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Prediction of Induced Draft Fan Power Consumption in Thermal Power Plant by using Fuzzy Logic

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Abstract

The coal fired power plants auxiliary power gulp a large amount (8-13 percent) of generated power here, the excessive auxiliary power by the improper management and usage due to the design and classical equipments of high power ratings, the power generation in a plant is not same/optimum over the day/period, It changes according to the load, so if the auxiliaries run at the maximum load there is a wastage of power during the period of minimum requirement of power. And also induced power fan (ID fan) generally consumes approximate 30-35% of the total power consumption of in house auxiliaries. So in this paper with the help of Fuzzy logic we are going to present a model where the auxiliary power varies simultaneously with the power generation.

Keywords: *Induced draft fan, Fuzzy logic, Regulation, Plant auxiliaries, Auxiliary power, Optimum power, Electrical drives, Power electronics devices*

INTRODUCTION

The power scenario of Indian electricity system is dominated by fossil fuels, which in 2017-18 produced about three fourths of all electrical power. The auxiliary power/parasitic power consumption (as shown in Table 1) in any thermal/coal fired power plant is around 8-13 percent of the total power generated at the full plant load. The in house auxiliaries like induced draft fans, air preheater, coal flow, primary air fans, forced draft fans, water pumps, electro static precipitators consumes a large amount of power, by using the appropriate techniques and methods and proper audit we can overcome/minimize the consumed excess auxiliary power. Power generation from different plant in India is shown in Figure 1.

Table 1:*The Consumed Excess Auxiliary Power.*

Installed capacity as on	**Thermal (MW)**				**Nuclear (MW)**	**Renewable (MW)**			**Total (MW)**
	Coal	Gas	Diesel	Subtotal		Hydro	Other renewable	Subtotal	
31-Mar-18	197,171	24,897	838	222,906	6,780	45,293	69,022	114,315	344,002

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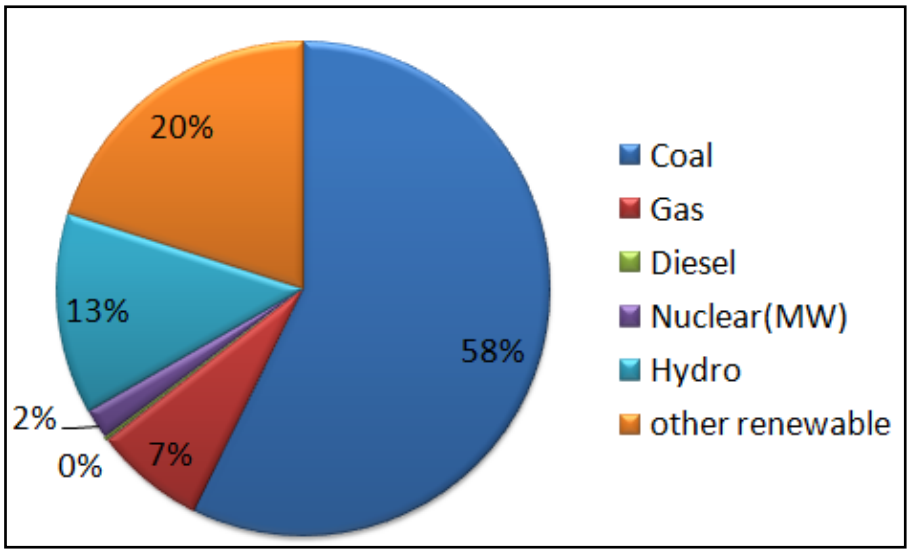

Figure 1:*Power Generation from Different Plant in India.*

REQUIREMENT AND BENEFITS OF AUXILIARY POWER CONSUMPTION REDUCTION

For minimizing the operational cost and fuel cost of any thermal plantwe need to overcome the extra or unnecessary excess powerthat generally consumed by the in house auxiliaries and particularly by the induced draft fan. For economic factor it must to be overcome in the reduction of in-house auxiliaries as well as Carbon-Di-Oxide (CO_2) and other harmful gases will decrease by the appropriate us of fuel.

The potential advantages of advancing assistant power utilization incorporate enhanced plant heat rate, decreased fuel cost and emanation and expanded net creating limit. Then again, diminishing certain helper burdens may conceivably build activity and support (O&M) costs and adversely influence unwavering quality. For instance, a 0.25% warmth rate enhancement at a run of the mill 500-MW unit working with a 90% limit factor can result in a fuel investment funds of more than $180,000 every year, and a decrease in CO2 emanations of 10,000 tons/year [3].

According to the size of the power plant auxiliary power also varies.Its range lies from 5.2% to 12.3% for differentsize of boilers starting from 30 MW units to 500 MW units at full load. The estimated auxiliary power used for running the coal-fired thermal power plants in India is about 11,340MW that shapes a normal of about 8.4% of coal based power plants and 4.9% of aggregate introduced limit. By decreasing the assistant intensity of coal-terminated stations in India by 1%, about 1350MW of intensity can be siphoned into the matrix that will diminish the CO2 outflow by10 million t/years. By diminishing the assistant power extra power will be accessible on the lattice. The plant stack factor of Indian coal-let go control plants had expanded from 55.3% (1991– 92) to 73.3% (2011– 12) and the relating explicit helper control had diminished from 9.46% to 8.47% [4].

Table 2:*Auxiliary Power Consumption Breakup.*

Equipment	Drive power % ofgross generation
Electrically driven boiler feed pump	2.50%
Draft fans and pulverizers	2.00%
Flue Gas Desulphurization unit (FGD)	1.50%
Other remaining auxiliaries	1.50%

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From Table 2, we can infer that the major part auxiliary power consumption takes place in the boiler feed pumps and the induced draft fans. In recent boilers supplied and commissioned all over the world, steam turbine driven boiler feed pumps have been employed. By employing the steam turbine driven pumps for boiler feeding the specific auxiliary power consumption have been reduced. However, in the case of induced draft fans energy conservation possibilities are still available. The retro fit of ID fans with Variable Speed Drives (VSD) will reduce generation costs by conserving auxiliary power [5].

Out of the auxiliaries mentioned earlier, this paperfocuses on ID fan power consumption. In this paper, the fuzzy logic has been used to predict of ID fan power consumption at the different operating conditions.Power plant utilities and operators can apply the methodology stated in this paper for predicting the auxiliary powerconsumed by induced draft fans.

SYSTEM DESCRIPTION IN BOILER

A. The Arrangement of ID Fan System

Figure 2 shows the arrangement of in-house auxiliaries and ID fan.In the capacity of 500MW plant generally two ID fans installed there for handling 50-60% flue gases separately, Normally Double suction radial fans which are capable of handling a large volume of fluid are employed for the induced draft system in 500MW across India. ID fans are selected based onthe flue gas quantity and draft required. Both the parameters are dependent on the coal quantity and ducting arrangement. Also during fan size selection, suitable design margins in head and volume shall be considered. These fans shall be driven byvariable frequency drive motor assembly. Usage of variable frequency drives motors saves a lot of power compared to hydraulic coupled drives at lower loads [1].

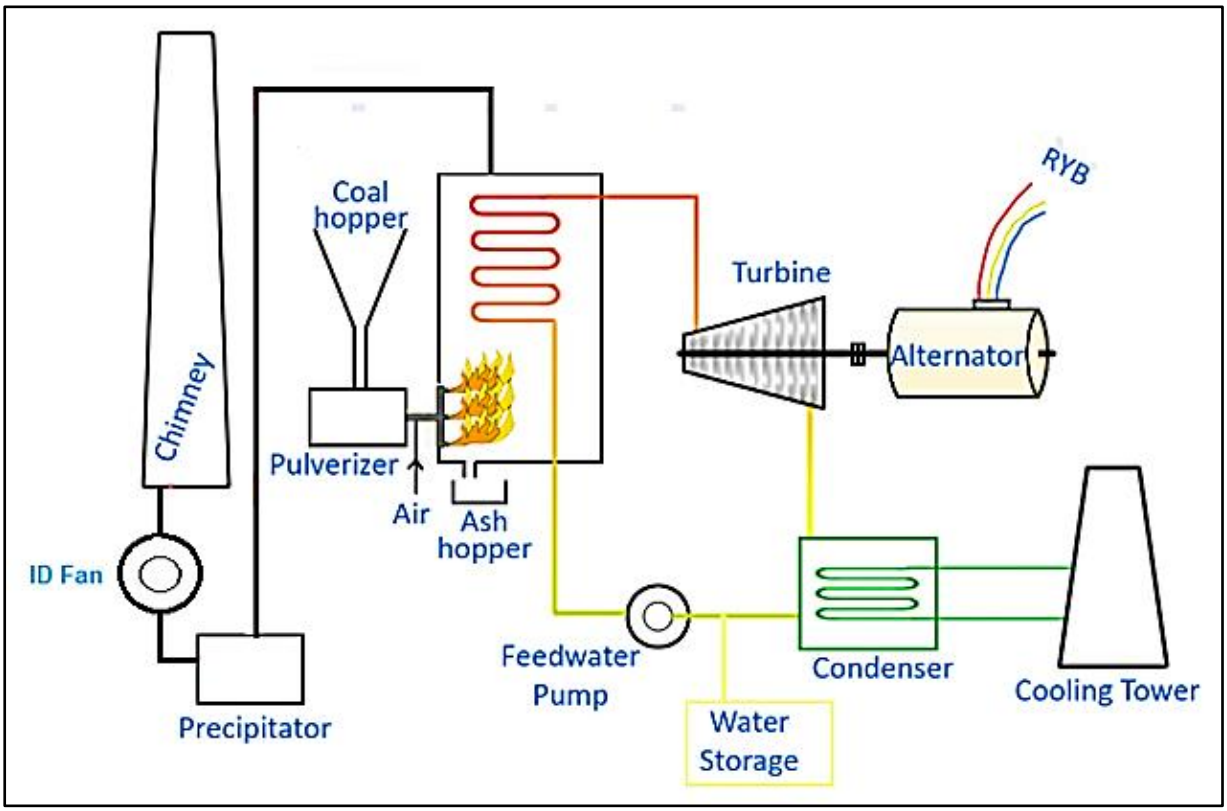

Figure 2:*Schematic View of ID Fan System.*

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B. Formation of Combustion Products

Raw coal from bunker shall be fed to the gravimetric feeders. The gravimetric feeders, in turn, shall feed the Bowl mills with the required amount of coal to boiler furnace. Primary air after getting heated by flue gas in the air preheater acts like drying medium for pulverised coal and transport the coal from mills to the Tangential fired burners. The fuel and combustion air will enter the furnace from four corners. From each corner's the fuel air mixture will enter at an angle, such that they are forming a tangent line to the imaginary fire ball at the center. Because of the tangential entry of fuel and air, a swirl movement of combustibles takes place and ensures proper mixing of fuel and air in the furnace [6].

The combustion of pulverized coal and primary air mixture with secondary air shall result in heat release and formation of hot flue gas. The hot flue gas that was formed after combustion of coal with air will be transported from the furnace to the chimney through the induced draft fan. The induced draft fan shall maintain a negative pressure in the furnace through air preheater and electrostatic precipitator. Because of the negative pressure, the flue gas will travel toward the ID fan through Air preheater and Electrostatic precipitator. After ID fan, the flue gas shall be released to the atmosphere through the chimney [1].

FUZZY LOGIC

Fluffy rationale was considered in the USA by Prof. L. A. Zadeh, in the mid-1960s. FL is a superset of customary (Boolean) rationale that has been stretched out to deal with the idea of halfway truth–truth esteems between "totally obvious" and "totally false".Fuzzy systems have been utilized in a wide assortment of utilizations in building, Science, business, drug, brain research, and different fields. A Fuzzy set is any set that allows its member to have a different grade of membership function in the interval of [0, 1]. There are several operations in Fuzzy set that can be performed likeFuzzy Intersection, Fuzzy Union, Fuzzy Compliment, Fuzzy Combination, and Fuzzy Concentration. The fuzzy theory has an important Membership Functions Shapes, It can be any real valued function, but in general normalized membership functions with values between 0 and 1, membership functions like-Triangular membership function, Trapezoidal fuzzy membership function, Gaussian or bell shaped membership function, Generalized membership function. In the atmosphere of the fuzzy logic operation is possible in MATLAB is either through tool box or using program commonly knowing as coding.The Fuzzy Logic Toolbox library contains the Fuzzy Logic Controller and Fuzzy Logic Controller with Rule Viewer squares. It additionally incorporates a Membership Functions sub-library that contains Simulink obstructs for the inherent participation capacities.In this paper proposed work (composition) has executed here with help of Fuzzy logic and MATLAB.

SITE DATA COLLECTION

The data of the running time is collected here from 5 power plants of India at the time of full load condition. Here is the average data of all the day.Thecollected data were used in the ID fan power consumptionprediction analysis. Steam generator operation parameters andcoal analysis data have been collected. The ID fan datacollected and their range have been furnished in Table 3.

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Table 3:*Input and Output Parameters in Fuzzy Environment.*

Sr. No.	Parameters	Type of Parameter	Minimum Value	Maximum Value
1	Air pre-heater leakage	Input	4.31	28.19
2	Air heater pressure drop across flue gas side	Input	28	214
3	Coal flow	Input	40	444
4	Total air flow(Primary air + Secondary air)	Input	350	1962
5	Operating unit heat rate	Input	1921	3024
6	Id fan operating head (delivery + suction)	Input	28	214
7	Induced Draft fan power consumption	Output	2045	4895

Table 3 shows the various operationalParametersidentified for data collection. The minimum andmaximum values of the parameters are also mentioned there some of the parameters like ID fan operating head, Fuel Ratio (FC/VM), Air preheater leakage, Excess air percentage, ID fan operating head: The important parameter that determines the ID fan power consumption is the total operating head developed by ID fans. The total head can be calculated by summing up the suction head and delivery head of ID fan. [5]. Input and Output parameters with different intermediate values with Mamdani method shown in Table 4.

ID fan operating head: The important parameter that determines the ID fan power consumption is the total Operating head developed by ID fans. The total head can be calculated by summing up the suction head and delivery head of ID fan.$O_{2(\text{APH outlet})}$

Air preheater leakage: Air preheater leakage can be calculated indirectly from dry O_2 % at economizer outlet and O_2 % at Air preheater outlet using the below formula [6]:

$$\text{APH leakage (\%)} = \frac{[\text{O2(APH outlet)} - \text{O2(APH inlet)}]}{[21 \text{ inlette he below}}$$

Table 4:*Input and Output Parameters with Different Intermediate Values with Mamdani Method.*

Sr. No.	Parameters	Type of Parameter	Very much low	Very low	Low	Medium	High	Very high
1	Air pre-heater leakage	Input	6.57	10.89	15.21	19.53	23.85	28.17
2	Air heater pressure drop across flue gas side	Input	75	103	131	159	187	215
3	Coal flow	Input	244	284	324	364	404	444
4	Total air flow(Primary air + Secondary air)	Input	1612	1682	1752	1822	1892	1962
5	Operating unit heat rate	Input	1924	2144	2364	2584	2804	3024
6	Id fan operating head (delivery + suction)	Input	211	241	271	301	331	361
7	Induced fan power consumption	Output	2045	2615	3185	3755	4325	4895

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FUZZY LOGIC MODEL WITH TRIANGULAR MEMBERSHIP FUNCTION, INPUT OUTPUT ANALYSIS

The fuzzy logic uses Mamdani method algorithm for training the system. This algorithm is very fast and easy in nature gives the result in less time. Figure 3 shows its input variables with triangular membership function; Figure 4 shows the performance details and output variables in triangular form, Figure 5 shows all the output results in the consolidated form in the result window.

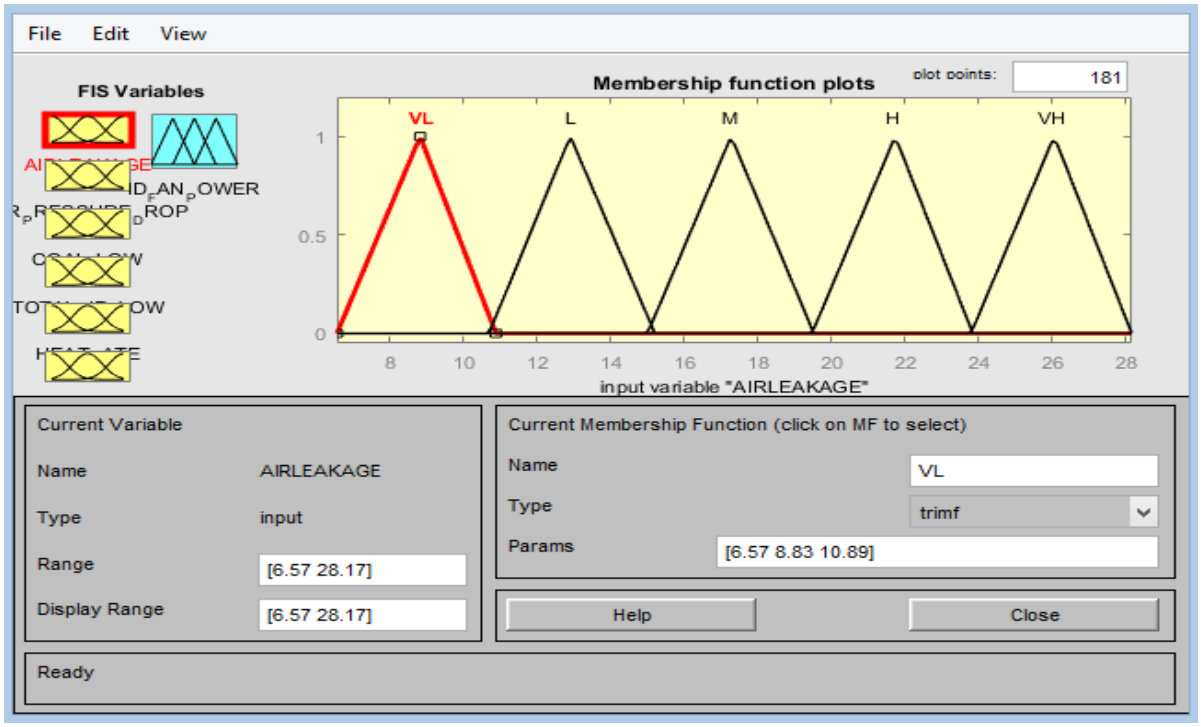

Figure 3:*Input Variable.*

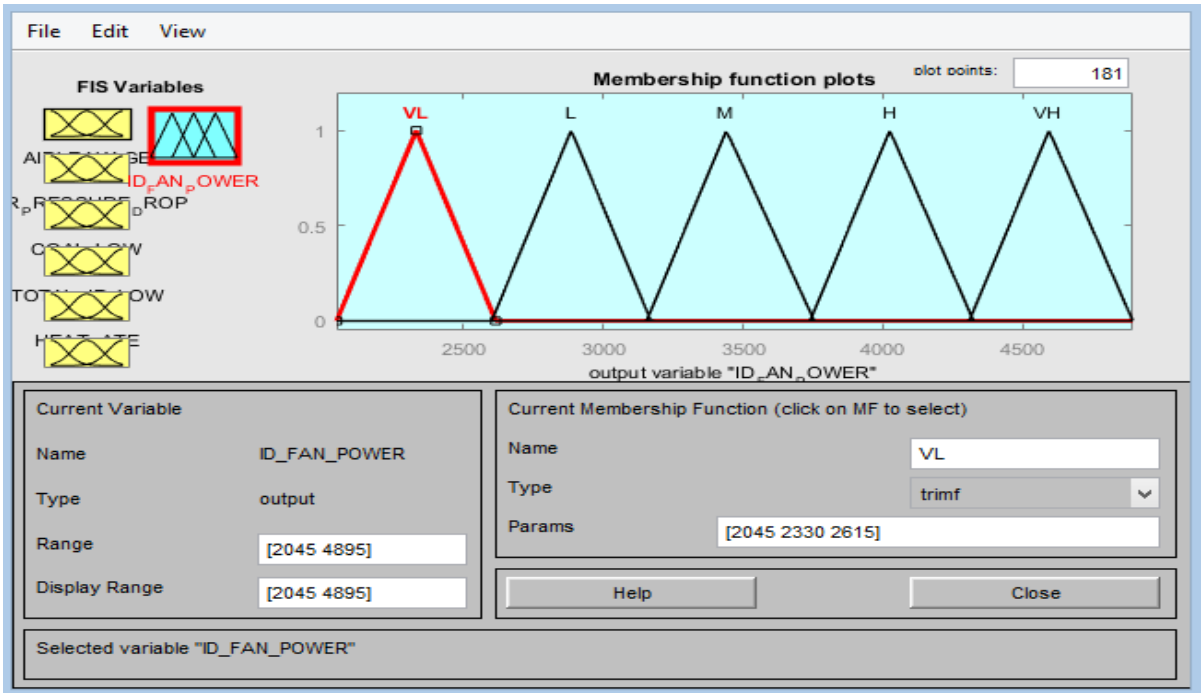

Figure 4:*Output Variable.*

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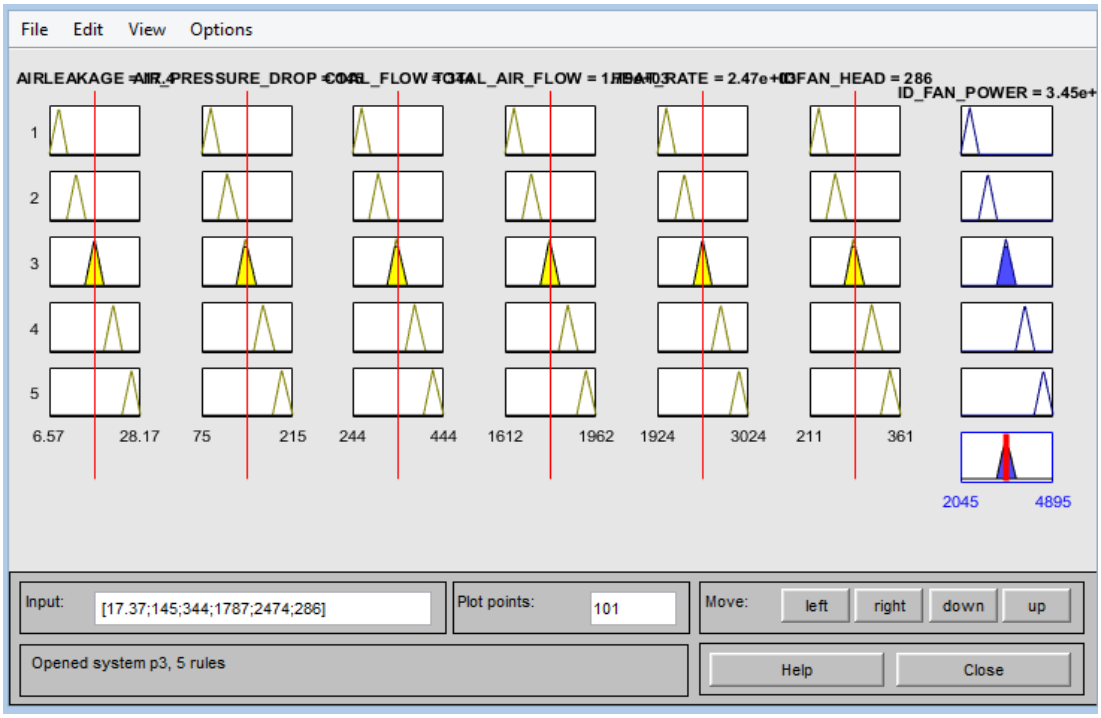

Figure 5: *Result Window.*

CONCLUSION

In this paper, Fuzzy rationale forecast demonstrate has been utilized for foreseeing the power utilization of Induced draft fan control utilization in power plants.In a thermal power plant the output power of auxiliaries and ID fan plays a very important role in operational conditions of power plant and steam generation. And the requirement of power for all the auxiliaries and ID fan is reliant on the working and other situations which mentioned in the paper but by proper estimation of required energy we can minimize the required amount of energy and also we can improve the performance and the efficiency of the thermal power plant.

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