Fuzzy Logic Execution in Boiler Control

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Abstract— Fuzzy logic represents soft computing method for solving problems where classical logic cannot provide satisfying results. Fuzzy logic for solving the control problems of boiler examples of water level in boiler drum and combustion quality control s presented. Fuzzy control rules were extracted from operator knowledge based on the relative relevance ruling criteria for existing boiler room. Proposed fuzzy control design a simulation system of fuzzy logic controller for water tank level control by using simulation package which is Fuzzy Logic Toolbox and Simulink in MATLAB software. In order to find the best design to stabilize the water level in the system, some factors will be considered. For this project, the water level was controlled by using three rules of membership function which then extended to five rules and seven rules for verification purpose and further improvement of the system. Besides that, several of different methods also been used in order to design the most stabilize system.

Key words: Boiler room, Fuzzy logic, control

I. INTRODUCTION

The application of the fuzzy logic design simulation of fuzzy logic controller for stabilizing the water tank level control which is done by using MATLAB/Simulink Fuzzy Logic. Fuzzy logic represents soft computing method for solving problems where classical logic cannot provide satisfying results. Fuzzy logic is multi-value logic derived from theory of fuzzy sets proposed by L. A. Zadeh (1965.). This kind of logic gained success because it makes use of the tolerance for imprecision and uncertainty to achieve tractability, robustness, and low cost solution. The key quality of fuzzy logic standpoint in the possibility of giving a formal and procedural representation of linguistic terms used to state human-centered concepts. First basic concept underlying fuzzy logic is a linguistic variable, that is, a variable whose values are words rather than numbers. Fuzzy logic is way of expanding classical logic because it allows values of variables to be different from simple true or false. Something is not always black or white; it can be any tone of grey also. Second basic concept is fuzzy if-than rule, that is, manner of dealing with consequents and antecedents in fuzzy world. There are several steps in fuzzy control systems design. As opposed to the modern control theory, fuzzy logic design is not based on the mathematical model of the process. The controller designed using fuzzy logic implements human reasoning that has been programmed into fuzzy logic language (membership functions, rules and the rule interpretation). It is interesting to note that the success of fuzzy logic control is largely due to the awareness to its many industrial applications.

Industrial interests in fuzzy logic control as evidenced by the many publications on the subject in the control literature have created an awareness of its increasing importance by the academic community. Starting in the early 90s, the Applied Control Research Lab. at Cleveland State University, supported by industry partners, initiated a research program investigating the role of fuzzy logic in industrial control. In order to achieve the project main objectives, there are some tasks that have to be done. The overall structure of the project will basically based on following:

1) Understand the foundation of fuzzy logic which covers the introduction to the general concepts.
2) Study and familiar with the fuzzy inference system which consists of methods of fuzzy inference used in the Fuzzy Logic Toolbox. Since the field of fuzzy logic uses many terms that do not yet have standard interpretations, so this step should be considered to become familiar with the fuzzy inference procedures and process.
3) Building system with the Fuzzy Logic Toolbox which goes into detail about the step taken to build and edit the fuzzy system using the toolbox.
4) Building the system with Fuzzy Logic Controller with Rule Viewer blocks using Simulink and integrates it with Fuzzy Logic Toolbox.
5) Evaluate the result obtained from the simulation. This project will be discussing and analyzing the result obtained to verify below mentioned items:
    1) Run the system using different numbers of rules to prove that the more accurate result can be obtained by adding the number of rules.
    2) Use several different methods and fuzzy membership functions to find the best method that should be used for the system to get the most accurate result as required.

II. MODEL DEVELOPMENT

In FIS editor first of all the structure of the system is defined. Here in the structure shown below there are 3 inputs and 3 outputs. The 3 inputs are:

1) Level
2) Rate
3) Pressure

The 3 outputs are:

1) Valve
2) Fire
3) Steam valve

The middle block contains the rules which are formed using different combinations of the inputs used.

One in all it can be said that the FIS editor displays the information about the fuzzy inference system.

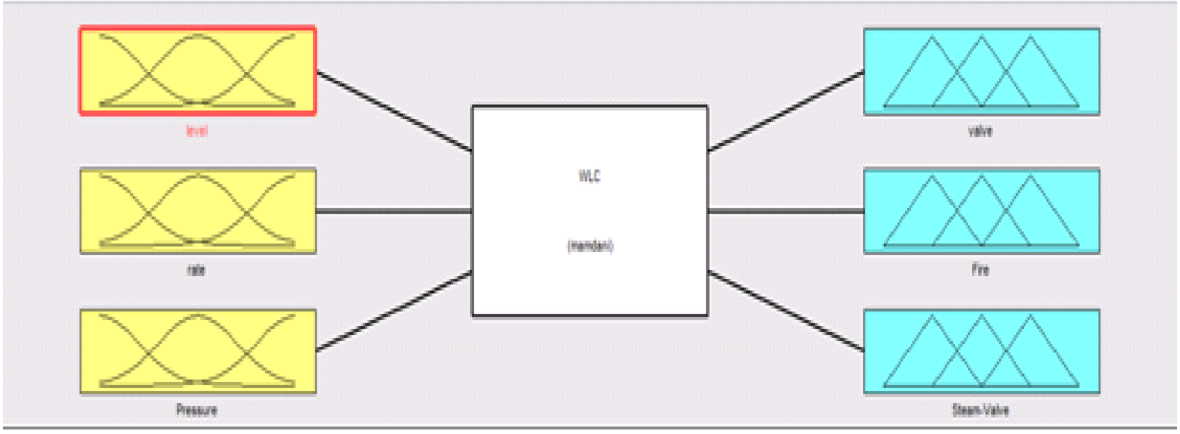

Fig. 1: FIS editor displaying the overall structure

III. DEFINING THE MEMBERSHIP FUNCTION FUNCTION AND MEMBER SHIP DEGREE FOR ALL THE INPUT AND OUTPUT VARIABLES

After defining the structure in FIS editor the GUI tool that come into play is membership editor. We can choose any type of membership function among the various types like trapMF, triMF, GuassMF etc. For the first input variable i.e 'Level' in this project the type of membership function used is guassMF. Also we can use any number of membership degrees for the membership function of a variable. There are 3 membership degrees have been used for the first input variable. They are:

1) Negative
2) Moderate
3) Positive

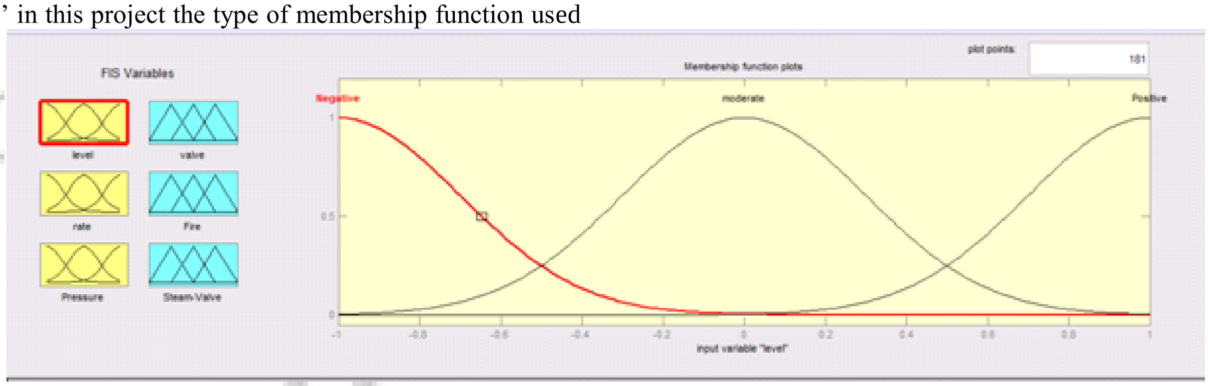

Fig. 2: Membership editing of the first input variable

For the second input variable i.e 'Rate' in this project the type of membership function used is guassMF. There are 3 membership degrees have been used for the second input variable. They are:

1) Negative
2) Zero
3) Positive

Similarly here also the range of the membership degree can be varied according to the requirement.

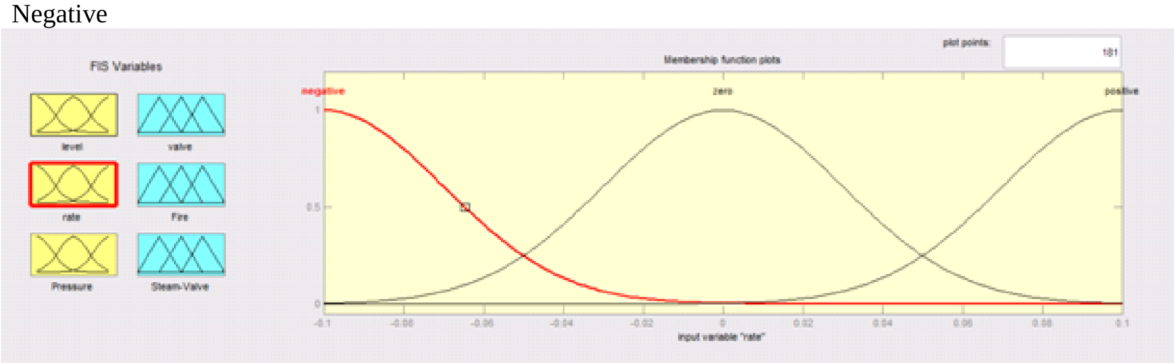

Fig. 3: Membership editing for the second input variable

For the third input variable i.e 'pressure' in this project the type of membership function used is triMF. There are 3 membership degrees have been used for the third input variable. They are:

1) Zero
2) Small
3) Large

Similarly here also the range of the membership degree can be varied according to the requirement.

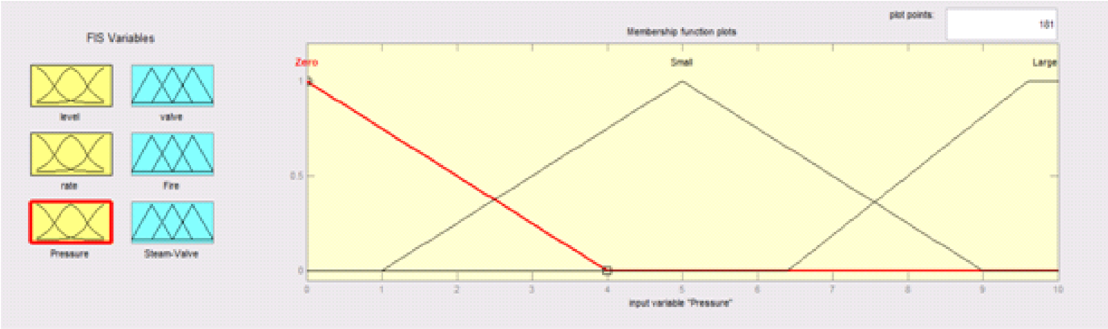

Fig. 4: Membership editing for the third input variable

For the first output variable i.e 'Valve' in this project the type of membership function used is triMF. There are 5 membership degrees have been used for the first output variable. They are:

1) Fast Closing
2) Slow Closing
3) Unchanged
4) Slow opening
5) Fast opening

Similarly here also the range of the membership degree can be varied according to the requirement.

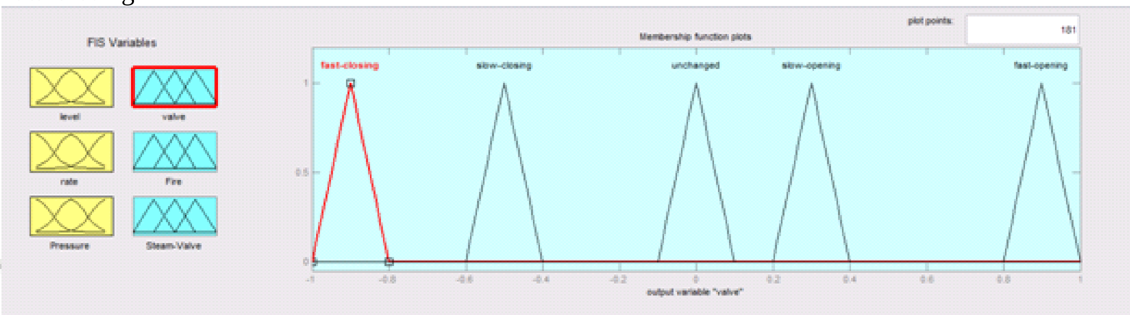

Fig. 5: Membership editing for the first output variable

For the second output variable i.e 'Fire in this project the type of membership function used is triMF. There are 2 membership degrees have been used for the output variable. They are:

1) OFF
2) ON

Similarly here also the range of the membership degree can be varied according to the requirement.

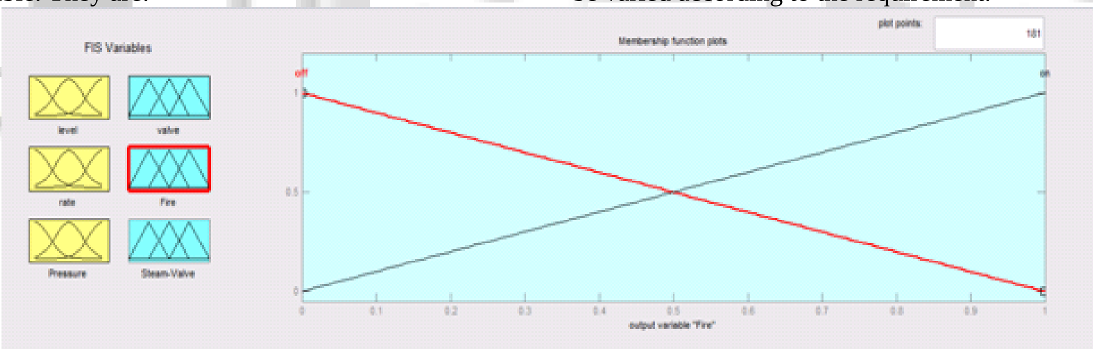

Fig. 6: Membership editing for the second output variable

For the third output variable i.e 'Steam Valve' in this project the type of membership function used is triMF. There are 2 membership degrees have been used for the output variable. They are:

1) Closed
2) Open

Similarly here also the range of the membership degree can be varied according to the requirement.

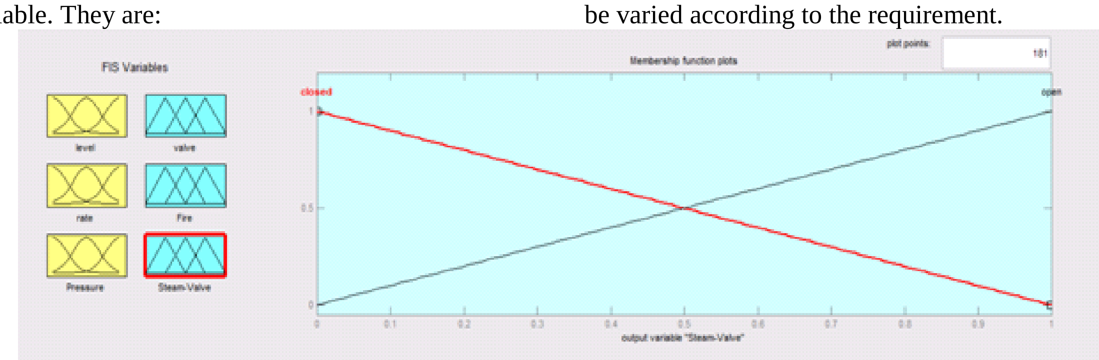

Fig. 7: Membership editing for the second output variable

A. Membership Editing For the Third Output Variable

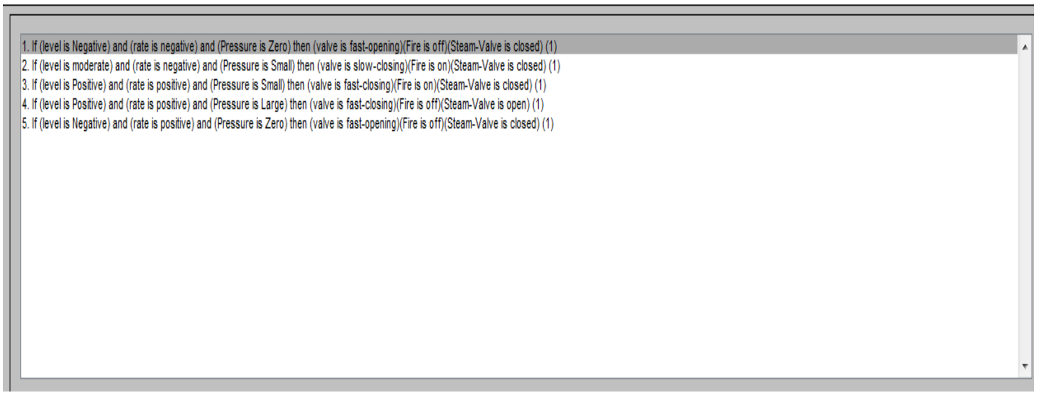

Fig. 8: Rule editor

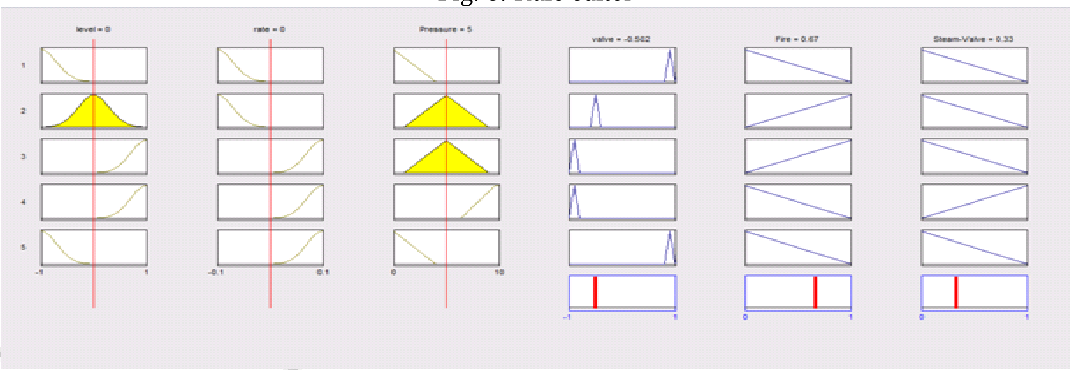

Fig. 9: Rule viewer

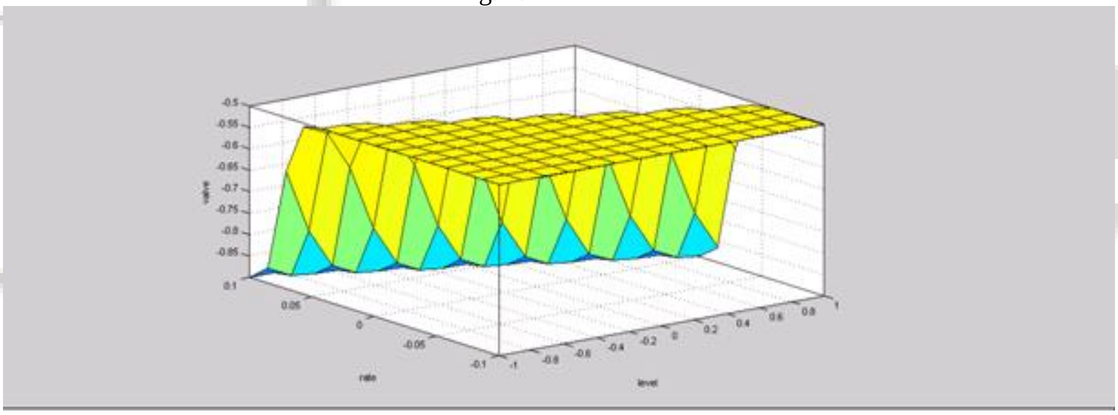

Fig. 10: Surface viewer

IV. SIMULINK DESIGN

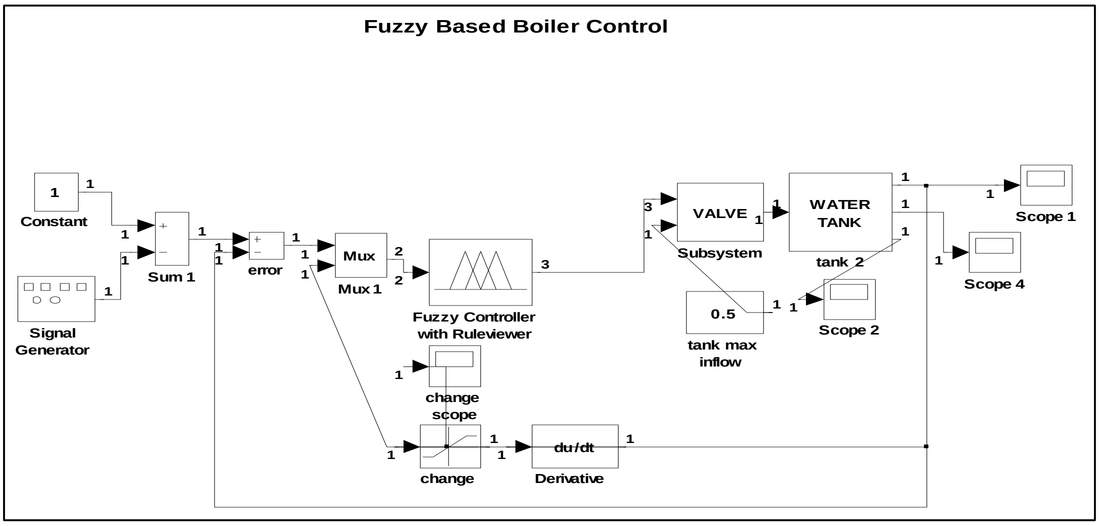

Fig. 11: Simulink Design

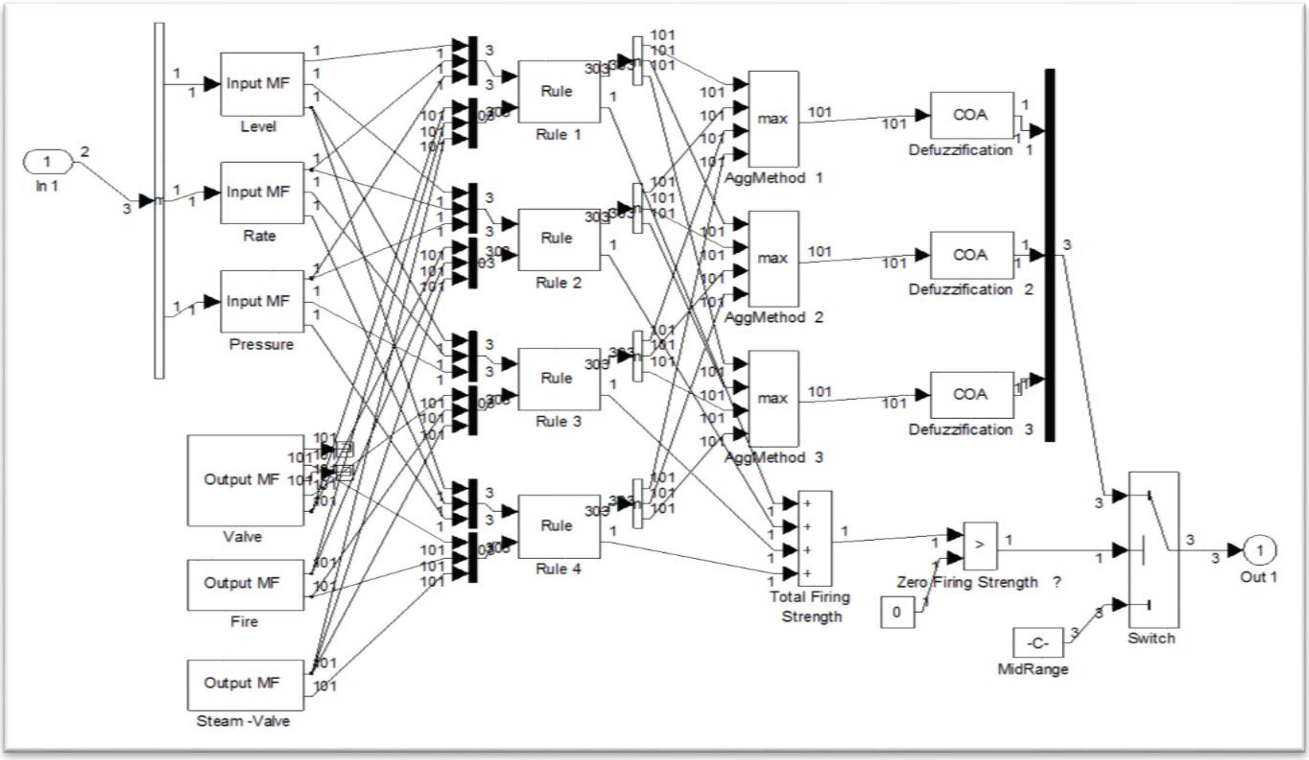

Fig. 12: Simulink Model Internal Structure

V. CONCLUSION

In direct approach used in fuzzy control design fully completed rules sets are sometimes hard to get from operators alone without designers rules post-tuning. Interpolation of missing rules was made to fulfill criteria of completeness by trial and error method. Fuzzy logic based control can be good choice if the controller designer has a sufficient amount of operational knowledge. Downside is that this method does not produce solutions that are more general so consequently this controller cannot be used on any other even similar system and uncovered work conditions of this system. This fact stands and remains for further study on generalization of lessons learned. One possible direction is usage of customize neural networks and genetic algorithm. For adjustment of fuzzy rules in training of supposed neural-fuzzy model genetic algorithm could be used to select rules for different working conditions (start-up, shutdown, normal) and enhance usage of direct human knowledge. Membership functions parameters in that case could be tuned in back-propagation manner and grab hold of real systems behavior. Further analysis is needed to soft computing provide control that is more general in case of boiler room.

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