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The Performance of Differential Pressure (DP) and Inlet Temperature by Using Fabric Filter at Coal-Fired Power Station

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Kata kunci:

Perbedaan tekanan;
Temperatur masuk;
Fabrikasi filter

ABSTRAK

Artikel ini menyajikan kinerja tekanan diferensial (DP) dan temperatur masuk dengan menggunakan filter kain pada Pembangkit Listrik Tenaga Batubara. Filter kain adalah salah satu metode ramah lingkungan yang populer digunakan di industri untuk menampung dan menyaring gas buang yang mengandung abu terbang, yang dihasilkan dari pembakaran batu bara bubuk di dalam tungku *boiler*. Penelitian ini berfokus pada analisis pembacaan tekanan diferensial dan temperatur *inlet* serta menentukan kondisi filter kain. Evaluasi dari hasil ini adalah dengan mempertahankan tekanan diferensial pada 14 - 18 mbar dan temperatur *inlet* pada 130 0C. Kinerja dari *fabric* filter akan di analisa dengan menggunakan laporan *monitoring* kinerja berdasarkan laporan inspeksi *walkdown* harian dan laporan jadwal kalibrasi. Berdasarkan hasil laporan tersebut membuktikan bahwa kinerja *fabric* filter dalam kondisi memuaskan dan memenuhi persyaratan DOE, di mana gas buang dalam pengamatan 30 menit hanya mengandung 150mg/m3 abu. Perlindungan sistem memastikan filter kain dalam kondisi optimal.

Keyword:

Differential pressure,
Inlet temperature,
Fabric Filter

ABSTRACT

This paper presents the performance of differential pressure (DP) and inlet temperature by using fabric filter at Coal-Fired Power Station. A fabric filter is one of eco-friendly methods that popular application in the industry to cater and filter the flue gas that contained fly ashes, that been produced by combustion of pulverized coal inside the boiler furnace. This study focuses on analyse the reading of differential pressure and inlet temperature and determining condition of fabric filter. The evaluation of this result is to maintain the differential pressure at 14 – 18 mbar and inlet temperature at 130 0C. The performance of the fabric filter will be analysed using the monitoring report performance based on daily walkdown inspection and calibration schedule report. Based on the report results prove that the performance of fabric filter is in satisfactory condition and met with DOE requirements, which the flue gas within in 30 minutes observation only contain 150mg/m3 of ash. The protection of the system ensures the fabric filter in optimum condition.

1. INTRODUCTION

The most significant causes of air pollution worldwide are coal-fired power stations, which produce significant amounts of flue gas pollutants [10]. In order to lessen the effects of the pollutants produced during coal combustion, air pollution control devices (APCDs) have been installed in numerous coal-fired power plants [12]. Due to the rising prevalence of respiratory ailments, air pollution has received a lot of attention lately. Volatile organic compounds (VOCs) have more negative effects on the environment and human health than other major air pollutants (such as SOx, NOx, and small particles) [17]. To separate dust particles from polluted gas, dust collection systems are used. The beg filter, in particular, is widely used in a variety of industrial fields [14]. In a fabric filter, particulate matter is gathered on the fabric after flue gas passes through a felted or woven cloth. Fabric filters are commonly referred to as baghouses since cylindrical bags are the most prevalent variety.

A bag house is made up of several vertically hung tubular bags. The collected fly ash is then transported to hoppers where it is stored and routinely cleaned [4]. The Coal-Fired Power Station has generated electricity by using pulverized coal. From the combustion of the pulverized coal the ash is produce. The plant uses low NOx burners and desulphurization facility to keep NOx and Sox emissions low. The plant uses Fabric filter to capture fly ash dust from the flue gas. In 2007, the WHO projected that air pollution in India results in 500,000 fatalities annually. At 1.65Gt annually, India was the third-largest emitter of carbon dioxide, a significant greenhouse gas [11]. An air pollution control tool that assists in removing particulates from gas or air generated during combustion is a fabric filter [6] . Fabric filters are constantly and closed monitored by unit operators and especially by Ash Unit operators. Parameters such differential pressure (DP) and flue gas inlet temperature are supervised by Ash Operators and engineers through daily site visits and checking.

The Fabric Filter, a particulate removal system, which are positioned between the induced draught (ID) fans' inlet and air heater exhaust. Optimizing filter sizing, total flue gas flow rate, and air-to-cloth ratio results in the number of compartments. The Fabric filter plant unit is equipped with the following functional components:

i. Two identical multi compartment pulse jet fabric filter casings with inlet and outlet plenum.
ii. Hoppers including heaters and level sensors and pre-coating nozzles, hopper vibrator and fluidization pads.
iii. Fabric filter compartment inlet dampers, outlet dampers
iv. Bypass dampers with seal air system.
v. Filter bags (PPS bags) and cages.
vi. Walk-in plenum to allow access to the tube sheet for inspection and maintenance.
vii. Weather enclosure with ventilation system.
viii. Compressed air pulse cleaning system, including compressed air headers, Optipow Valves and controls and Pulse Pipes.
ix. Walk-in Plenum ventilation system for maintenance

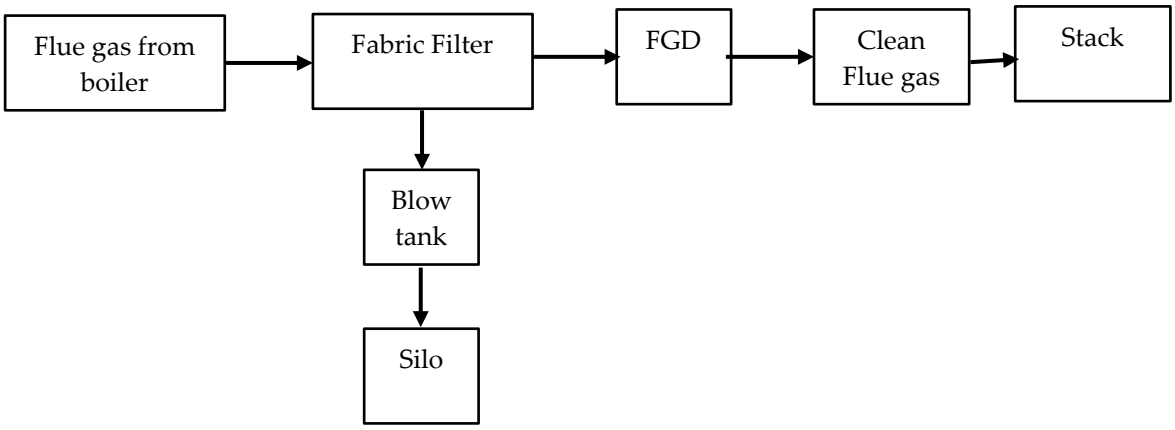


Figure 1 : The Process of Fabric Filter

Figure 1 refers to the process of fabric filtering. Flue gas from the boiler will be removed by using an induced draught fan (ID Fan). Fabric filters trap the fly ash. At certain times, air from the pulse jet will purge the fabric to remove the ash from the bag filter. The ash drops into the hopper and goes to the blow tank. In the blow tank, the heater will be used to make sure the fly ash is always dry. Lastly, the fly ash from the blow tank will go to the silo and the ash will be collected by the construction supplier.

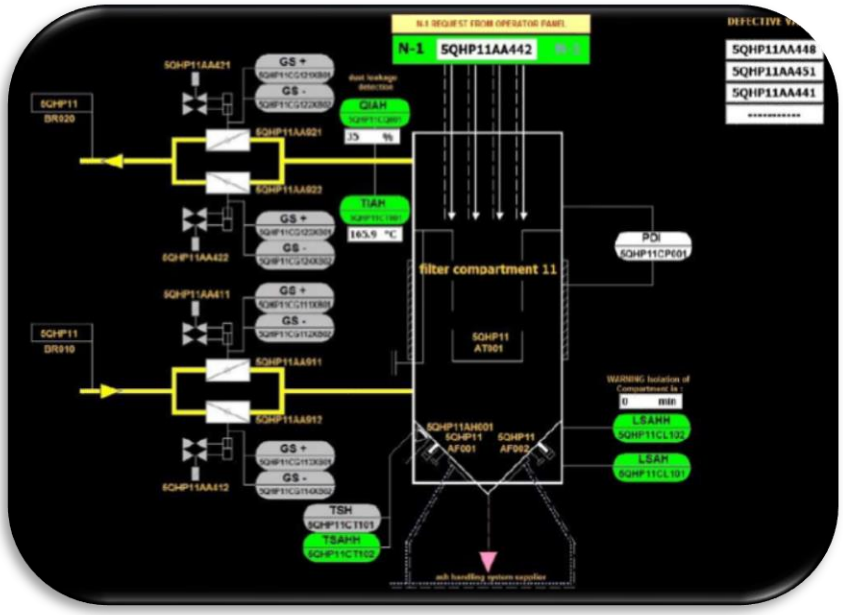


Figure 2 : The Layout of Fabric Filter

Figure 2 refers to the layout of the Fabric Filter. The legend of yellow DR010 is the inlet flue gas from the boiler and controller by solenoid valve. The flue gas goes through to the filter compartment. In the filter compartment, there are around 1000 bags filtered to filter the ash. At a certain time, set by set points of time, the vibrator will vibrate and the ash in the fabric filter will fall into the hopper. The clean flue gas will go out to the DR020.

In line with promoting green harmonious environment, coal-fired power station is designed with full compliance to the local as well as international World Bank environmental requirements, the emission statistic of which compared as follow:

Table 1. Emissions Standard (mg/Nm^3) [5]

Aspects	Parameters
Particulate	400
Sulphur Oxide	3500
Nitrogen Oxide	1700
Ash	150

2. MATERIALS AND METHODS

2.1 Description of bag filter

The Fabric Filter Model been designed to cater and filter the flue gas that contained fly ashes, that been produced by the combustion of pulverized coal inside the boiler furnace. It is important to have a reliable Bag Filter system to ensure that the emission from the chimney been properly filtered before being released to the environment. Below are the details about Beg filter system that design :

Table 2. Fabric Filter General Information [1]

Aspects	Parameters
Fabric Filter Model	2 MEGA 2*5-1200-10
Number of Filter Casings	2
Number of compartments per filter casing	10
Number of compartments which can be down for normal operation of the system	1 in 20
Number of bags per compartment	1200
Bag dimensions (Nominal)	127 mm dia x 10 m long
Number of valves per compartment	40
Valve Type and Size	Optipow 135

Each bag filter has 1200 compartment houses and fitted in the cage suspended from tube sheets with 2 bag nests per compartment. There are 30 bags per valve row and the arrangement are in parallel and staggered. The Bag filter also using the coated to protect durability of the bag filter. Usually, the durability of Bag Filter is within 5 years to maintain the effectiveness of the filter. Each utility or facility has its own concept regarding total bag replacement, which is typically based on highly important factors decreasing pressure or increasing the failure rate [13].

On all types of boilers, pressure decreases are lower for the Pulse Jet type than for the reverse-gas with sonic assistance (RG/S) and shake-and-deflate (S/D) baghouses. Compared to RG/S and S/D baghouses, PJFFs can thus be sized and run at larger air-to-cloth ratios [15].

2.2 Pulse Jet Cleaning system

Pulse jet cleaning system comprises of pulses valves, pulse air manifold tanks, pulse pipes and pulsing nozzles. There are 2 manifold tanks per compartment and 20 solenoid operated pulse valves per manifold tank. Every time 1 pulse generated from pulse valve, it will go through pulse pipe which equipped with 30 nozzles. Thus, 1 row of 30 bags cleaned in one pulse.

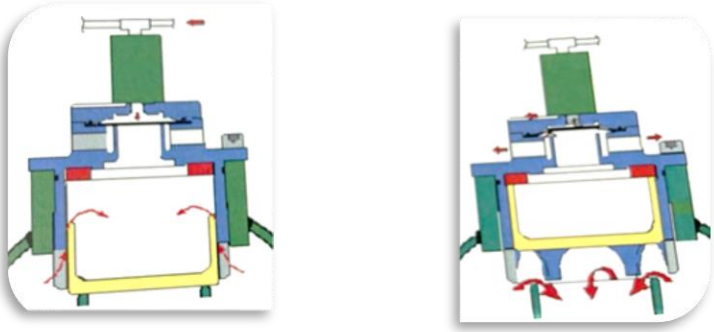


Figure 3. (a) Compressed Air Flows (b) Compressed Air released from valve [1]

Pressure gauge is used to monitor and display pressure at manifold tank. Pressure range for pressure gauge is 0- 5 bar(g) but minimum required pressure is 2.5 bar(g) and never to exceed 4.3 bar(g). If the pressures greater than 4.3 bar(g) can cause mechanical failure of filter bags and then an alarm will be generated as shown in Figure 4**.**

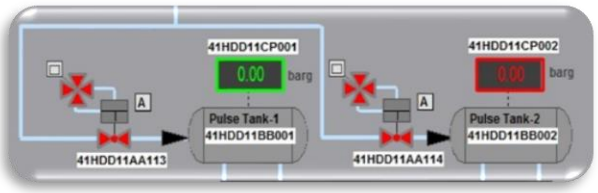
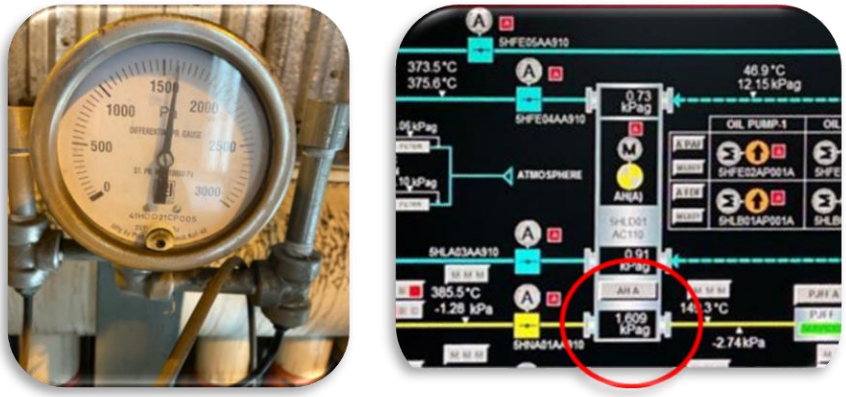


Figure 4. Pressure gauge display from control system [1]

2.3 Differential Pressure (DP) And Inlet Temperature

A differential pressure transmitter (DP) is the difference in pressure measurement between two points in a system. In the fabric filter system, the function of the differential pressure is to measure the inlet and outlet pressure, then compress the air pressure. The control system monitors the differential pressure across the fabric filter with the help of two pressure transmitters located upstream and downstream of the filter as shown in Figure 5.



(a) **(b)**

Figure 5: (a) Differential Pressure gauge (b) Differential Pressure control system [1]

Every time air moves through the filter, it creates resistance between the dirty part of the filter and the clean part. The greater the accumulation of dust on the filter, the higher the resistance to air flowing through the system. Readings for differential pressure values can be monitored and displayed through the Differential Pressure Gauge and through the control system as shown in Figure 5.

The fabric filter differential pressure (DP) has three (3) set points that are used for interlocking and/or generating alarms:

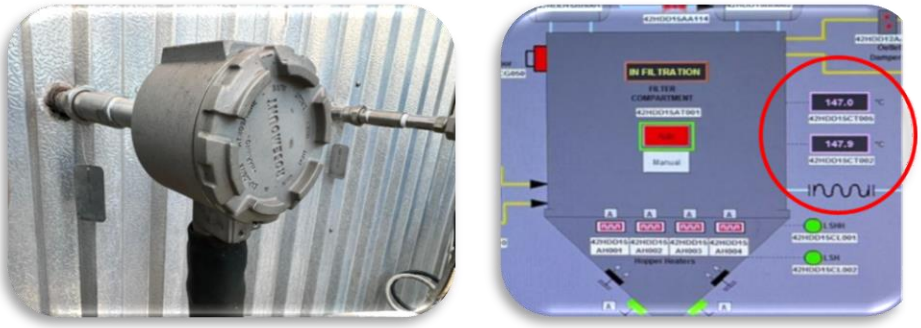
i. HIGH-HIGH DP level.
This set point activates an alarm that indicates that the differential pressure is too high, which the DP cannot more than 18mbar. If the pressure more than the limit it shows the performance of the fabric filter is decrease. The operator will need reduce the boiler load, as needed. Meanwhile manual checking is also essential to investigate the actual problem.

ii. DP value higher than DP Set Point / DP Dynamic will activate the normal cleaning cycle.

iii. DP value higher than DP High Set Point will activate the accelerated cleaning cycle, with a shorter valve interval timer to reduce the DP faster.

iv. DP value lower than DP High Set Point / DP Dynamic will de-activate the cleaning cycle.

Then, to measure the inlet temperature it uses a temperature sensor. A temperature sensor Resistance Temperature Differential (RTD) is used as protection for the filter bag as shown in Figure 4 which is in the inlet duct for each compartment fabric filter. This means that the filter must handle all the specified temperatures coming from the boiler during normal operating conditions. According to the specification, the filter bag is designed to operate at a flue gas inlet temperature of 140°C continuously and should be suitable for a maximum excursion temperature of 180°C, with a peak temperature limit that should occur twice a day. Therefore, temperature data will be taken once an hour. Since the flue gas is already at standard condition temperature, ordinary fly ash can be used for pre-coating. If from the measurements, we find that any one of the temperatures at the inlet of a specific filter is outside the acceptable range then the relevant filter will be put in bypass mode till normalcy is restored for the line. The reading of the temperature inlet value can be monitored and displayed through the control system as shown in Figure 6 which is detected by temperature sensor.



(a) **(b)**

Figure 6. (a) Temperature sensor (b) Reading of temperature inlet value [1]

2.4 Conduct of performance monitoring

There are many initiatives that can be taken to improve the performance monitoring of Bag filter systems. Performance monitoring for this bag filter system has been implemented by updating the Bag Filter status for each shift which is three times a day for every 8 hours. In addition, daily visual inspection is performed to check bag filter system parameters and filter bag samples are also taken out during outages to analyze bag and system conditions. Besides that, Proper inspection and maintenance is also doing, in case of high emission peaks or broken bag alarms will ensure desired filter bag life and fabric filter performance. Alarms will be raised to alert the operator of any abnormal operating scenario in the fabric filter system.

3. RESULTS AND DISCUSSION

3.1 Performance Monitoring Report Results for Differential Pressure (DP)

The graph in Figure 7(a) and 7(b) shown the reading for FF1 Different Pressure (DP) in mbar from November and December. All the readings taken are average reading extracted from hourly reading taken for 1 day. From the Figure 7(a), it is observed the DP reading on 25 th November dropped to 5mbar due to unit tripped. DP for the month of December as shown in Figure 7(b) dropped to 0 mbar due to planned unit outage (5 days). DP increased back the 28th during unit light up. DP on the 1st December showed a low DP as unit was tripped on 30th November and maintained a low load until 4th of December. The less dense compressed air in low-pressure filters is anticipated to result in a higher axial velocity in the purge tube and a consequent increase in jet misalignment [2]. If the pressure drops, one of the critical parameters of the filter media, is extremely high, the energy consumption of the dust removal system is directly increased [16]. The ideal reading for the DP is between 15 mbar and 18 mbar. If the reading is higher than set points, the indicator will show that the filter bag is clogged with ash. This can happen if the temperature of the inlet is decreased. This phenomenon can make the ash become sludge and get stuck in the filter bag. So, when this happens, the pressure between the inlet and outlet can be different. Besides that, the reading shows the DP pressure drop during the unit shutdown or outages, because the fabric filter can only turn on when the plant is operating at full load. During the plant light up, the fabric filter will turn off and all the flue gas from the combustion process will pass through the fabric filter and go directly to the stack/chimney. If the reading of DP is low, it shows there is a plugged differential transmitter line or improper output from the DP transmitter. So, to solve this problem, disconnect both lines at the differential pressure transmitter and blow them out with compressed air. This will calibrate the instrument. In conclusion, if the fabric filter cannot maintain the value of DP, the performance of trapping the ash from flue gas will decrease and it will be affected by the particle dust going out of the stack/chimney. Besides that, it also can give the effect of lifetime of the filter bag.

Table 3. Differential Pressure Reading (mbar) between November 2021 until February 2022

	November	December	January	February
1	15.8	9	13	18
2	16	10.5	15.5	18.4
3	15	12.5	15.8	16.1
4	15.5	14.5	15.5	8
5	16	15.8	15	15.8
6	16.2	15.8	13.5	16.5
7	16.2	15	13.8	18
8	16	15	15.8	21
9	16.2	14.5	15.5	18
10	15.8	14	16	18.2
11	15.8	14.5	16.5	15.8
12	16	14.5	15.8	17.7
13	16	14.5	14.2	17.8
14	16	14	14.5	18
15	15.5	15	16	15.8
16	16	14.5	16	14.2
17	16.5	14.5	17.8	13.6
18	16.5	16	18.2	13
19	16	10	18.5	15.8
20	15.8	16.5	17	17.6
21	16	16	15.8	17.8
22	16	15	16.5	18
23	16.2	6	9	17.9
24	15	0	16.5	17.5
25	6	0	16.3	16.2
26	12	0	16.1	17
27	15	0	15.5	16.2
28	15.8	4	15	17.2
29	15.8	8.5	16.5	
30	15.8	9	17	
31		10	16.5	

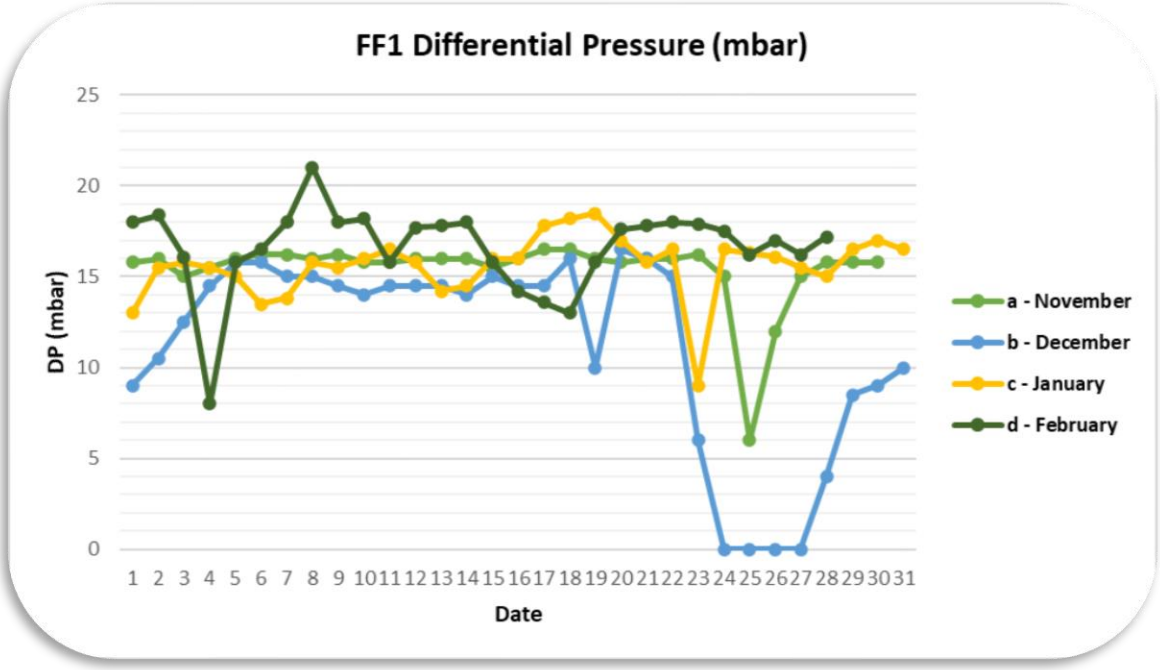


Figure 7. FF1 Differential Pressure Reading from November 2021 until February

The graphs shown in Figure 7(c) and 7(d) are the DP for the month of January and February. For January, DP observed are between 13 to 19 mbar (due to coal changes). DP dropped to 9 mbar due to unit tripped on 23rd January. For the month of February, once again unit tripped on the 4th of February contributing to the DP dropped. The DP reading on 8th February was up to 21 mbar due to coal change. Typically, the pressure drop across a filter bag increases with dust loading, resulting in a lower gas flow rate. To compensate for the decrease in gas flow rate, an induced draught fan controlled by an inverter and a pitot tube were used. [7]. Besides that, the types of coal also give the effect to the pressure reading. When dust collects on the filter media, which is cleaned on a regular basis by the pulse jet, the pressure drops across the filter increases. High pressure drop can also cause shorter bag life due to the additional cleaning cycles that the fabric must withstand [9]. As a result, the pressure drops due to dust collection increases with operation time until the next cleaning operation, and then drops dramatically when the pulse jet is injected. This operation cycle is repeated. Because the cleaning operation removes almost all the dust accumulated on the filter media but does not adequately remove the dust within the filter media, repeating the cleaning operation increases the amount of dust remaining inside the filter media and the residual pressure drop (minimum pressure drop in one cycle) [8].

3.2 Performance Monitoring Report Results for Inlet Temperature

On the 25th November, unit tripped and that resulted in temperature dropped to 112.5°C. For the inlet temperature in December, as in Figure 8, temperature dropped on 23rd December due to Planned outage. The low inlet temperature of the fabric filter had a significant promotional effect on the simultaneous removal of dust, NOx, and SOx gases. The smaller particle size of fly ash can aid in the adsorption of hazardous trace elements [3].

Table 4. Inlet Temperature Reading (degree) between November 2021 until February 2022

	November	December	January	February
1	131	130	126	132
2	132	125	128	131
3	130	130	127	130
4	131	135	129	120
5	130	137	128	133
6	130	136	129	132
7	131	135	130	131
8	131	136	129	130
9	132	135	130	132
10	131	134	129	131
11	130	137	128	130
12	131	136	127	132
13	131	137	126	133
14	132	137	127	131
15	131	135	129	130
16	131	134	130	128
17	130	134	131	129
18	130	136	132	129
19	131	120	133	130
20	132	130	130	131
21	133	135	131	132
22	132	130	131	133
23	131	70	120	134
24	131	32	132	130
25	112.5	30	133	131
26	127	28	130	130
27	129	40	130	131
28	130	98	129	132
29	127	130	132	
30	126	128	133	
31		129	130	

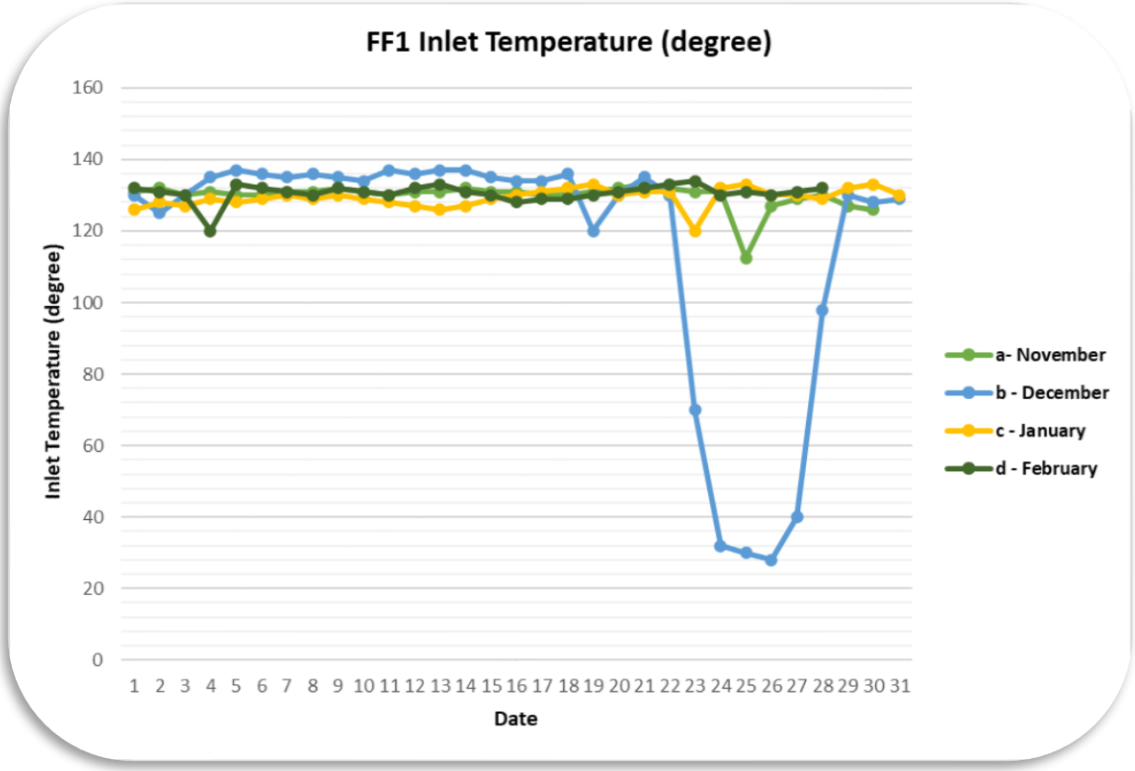


Figure 8. FF1 Inlet Temperature Reading from November 2021 until February 2022

For the month of January and February, inlet temperature readings stable in between 126°C to 134°C. However, month of January recorded a tripping on the 23rd and February on the 4th which shows a dip in both graphs above. Temperature was back to normal average reading after unit is back in service. The readings of inlet temperature are constantly to 130^{0}C to maintain the durability of the bag filter. If the temperature is more than 140^{0}C the bag filter can be burn out and if the temperature less than 120^{0}C, the ash or molecules will trap and stuck at the bag filter. To avoid damages of the filter media bypass will automatically open if a maximum inlet temperature of 162°C has been exceeded longer than 30 minutes or equal 180°C and clean gas and raw gas dampers will be closed simultaneously, shortly after limit switches of the bypass dampers have reached open position. Together with opening the bypass pulse jet damper both pneumatic valves upstream and downstream the sealing gas blower will be closed simultaneously, and the active sealing gas blower will be shut off to avoid contamination of the sealing gas system.

4. CONCLUSION

In this paper, the performance of differential pressure and inlet temperature of fabric filter has been presented and it is dependent upon on design, types of coal and material of fabric filter. Thus, to ensure the performance of fabric filter is good, the reading of differential pressure need between 14 – 18 mbar and inlet temperature at 130^{0}C. If the differential pressure more than 18 mbar the effectiveness of the fabric filter will decrease and if the temperature more or less than 130^{0}C, it will be affected to durability of the bag filter. Besides that, the differential pressure and inlet temperature of the bag filter system is in parallel with the shutdown of the unit as shown in the graphs for the monitoring result.

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