



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3

Issue: X

Month of publication: October 2015

DOI:

www.ijraset.com

Call: ☎ 08813907089

E-mail ID: ijraset@gmail.com

Boiler Cleanliness Factor Control Using Fuzzy Logic

Manoj Kumar
TSPL, India

Abstract: Power generation today is an increasingly demanding task, worldwide, because of emphasis on efficient ways of generation. A power station is a complicated multivariable controlled plant, which consists of boiler, turbine, generator, power network and loads. The power sector sustainability depends on innovative technology and practices in maintaining unit performance, operation, flexibility and availability. The demands being placed on Control & Instrumentation engineers include economic optimization, practical methods for adaptive and learning control, software tools that place state-of-art method. As a result, Fuzzy techniques are explored which aim to exploit tolerance for imprecision, uncertainty, and partial truth to achieve robustness, tractability, and low cost. This paper proposes use of fuzzy technique in critical areas of Soot Blowing optimization. Presently, in most of the Power stations the soot blowing is done based on a fixed time schedule. In many instances, certain boiler stages are blown unnecessarily, resulting in efficiency loss. Therefore a fuzzy based system is proposed which shall indicate individual section cleanliness to determine correct soot blowing scheme. Practical soot blowing optimization improves boiler performance, reduces NOx emissions and minimizes disturbances caused by soot blower activation. Therefore an fuzzy based system is proposed to replace the existing conventional controllers

I. INTRODUCTION

The Private owned Power station in India that has been considered in this paper is a Coal fired 660 MW Power Station. The overview of a 660 MW unit is shown in figure 1. The Soot blowing system consists of 104 Wall Blowers in a 660 MW Coal based power plant in India. The paper presents a Fuzzy rule-based system to estimate the cleanliness factor of the boiler. The cleanliness factor is calculated based on certain identified variables. In the first strategy the PID controller gains are varied based on fuzzy logic rules. Fuzzy rules are utilized on-line to determine the controller parameters based on tracking error and its first time derivative.

II. SOOT BLOWING SYSTEM

The soot blowing is done based on a fixed time schedule in many Power stations. This paper propose a Fuzzy logic system designed to advise on Where and When to blow the soot depending on a single attribute called Cleanliness Factor. In contrast to the standard approach regarding soot blowing, cost optimized soot blowing determines continuously, when a specific soot blower group (level) shall be operated. Thus the soot blowing strategy inevitably changes from cleaning of the entire boiler to cleaning of individual heating surfaces.

Furnace and convective pass slagging and fouling have a negative effect on boiler performance, emissions, and unit availability. Furnace Slagging reduces heat transfer to water walls and increases amount of heat available to convection pass leading to higher FEGT (Furnace Exit Gas Temperature), higher steam temperature, higher desuperheating spray flows, reduced performance and higher NOx emission. Convective Pass Slagging and Fouling reduces heat transfer in convection pass leading to lower steam temperature, reduced performance ,lower desuperheating spray flows and increased flue gas temperature at boiler exit. However regular sootblowing can result in over-cleaning of furnace walls leading to low steam temperatures , increased moisture levels and erosion damage in last stages of LP turbine, lower turbine and unit power output (due to reduced reheat steam temperature) . Sootblowing of boiler convective pass increases heat transfer in that region resulting in increases steam temperatures and desuperheating sprays, and reduces flue gas temperature at boiler exit. Hence for best performance it is important to maintain an optimal balance between furnace and convective pass heat transfer. The resultant requirement is the SootBlowing Optimization.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

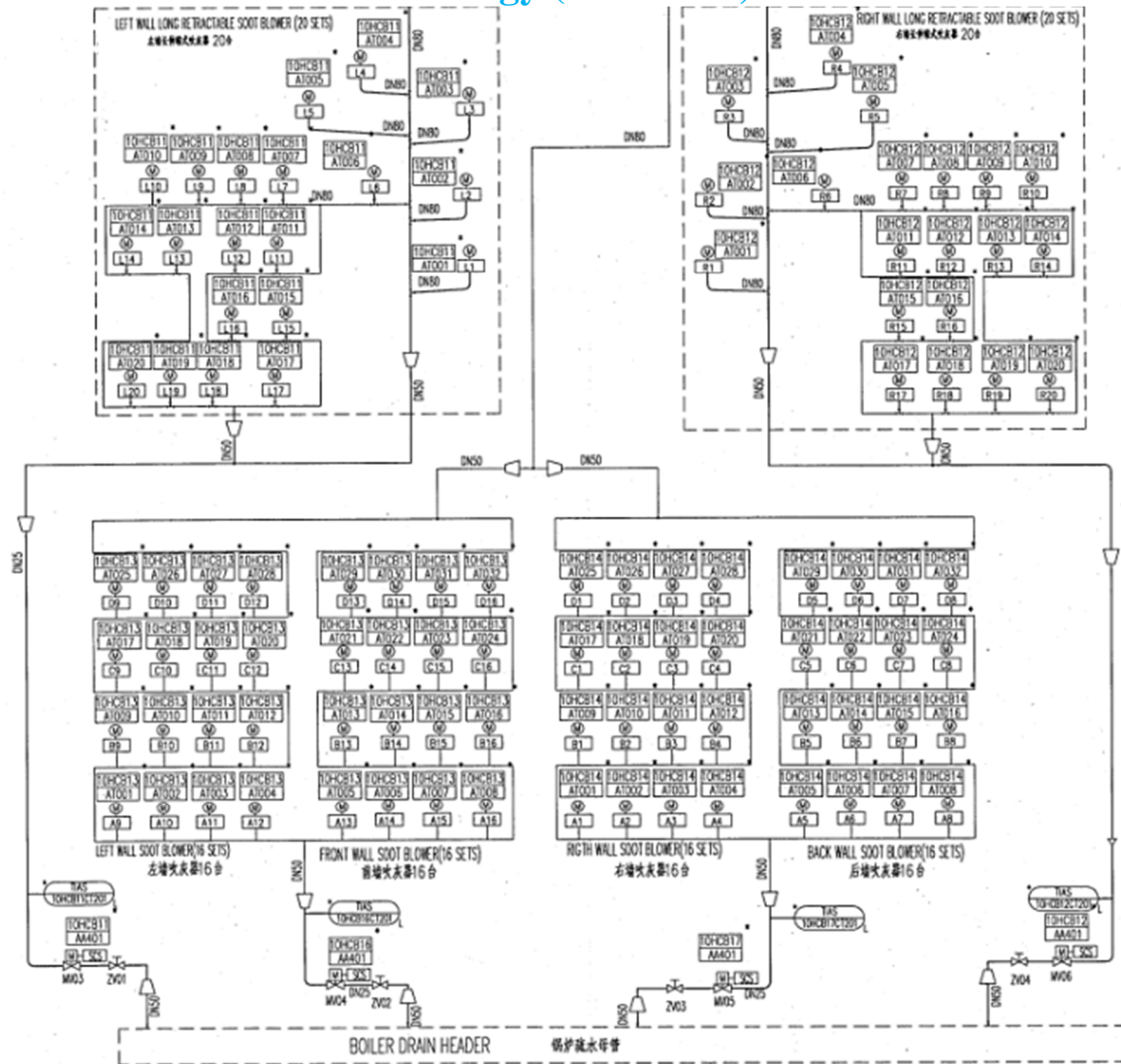


Fig.1 General Layout of Soot Blowing system in a 660 MW unit

A fixed sootblowing schedule programmed into the sootblower control system indicated that sequential activation of all 88 wall blowers produced large cyclic variations in main steam temperature. The main steam temperature rose as the convection pass was cleaned and fell as slag was scoured from the furnace water walls. Such cycling of main steam temperatures is not desirable because it stresses both the boiler and the steam turbine.

The boiler section fouling status can be quantified by the section cleanliness factor (CF). By definition, cleanliness factor is the ratio of actual to design heat transfer rate.

III. FUZZY LOGIC DESIGN

The fuzzy logic system consists of three different types of entities. -Fuzzy sets, fuzzy variables and fuzzy rules. The membership of a fuzzy variable in a fuzzy set is determined by a function that produces values within the interval [0,1]. These functions are called membership functions. The fuzzy rules determine the link between the antecedent and consequent fuzzy variables and are often defined using natural language linguistic terms. A fuzzy if-then rule associates a condition about linguistic variables to a conclusion. The degree the input data matches the condition of a rule is combined with the consequent of the rule to form a conclusion inferred by the fuzzy rule. A fuzzy logic controller consist of three sections namely fuzzifier, rule base and defuzzifier as shown in fig.3. The fuzzifier transforms the numeric/crisp value into fuzzy sets; therefore this operation is called fuzzification. The main component of the fuzzy logic controller is the inference engine, which performs all logic

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

manipulations in a fuzzy logic controller. The rule base consists of membership functions and control rules. Lastly, the results of the inference process is an output represented by a fuzzy set, however, the output of the fuzzy logic controller should be a numeric/crisp value. Therefore, fuzzy set is transformed into a numeric value by using the defuzzifier. This operation is called defuzzification. For the proposed study fuzzy inference engine is selected and the centroid method is used in defuzzification process.

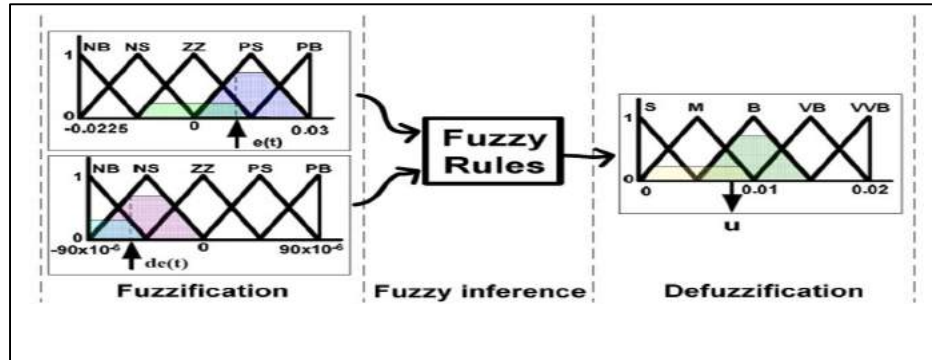


Fig. 2 Fuzzy Logic system

A method of estimating the cleanliness factor in furnace is estimated by using fuzzy logic. The following input variables are identified for fuzzification.

- A. Load
- B. SH metal temperature
- C. Total spray flow
- D. Burner Tilt
- E. Mill Combination
- F. Time since last soot blowing

The fuzzy sets defining for the above variables are as follows: LOAD (MW): {Low, Normal, High}

TEMP (C) : {Low, Normal, High} SPRAY(TPH): {Low, Normal, High}

BURNER TILT (deg.): {Down, Normal, UP} MILL COMBINATION: {Lower, Level, UP}

TIME SINCE LAST SB (hr.): {Short, Average, Long.}

The cleanliness factor, chosen as the objective function CF is given by: CF (%) - {Dirty, Clean}

The Linguistic variables and their ranges are given in Table –1

Linguistic Value	Notation	Ranges
Gaussian MF	LOAD	
Low	L	[610,640]
Normal	N	[630,660]
High	H	[650,680]
Bell MF	SH Temperature	
Low	L	[520,530]
Normal	N	[530,540]
High	H	[540,550]
Gaussian MF	Spray Flow	
Low	L	[20,40]
Normal	N	[25,55]
High	H	[40,60]
Gaussian MF	Burner Tilt	

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Down	D	[-30,0]
Normal	N	[-20,20]
Up	U	[0,30]
Gaussian MF	Mill combination	
Lower	Low	[0,.5]
Level	Lev	[.1, .9]
Upper	U	[.5, 1]
Bell MF	Time since last SB	
Short	S	[0,4]
Average	A	[3,21]
Long	L	[10,24]
Bell MF	Cleanliness Factor	
Dirty	D	[0,80]
Clean	C	[70,100]

Table-1

Considering most of the possible scenarios in the Boiler operating conditions twelve rules are framed for the Fuzzy system.
Table-2

Rule	Load	Temp	Spray	Tilt	Mill Com	Time	Output (CF)
1	Lo	Lo	Lo	Nor	Lower	Lo	Clean
2	Lo	Hi	Hi	Down	Upper	Hi	Dirty
3	Avg	Nor	Nor	Nor	Level	Avg	Clean
4	Avg	Hi	Hi	Down	Level	Hi	Dirty
5	Hi	Lo	Lo	Nor	Upper	Avg	Clean
6	Hi	Hi	Hi	Down	Level	Hi	Dirty
7	Hi	Hi	Nor	Nor	Upper	Avg	Clean
8	Avg	Hi	Hi	Down	Lower	Avg	Dirty
9	Lo	Nor	Nor	Up	Upper	Avg	Clean
10	Hi	Hi	Hi	X	Level	Hi	Dirty
11	Hi	Hi	Hi	Down	Lower	Hi	Dirty
12	X	Hi	Hi	Down	X	X	Dirty

Table-2

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

The Configuration of Fuzzy logic using MATLAB is shown in Figure 3 & 4. The configuration has 6 input variables and 1 output variable.

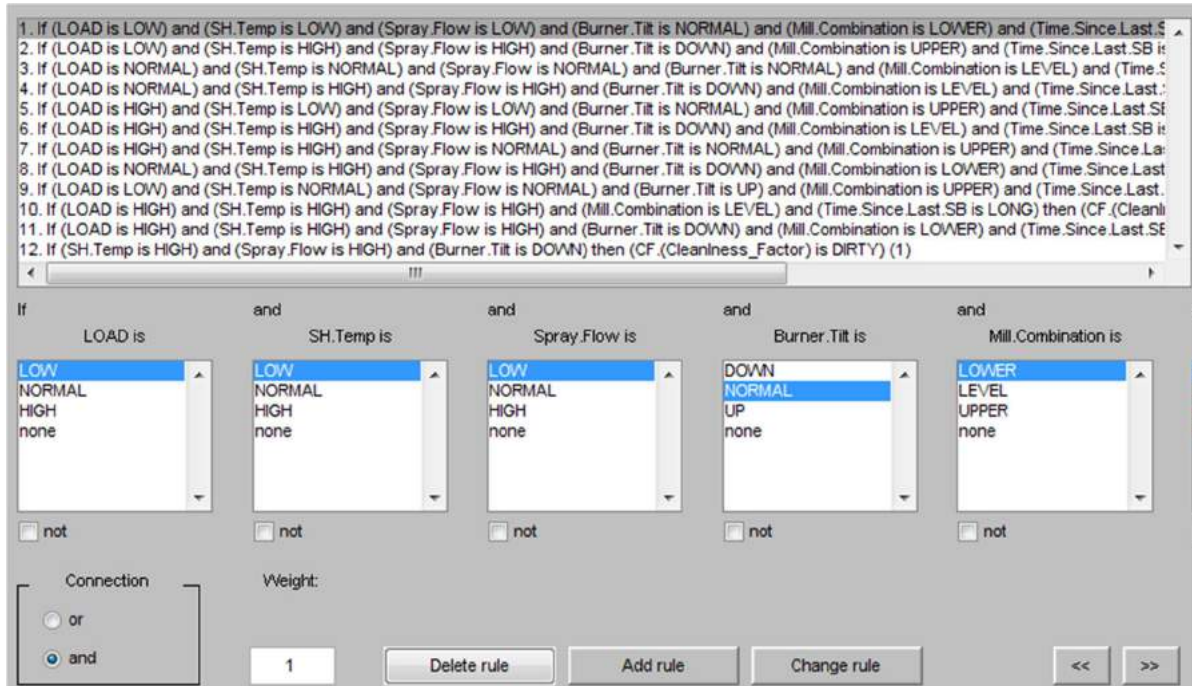


Fig.3 General Layout of Soot Blowing system in a 660 MW unit

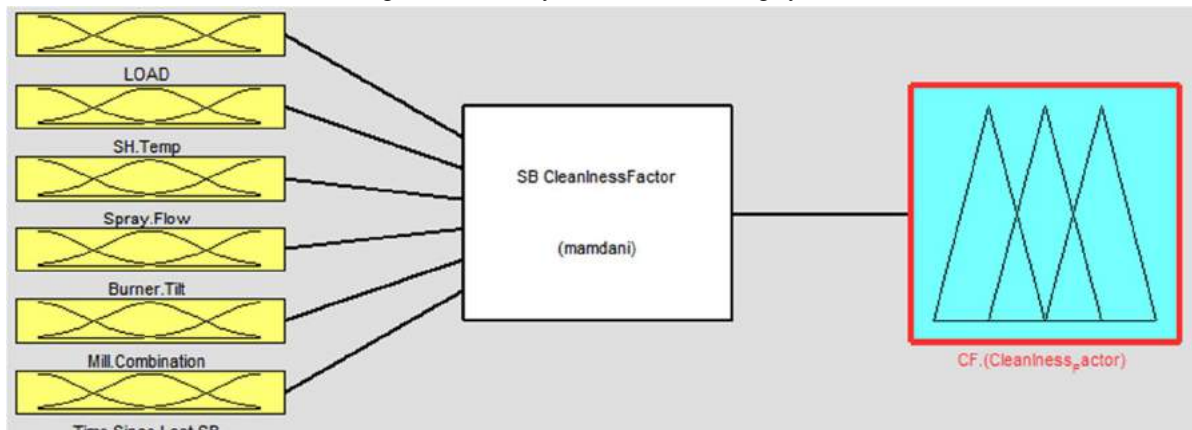


Fig. 4 Configuration of Soot blowing System in Fuzzy Log

IV. FUZZY INPUT / OUTPUT MEMBERSHIP FUNCTIONS

The membership function for all the six input variables and one output variable is discussed.

The fuzzy sets describing LOAD, TEMP, SPRAY, TILT, MILL COMB, TIME and Output Cleanliness Factor (CF) are illustrated in figures 5 to 12.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

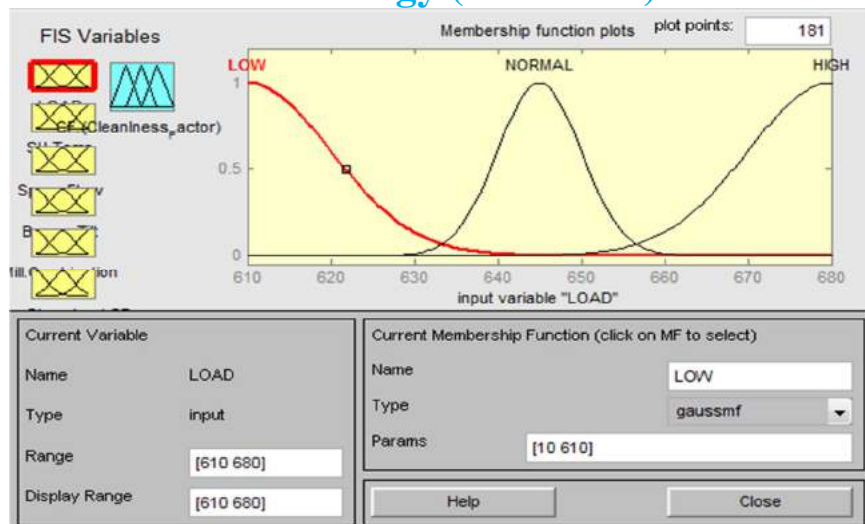


Fig.5 LOAD

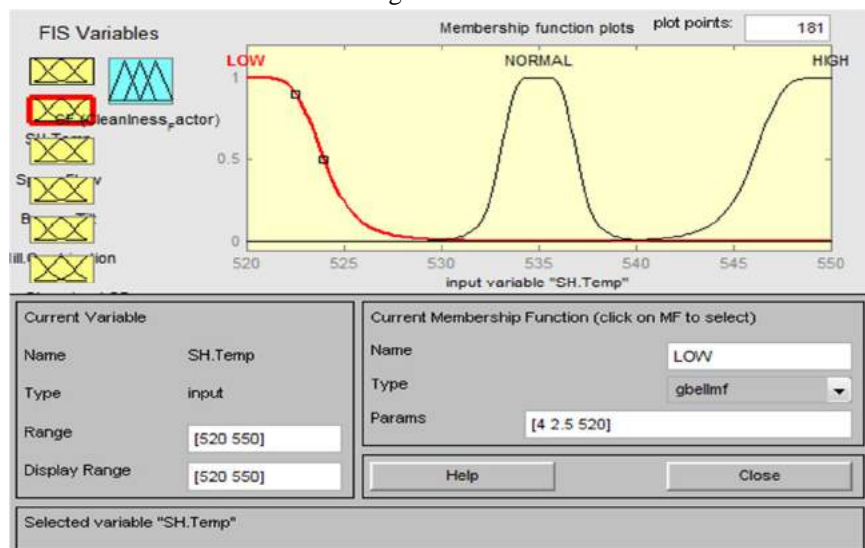


Fig. 6 SH Temp.

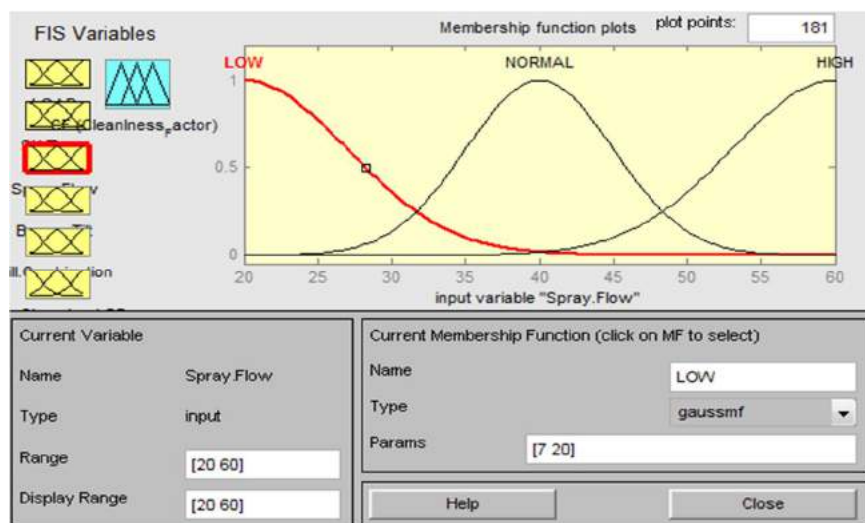


Fig. 7 Spray Flow

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

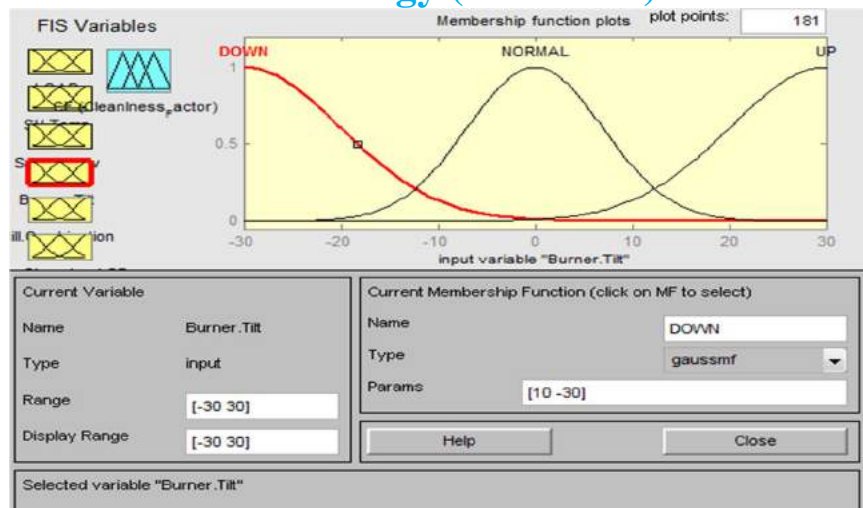


Fig. 8 Burner Tilt

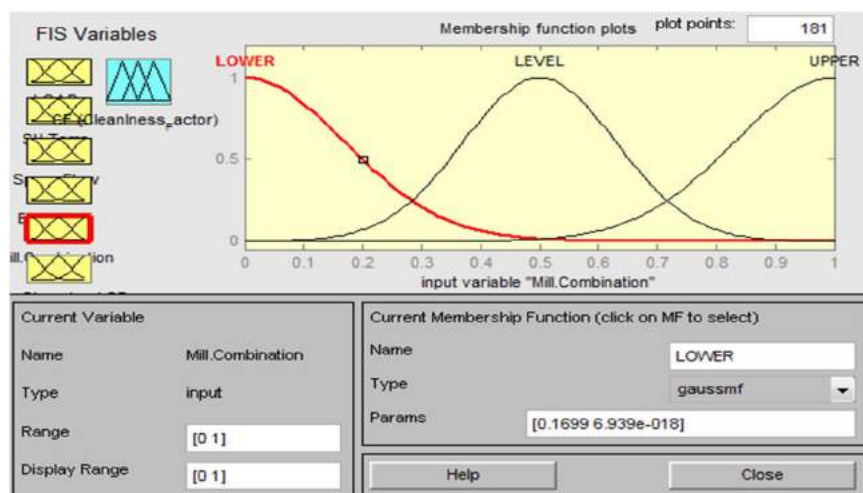


Fig. 9 Mill Combination

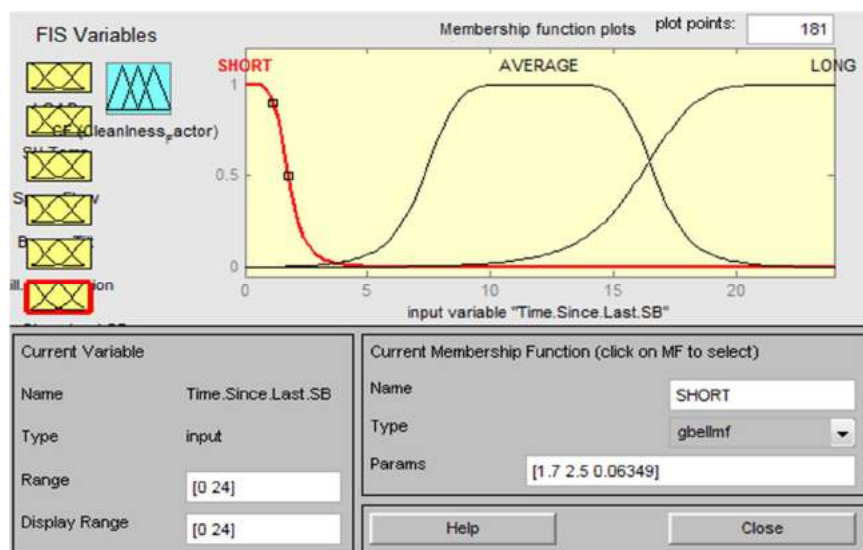


Fig. 10 Time since Last Sootblowing

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

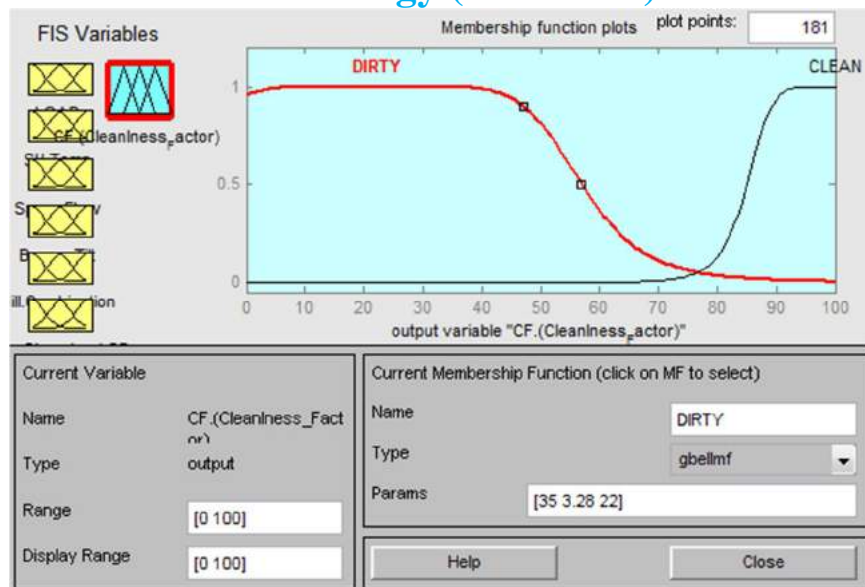


Fig. 11 Cleanliness Factor

The surface view of various input combinations and Command Output (CF) is shown in Figure 12

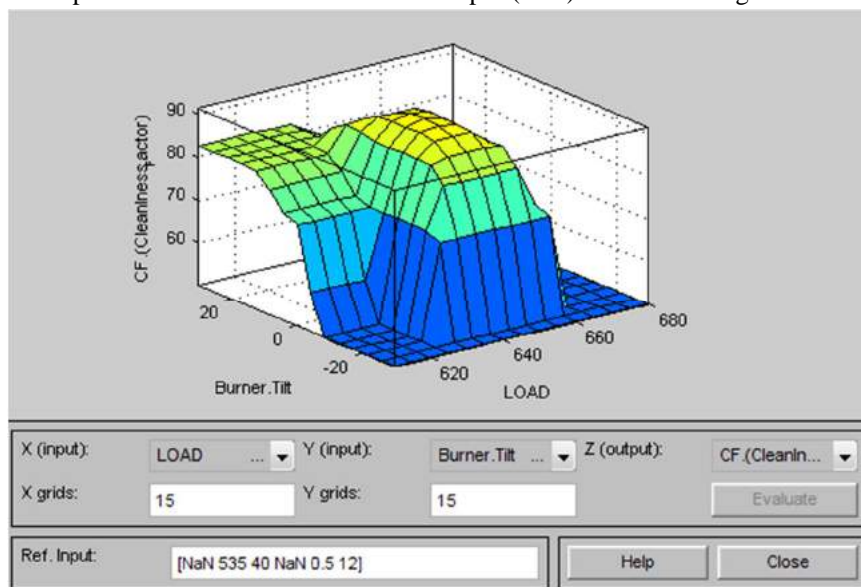


Fig. 12 Surface view of Load, Burner tilt and CF

A MATLAB based program is developed to compute the values of the output for given different input values. This program utilizes 'Fuzzy Inference System'. It calculates the crisp values of the outputs for given inputs. The Fuzzy based soot blowing strategy satisfies the optimization objectives of Lowest operating cost, maximize power generation, Minimizes maintenance cost and avoids unmanageable soot build up. The sample results of the MATLAB with six inputs as shown below, estimates the Cleanliness Factor from the Fuzzy Soot Blowing Model.

A. Results

Enter LOAD: (MW): 645
Enter SH METAL TEMP (C): 535
Enter TOTAL SPRAY: (T/H): 40
Enter BURNER TILT (degree): 0
Enter MILL COMBINATION: 0.5

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Enter TIME SINCE LAST S/B: 12

CLEANLINESS FACTOR OF THE FURNACE is 91.5

V. CONCLUSION

The purpose of this paper is to demonstrate the fuzzy techniques in a Power Station. The intelligent soot blowing system proactively modifies the soot blowing activities in response to real-time events or conditions within the boiler. The intent is to intelligently blow soot while satisfying multiple and specific user defined objectives using on-line, automated techniques. This application provides an asynchronous, event-driven technology that is adaptable to changing boiler conditions. This shall help in optimized soot blowing operation in a Power Plant. This application can further be implemented for all domains in the process plant. This will ensure the conversion of human expertise to knowledge base wherein the linguistic descriptions are translated into numeric data that yield qualitative results. Results of simulation experiments demonstrate that the Fuzzy algorithm may improve the performance of Sootblowing control loop well beyond that obtained in conventional PID algorithm. Hence, the Fuzzy logic proposed approach makes it possible to easily build high performance tailor-made controllers for any specific control loop in the Power Plant thereby optimizing power plant efficiency and cost.

REFERENCES

- [1] Hazzabl, A. Laoufi, I. K. Bousserhane, M. Rahli "Real Time Implementation of Fuzzy Gain Scheduling of PI Controller for Induction Machine Control"
- [2] Hamid Bentarzi, Rabah Nadir belaidi Samah "A New Approach Applied to a Thermal Power Plant Controller Using Fuzzy Logic plants"
- [3] Mohammad Hadi Amoozgar, Abbas Chamseddine, Youmin Zhang "Fault-Tolerant Fuzzy Gain-Scheduled PID for a Quadrotor Helicopter Testbed in the Presence of Actuator Faults"
- [4] M. Esfandiyari, M. A. Fanaei "Comparison between classic PID, fuzzy and fuzzy PID controllers" [5] NTPC Power Plant Model for 500 MW units
- [5] Enrique Arriaga-de-Valle and Graciano Dieck-Assad "Modelling and Simulation of a Fuzzy supervisory controller for an Industrial Boiler"
- [6] A Tanemura, H. Matsumoto, Y. Eki, S. Nigawara "Expert System for startup scheduling and operation support in fossil power plants"
- [7] Xu Cheng, Richard W. Kephart, Jeffrey J. Williams "Intelligent Sootblower Scheduling for Improved Boiler Operation"
- [8] İlhan, Ertuğrul, Hasan Tiryak "An Investigation Of Productivity In Boilers Of Thermal Power Plants With Fuzzy Gain Scheduled PI controller"
- [9] Vjekoslav Galzina, Tomislav Šarić, Roberto Lujic "Application of fuzzy logic in Boiler control" [11] Bao Gang Hu & George K I Mann, "A systematic study of Fuzzy PID controllers." P 699-712 [12] T P Blanchett. "PID gain scheduling using fuzzy logic"
- [10] Cheng Ling, "Experimental fuzzy gain scheduling techniques" [14] Energy Research center, Lehigh university, 610-758 4090
- [11] Storm RF and Reilly TJ Coal Fired Boiler performance improvement through Combustion optimization.
- [12] Ilamathi p, Selludurai v, Balamurugan k "Predictive modelling and optimization of power plant nitrogen oxides emission" IAES, 2012
- [13] Proceedings: "Workshop on Intelligent Soot Blowing Application" EPRI project Report, March 1999, TR- 111631
- [14] Proceedings, "Guidelines for Intelligent Soot blowing Control" EPRI "2000, TR- 1000410
- [15] Intelligent Sootblowing and Waterwall Temperature Monitoring- T. Ziegler, AmerenUEM, J. Dooley, A. G. Ferry and M. Daur
- [16] Benefits from Selective Sootblowing using Boiler Cleanliness Monitor Stan Piezuch, Black & Veatch,
- [17] Combustion and Sootblowing Optimization using Advanced Instrumentation, Control and Artificial Intelligence Techniques Mark A. Rhode,
- [18] Sootblowing Optimization-Nenad Sarunac and Carlos E. Romero
- [19] I&C Enhancements for Low NOx Boiler Operation-E Levy, T. Eldredge, C. Romero, and N. Sarunac
- [20] Expert system for Boiler efficiency deviations assessment I. Arauzo and C. Cortes
- [21] Advanced Technologies Provide New Insights for Assisting Energy from Waste (EfW) Boiler Combustion Monitoring, Operations and Maintenance Stephen G. Deduck, P.E. Covanta Energy, Inc

AUTHOR

Manoj Kumar received the B.Tech. Degree in electronics and communication engineering from Shaheed bhagat singh college of engineering and technology (SBSCET), ferozepur, in 2011 and pursuing M.Tech. (Part time) degree from Guru Kashi University (GKU), Talwandi Sabo in 2015 in electronics and communication engineering. He is currently with SEPCO1 (TSPL) as Senior engineer (Control & Instrumentation). His research interests include power plant measurement and control, Soft computing & data mining in power plants.



10.22214/IJRASET



45.98



IMPACT FACTOR:
7.129



IMPACT FACTOR:
7.429



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24*7 Support on Whatsapp)