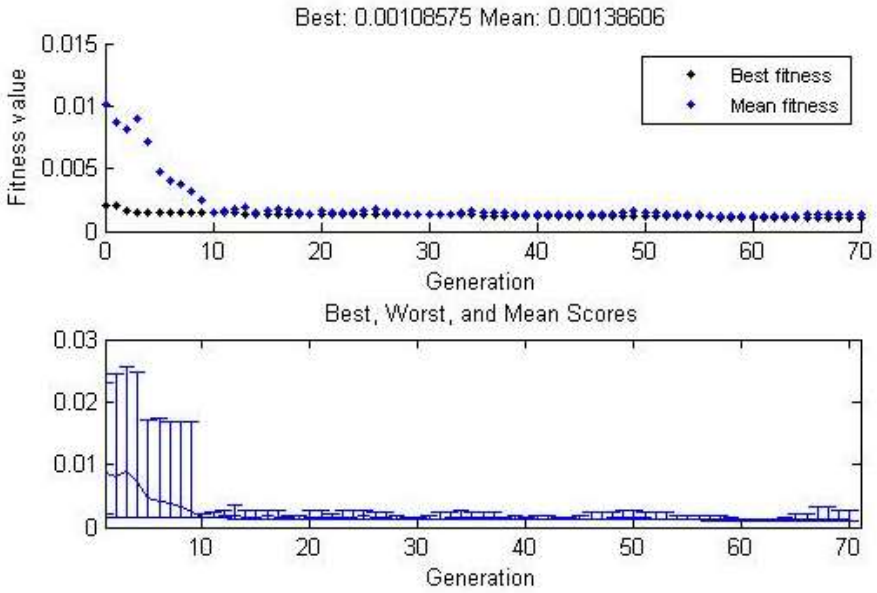

Fig .4.3 Convergence diagram for fitness value (minimize start-up friction torque) for two variable (population size 20, Crossover probability 0.7)

V. Conclusions

The friction torque in start-up of hydrodynamic journal bearing has been minimized. Two variables are radial clearance and oil viscosity played very important to reduce power loss optimization is done using genetic algorithm which has been used to minimize the friction torque and power loss in hydrodynamic plain journal bearing. The value of oil viscosity μ and radial clearance C is considered as **(1 to 6 mPas) and (35 to 7 μm**) respectively as design variables.

Fitness value based optimization method in 70 generation is used. In this optimization method initial population size 20 and crossover probability 0.7, probability of mutation 0.1 is considered. Set of design variable (1.00/69.999) are generated and the minimum start-up friction torque for this variable is calculated as **1.0583 N-m**.

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