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Efficiency Improvement Method in Ship AC Grids

Lakshmi C Raveendran, Devika R G
Mohandas College of Engineering & Technology, Thiruvananthapuram, India
lakshmicrtvm@gmail.com , rgdevika@gmail.com

Abstract—Reduction of power quality due to the power fluctuations in the generated power, is the major problem in the grids of the power producers. To resolve this problem, different power smoothing strategies can be used. The AC grids in the marine power plant also faces the power fluctuation problems in battery, which is used as the energy storage system. These fluctuations reduce the efficiency of the power plant. In this paper, a power smoothing strategy in marine power plants is described, which are used to reduce the power fluctuations for increasing the overall efficiency. The proposed method is the power smoothing for increasing the overall efficiency method by fuzzy predictive controller with an additional battery using fuzzy logic. The simulation result of this system is the graph shows the stable efficiency which is compared with the current efficiency of the system.

Index Terms— **Marine** *power plant, State of Charge, Fuzzy predictive controller, Power quality, Fuzzy logic.*

I.INTRODUCTION

Recently marine vessels with diesel electric power plant undergo power variation problems because of weak AC grid. The storage system in the marine power plants is battery, which is most affected part in the plant. If there is any problems in the stored power such as power fluctuations, frequency variations in the generated power, etc. leads to the problems in the battery conditions such as temperature variations and charge variations. These variations cause the reduction in overall efficiency of the plant and reduce the power quality.

The two parameters that determines the condition of the battery or the energy storage system is the state of charge and temperature. The power variations also affect these two parameters. For the stable or optimal efficiency, these two parameters do not have any variations and should in working order.

Conventional marine electric power system [2] is shown in figure .1.

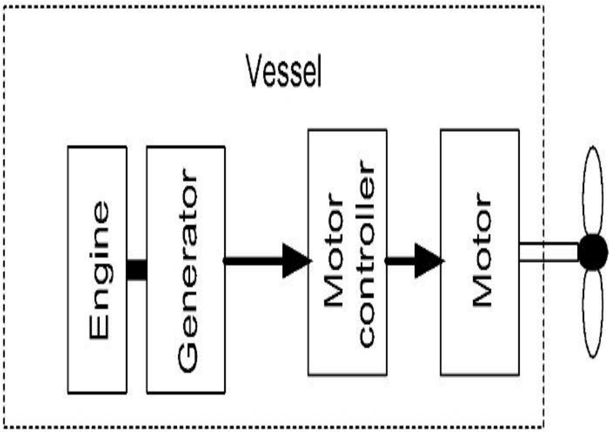

Fig .1. Diesel Electric Power System

AC grid in the marine vessel consists of a diesel engine which is connected to the generator. The shaft is connected with the motor, in which motor is controlled by motor controller. The power fluctuations in this vessel cause the temperature variations, these variations may causes dynamic limitations in the movement of the shaft. Not only the power fluctuations but also the load fluctuations cause these problems.

The power generated in the ship AC grids in the marine plant is used for the movement of the ship through shaft and for the ship services. The problems due to these fluctuations affect the ship movement and the ship may be float on the ocean or other water resources without movement.

The efficiency in which to be achieved is the major factor to determine the quality of the operation of a system. Theses fluctuations are the major reason for the lack of efficiency. There are many methods are existing for smoothing the fluctuations in the power plant to improve the efficiency.

Distributed control system [3] for reduction of frequency variation is the one of the efficiency improvement strategy used in the wind diesel hybrid system. This system has three nodes with a PID regulator. The distribution control system with the battery energy storage system is used to reduce the fluctuation for increasing the efficiency of the power system.

Extended Kalman filtering [4] is used for improving the efficiency in battery management system of LiPB-based HEV battery packs by estimating the state of charge of the battery, power fade and current stored power.

The model predictive control with an additional battery [1] is used for reduction of fluctuation in marine power plants is the recent method. In this method optimization of some cost factors for getting the optimal efficiency. The power spectral density is used with the MPC.

Here this paper describing a n efficiency improvement with the reduction of power fluctuations in the ship AC grid. The fuzzy logic controller can be based on two types: mamdani and sugeno. Fuzzy design are well defined and user friendly. If the designer of the controller knows the controlling process, the fuzzy logic controller can be designed easily. As in the [1], fuzzy predictive controller is used with an additional battery. The precise controlling using fuzzy logic provides the optimal overall efficiency of ship AC grid of the marine system.

III. PROPOSED METHOD

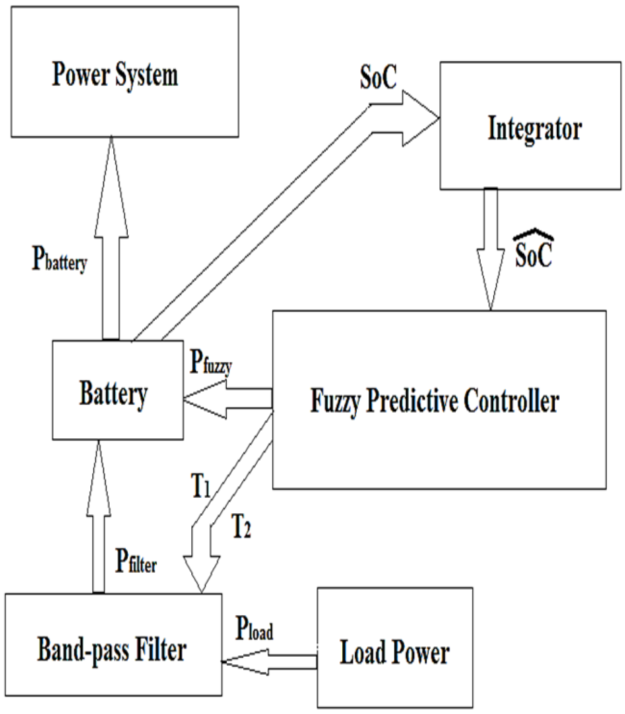

Fig.2. Block Diagram

The proposed method is the control strategy consists of a battery, band-pass filter and fuzzy predictive controller. The input to the strategy is the load in terms of power. The battery is used for estimating the controlling parameters and the output of the battery is the battery power, which is given to the power producer.

The band-pass filter in the system is designed on the basis of attenuating high frequency signals and low frequency signals. The output –input relation of this filter is

$$P_{filter} = H(j\omega) \times P_{load} \quad (1)$$

T1 and T2 are time constants of the filter. These are fetched from the fuzzy predictive controller. Integrator in the system is used to integrate the maximum value to the minimum value of state of charge. The power from the battery can be written as

$$P_{battery} = V_{battery} \times I_{battery} \quad (2)$$

Based on the thermodynamics of the systems, the battery can estimate the temperature by Newton's law of cooling [6]

$$T' \propto \Delta T \quad (3)$$

T' is the differentiation of temperature with respect to time.

The state of charge represents the current charge in the battery. The current is the rate of change of charge [7]

$$SoC = \frac{-I}{Q_{nominal}} \quad (4)$$

From the block diagram,

$$P_{fuzzy} = P_{battery} - P_{filter} \quad (5)$$

By combining these equations the $P_{battery}$ can be derived,

$$P_{battery} = V_{battery} \times \frac{CT - [hAT_{air} - T]}{R_i Q_{nominal} SoC} t \quad (6)$$

The fluctuations are occurred at every 1000ms. Therefore the time t=1000ms, that means

t= 1s

V.DESIGN OF FUZZY CONTROLLER

According to the derived equation fuzzy can be designed figure 3.

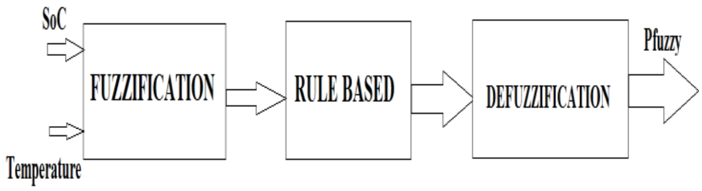

Fig. 3 Basic Structure of Fuzzy Controller

The controlling parameters state of charge and temperature are used to design the fuzzy controller. Steps for the design of fuzzy logic and predictive controller are: Fuzzification, rule based interaction and defuzzification.

In the fuzzification step, the crisp set is converted to user readable form and applied to the rule based interaction. This is shown in figure.4 and 5.

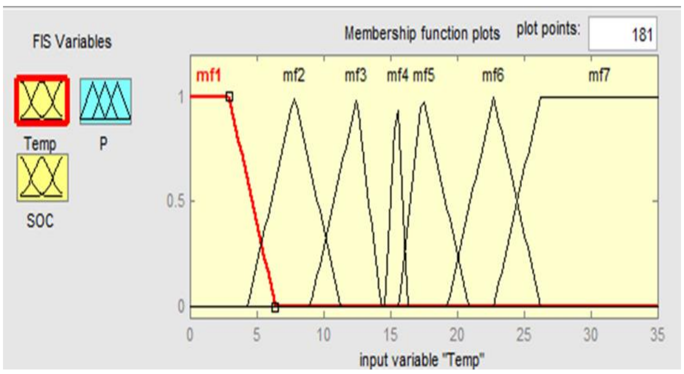

Fig. 4. Temperature

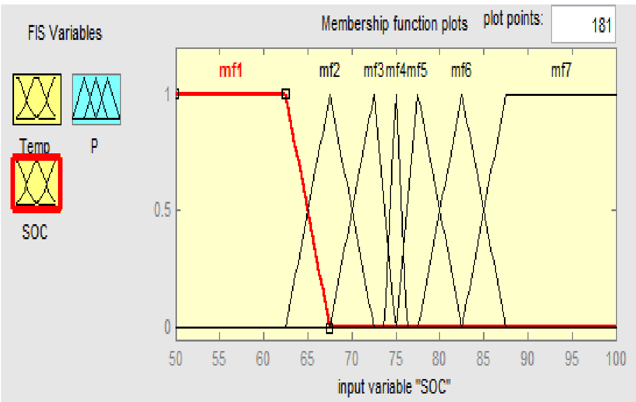

Fig. 5. State of Charge.

After fuzzification, the rules are applied to it. The figure 6 shows the rules applied to it.

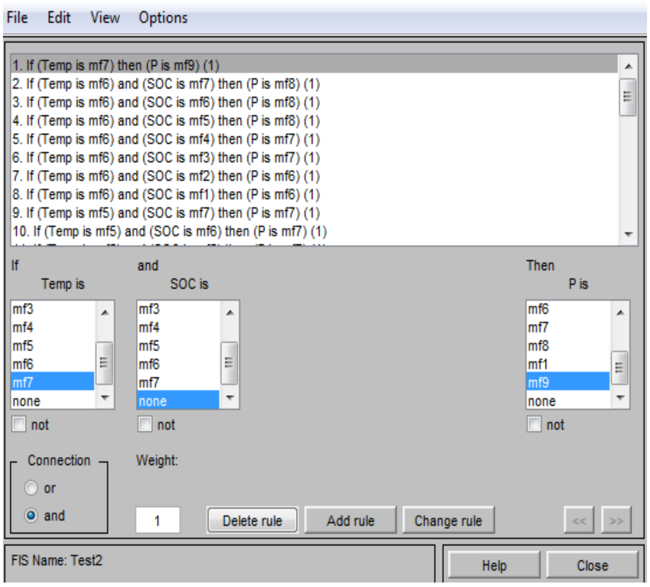

Fig. 6. Rule based interaction

Defuzzification applied for the conversion of readable form into crisp set or fuzzy set. The power from the fuzzy controller shows in figure 7.

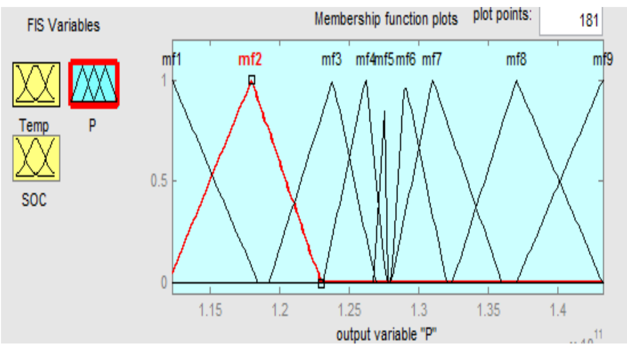

Fig. 7. Power

VI.SIMULATION RESULTS

The simulation results shows the proposed system can gives the optimal output. That means the overall efficiency can be maintained by using this control system. The result shown in figure.8, is the comparison of the current efficiency with simulated efficiency.

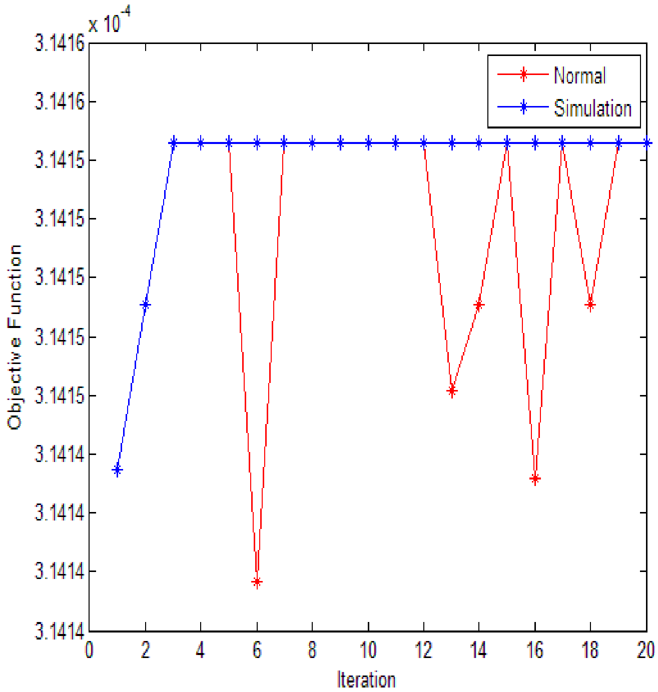

Fig. 8. Simulated efficiency

The red line in the figure shows the system can give stable efficiency and the blue line shows current, which is the efficiency before applying the proposed method to the ship grid.

VII CONCLUSION

The proposed control stsrategy is used for improving the overall efficiency of the ship AC grid. The ship AC grid becoming heat and weak due to the large consumption of power. These produces the fluctuations and variation in the whole marine system and reduces the efficiency. Here the described system improves the efficiency by reductig the fluctuations. The variation in the efficiency means working of the marine is not proper. This system avoid these varfiations and provide a stable and better efficiency of the AC in the marine vessel. The fuzzy logic applied for the design of the system. The controller in the method is the fuuzy predictive controller for providing a fuzzy output to control and smooth the fluctiuated power generated in the grid. This fuzzy based control strategy is easy to implement and more relaible.

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