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ESTIMATION OF VENTILATION NETWORK PARAMETERS OF ASYNCHRONOUS GENERATOR BY GENETIC ALGORITHM

Summary. In this paper the use of genetic algorithm methods for the parameter identification of asynchronous generator ventilating network is presented. The problem of ventilating network design is that many empirical parameters are used. It result in various results obtained from experimental measurements and simulations of ventilating network. The genetic algorithm was used for identification of empirical parameters to optimise simulation results in relation to the experiment.

Key words: genetic algorithm, ventilating network and asynchronous generator

1. INTRODUCTION

A calculation of ventilation characteristics of electrical machines is the basic input to thermal calculations. In this paper the approach of using the ventilation network to solve the ventilation characteristics is used. The problem of ventilating network design appears because of many empirical parameters used. A designer usually chooses these parameters basing on his experience. It causes that the experimental measurement and the simulation of ventilating network give various results. In this paper there is presented the use of genetic algorithm methods for identification of empirical parameters of asynchronous generator ventilating network.

2. VENTILATION NETWORK

The asynchronous generator ventilating network (Fig.1) consists of pressure sources and ventilating resistances. Pressure sources depend on type of ventilating fan. Ventilating fans are of two basic types: axial and radial. The ventilating fan is fixed to a shaft. The pressure of a coolant depends on the shape of blading and the shaft angular speed. The magnitude of ventilating resistance is influenced by some factors, for example the density of coolant, shape of channels, surface roughness etc. Each branch of the ventilating network corresponds to individual part of electrical machine. The solution of ventilation network is analogical to that of electric circuit. To electric circuit the Ohm's law is applicable, which is defined as U=RI. Atkinson's law is applicable to ventilation network. It is defined as:

$$H=KQ^2. \qquad (1)$$

Where

- H is the pressure, which is analogical to the electric voltage
- K is the ventilation resistant, which is analogical to the resistant
- Q is the flow of coolant, which is analogical to the current

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Solutions of ventilating network lead to a non-linear system of equation. The equations results of this system of equation are flows of coolant in individual parts of electrical machine. For nonsymmetrical electrical machine ventilating network can be three-dimensional.

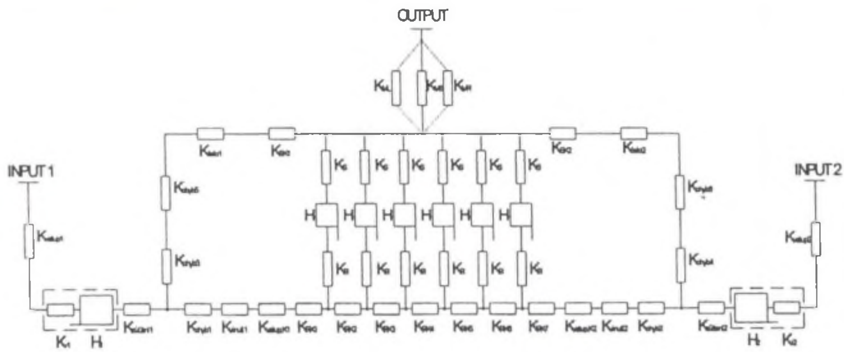

Fig. 1. Ventilation network of asynchronous generators

In this work the presented methods are used for an asynchronous generator (P=420 kW, U=400 V, n=2245 rpm), which has two own ventilators. The coolant is forced into the generator by ventilators. After that the coolant is distributed to a stator and rotor. In the rotor it passes through six radial channels. Finally, the coolant flows out through one outlet in a machine case. The ventilation network consists of ten nodes and eighteen branches.

3. MEASUREMENT OF VENTILATION CHARACTERISTICS OF ASYNCHRONOUS GENERATOR

The measurement taken on a machine is shown in Fig. 2. The coolant is supplied into the asynchronous generator by two external ventilator units. The measurement of the coolant flow quantity was performed by measuring the velocity profile in additional channels. An anemometer was used for the measuring of velocity.

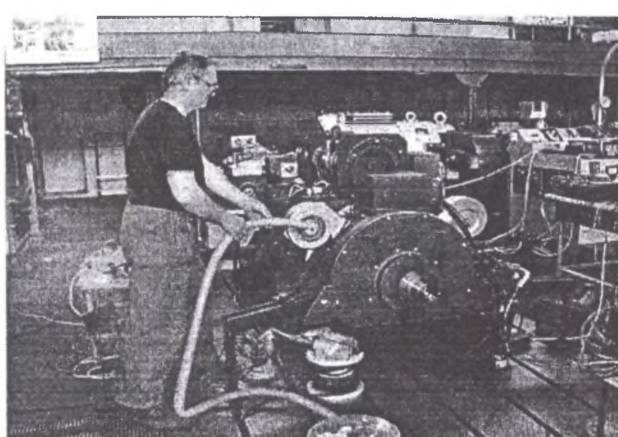

Fig. 2.Measurement on asynchronous generator

The experimental results are recapitulated below.

Flows in individual inputs (through ventilator units):

- Input flow quantity (Input 1): 0,535 m^3/s

- Input flow quantity (Input 2): 0,552 m^3/s
- Total flow quantity (Output): 1,087 m^3/s

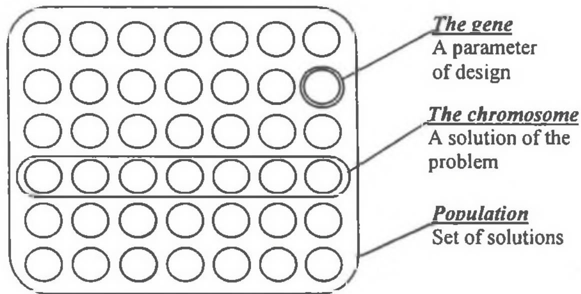

Fig. 3. Scheme of genetic algorithm data structure

4. GENETIC ALGORITHM

The genetic algorithm is a stochastic optimization method based on analogy with nature. John Holland was the first who described the basic principles of the Genetic algorithm in 1970. A solution of the general problem can be described by basic data structure presented in Fig. 4. We can resume these principles (as shown in Fig. 5) into the following steps:

1. **Creation of initial random population** - In first step, the set of chromosomes is randomly designed and each gene is set to a random value.

2. **Evaluation** – The real value is assigned to each chromosome of population. The chromosomes are ordered rising. It means that the best solution (the best chromosome) is on the top of the list, while the worst is at the end.

3. **Selection** – Now the algorithm decides, which chromosome (individual) will be crossovered with the other one. The population will be divided into two parts. The first part will be used for the creation of offspring's population while the second one will be removed.

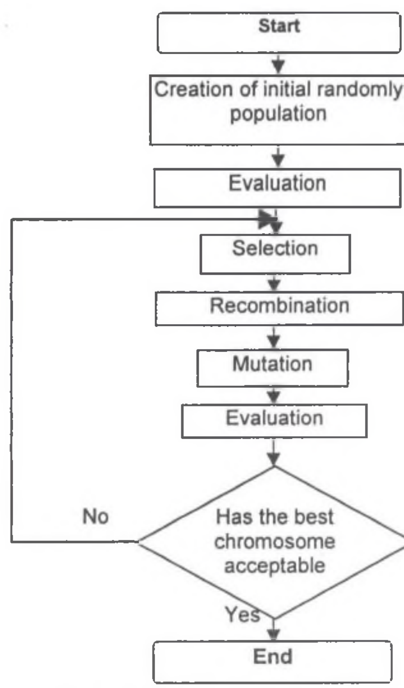

Fig. 4. Basic concept of Genetic Algorithm

4. **Recombination** – It means the recombination of selected genes between the selected parents.

5. **Mutation** – In the mutation, few genes are randomly selected and then the values of these selected genes are randomly changed.

6. **Evaluation** – This step is the same as step 2.

7. **Test of the final condition** – It is the test of the best solution acceptability, which is represented by the best chromosome. If the result is similar to the desired value, the process will be stopped, otherwise it will be repeated from step 3.

In the case of ventilation network optimization we optimized eight parameters of the network shown in Fig. 1. Those parameters were:

- Hydraulic resistances in each branch of the ventilation network (Fig. 1)
- Pressure sources of ventilators

We used Matlab and the GAOT toolbox for optimization of the ventilating network. The entire calculation took about 15 hours on PC with Pentium II processor, 333 MHz clock frequency.

5. RESULTS

The results of the optimization of asynchronous generator ventilation network are presented in Table 1. They are compared with the results of experimental measurement on the same (see Table1).

Table 1

Experimental and simulation results

All values in [m^3/s]	Experiment	Calculation with no optimization	Calculation with optimization
Input 1	0,535	0,4384	0,5199
Input 2	0,552	0,4424	0,5248
Output	1,087	0,8808	1,0446

6. CONCLUSIONS

The use of genetic algorithm optimization methods seems to be a very powerful tool for this type of problems. A deviation between the experimental values and calculated no optimized ones is up to 20%. The maximum deviation is 5% in case of the optimized values. These result confirm usefulness of application of the artificial intelligence methods such as genetic algorithm to engineering field.

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