Chaos, Solitons and Fractals 89 (2016) 20–26

Contents lists available at ScienceDirect

Chaos, Solitons and Fractals

Nonlinear Science, and Nonequilibrium and Complex Phenomena

journal homepage: www.elsevier.com/locate/chaos

Complex fluid network optimization and control integrative design based on nonlinear dynamic model☆

Jinxue Sui [a], Li Yang [a,1,*], Yunan Hu [b]

[a] School of Information and Electronic Engineering, Shandong Institute of Business and Technology, 191 BinHai Road, Yantai, China
[b] Control Engineering Department, Naval Aeronautical Engineering University, Yantai, China

ARTICLE INFO

Article history:
Available online 23 December 2015

MSC:
00-01
99-00

Keywords:
Fluid network
Optimization design
Nonlinear control
Nonlinear dynamic model
Template

ABSTRACT

In view of distribution according to complex fluid network's needs, this paper proposed one optimization computation method of the nonlinear programming mathematical model based on genetic algorithm. The simulation result shows that the overall energy consumption of the optimized fluid network has a decrease obviously. The control model of the fluid network is established based on nonlinear dynamics. We design the control law based on feedback linearization, take the optimal value by genetic algorithm as the simulation data, can also solve the branch resistance under the optimal value. These resistances can provide technical support and reference for fluid network design and construction, so can realize complex fluid network optimization and control integration design.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Fluid network research is one of the important research topics that related to the industrial production and the residents living. Whether complex mine ventilation system (including tunnels, wall, fan), or city central heating system (including delivery pipe, all kinds of regulating valve, pumping station and other), city gas transportation system, water supply system, central air conditioning system (HVAC), petrochemical compressor pipeline, aircraft fuel system and medicine circulation system and other fluid pipe network system, they all have a common feature that composed of fluid conveying pipe, some regulating facilities and power facilities, all are connected together to form a fluid network [1–12].

They have large fluid transmission problems need to be solved. The correct design and reasonable use of fluid dynamic and fluid control system, study the fluid drive and transient problem in pipe, whether in theory or practice, is very important.

Fluid network control does not directly control the density of the fluid, but through control the fluid flow of the network every branch to achieve the objective, the actuator can be fans, compressors and so on, distribute in the network according to a certain strategy, fluid control problem has received considerable attention in the 1970s and the 1980s.

Fluid network is an important part of fluid transmission, the fluid is safety transported to various network branches through all levels pipeline, and meets the flow, pressure and fluid quality requirements at the same time. In the entire fluid network system, network investment generally accounted for 50–80% of the total investment in the project. Therefore, whether the planning, design and operation management of the fluid network system are scientific, economic and practical or not, directly affects the total project investment, the operating cost and system reliability. Under the limited capital investment, the optimum design of pipe

☆ Fully documented templates are available in the elsarticle package on CTAN.

* Corresponding author. Tel.: +86 5356883211.
E-mail address: yangl-2005@163.com (L. Yang).
URL: http://www.sdibt.edu.cn (J. Sui)

[1] Since 1880.

http://dx.doi.org/10.1016/j.chaos.2015.09.009
0960-0779/© 2015 Elsevier Ltd. All rights reserved.

network system can achieve the method which meets the requirements of flow and pressure, and can make the minimum whole system cost and good system reliability design, to save investment, reduce energy consumption, increase economic benefits and social benefit has important practical meaning.

Fluid network optimization design has been paid more attention by engineering designers in the city water supply planning and design in the 1960s. In the recent years, fluid network optimization models and algorithms in engineering practice have been widely used, they have become the important tools to improve the system design level and efficiency. Whether mine ventilation system, or city water supply, heat supply and agricultural irrigation systems are needed for optimization, and find a combination of the most economic and feasible flow and pressure, at the same time, we can make the appropriate ventilation, water supply and irrigation pipe network construction according to the flow and pressure.

The global search ability of genetic algorithm is better than the traditional optimization method is more suitable to solve complicated nonlinear problems. Based on fluid network modeling and controller design, using genetic algorithm for solving the optimal value of the pressure and flow to meet fluid transmission and security requirements, and then take the optimization value as the initial value, the optimized value as a the reference value for the controller simulation, so that not only can reasonable layout actuator to achieve optimal control, but also can solve branch resistance R on the basis of optimization of Q and H combination, thereby provide technical support for fluid network construction and transformation, to achieve the integrative design for fluid network optimization and control.

2. Fluid network optimization design based on genetic algorithm

2.1. Genetic algorithm (GA) [13–15]

The idea of Genetic Algorithm (GA) comes from the natural law of survival of the fittest during biological evolution process. The basic concepts of GA are detailed as follows:

(1) String: formulation of an individual, which is generally represented with binary code. It corresponds to the chromosome in genetics.
(2) Gene: element in the string, which means different characteristics. For example, the 1, 1, 1, 0, 1 in the above example is the gene in string S.
(3) Population: individual set or all the chromosomes.
(4) Population size: the amount of individuals (or chromosomes) in a group.
(5) Fitness: acclimatization of an individual in a group to an environment.

There are many kinds of basic operators of GA. Now, the major operators used in this paper are summarized as follows:

(1) Selection: assign propagation chance according to the fitness of an individual. The individual with relatively higher fitness will have more propagation chances. On the contrary, the one with lower fitness will have less propagation chances or even be replaced by its offspring with better performance. This embodies the idea of Darwin, survival of the fittest.
(2) Crossover: select two individuals randomly in the population according to crossing rate and exchange the same bit randomly within the string length l. It simulates the copulation in the nature. Genetic crossover operator can generate new individual in order to check new points in the space. And the two descendant strings generated by crossing operators are usually different from their father strings. Additionally, they are also different from each other.
And each descendant string contains the genetic information of the both father strings.
(3) Mutation: mutation simulates the gene mutation caused by accident or other factors in biosphere. It randomly changes some bits of chromosome string with a very small probability pm.

The following four steps must be finished before solving the problem:

(1) Define the mathematic expression method of the problem;
(2) Determine the fitting function;
(3) Determine the variables and parameters of the algorithm;
(4) Define the result affirmation method and the stop criterion.

Genetic algorithm compared with traditional optimization method has many advantages, such as for some numerical concepts or very difficult to have the value concept, and only the code concept optimization problem which has many unique advantages; More convenient for solving the objective function is unable or very difficult to differentiate, is more suitable for function optimization problem that the derivative does not exist, and combinatorial optimization problems; Global search ability is strong, can effectively avoid the local optimal solution, and obtain the global optimal solution and so on. Genetic algorithm can be used in fluid network optimization theoretically, some special advantages to make up for the shortcomings of the traditional method, has certain advantages.

2.2. Fluid network optimization modeling

In view of the mine ventilation system is a typical representative of the fluid network, this paper is based on the complex mine ventilation system as an example to control and optimal design.

In the adjustment, the air control plan should be safe, economical and feasible. The security and the feasibility may be reflected on the bound for the air quantity requirement, the air quantity and the adjustment quantity and the branch controllability in generally, such as mine ventilation network. Therefore, the objective function of the optimized adjustment question is generally considered from the economic aspect, namely, causes the total cost to be smallest.

Download English Version:

https://daneshyari.com/en/article/1895371

Download Persian Version:

https://daneshyari.com/article/1895371

Daneshyari.com