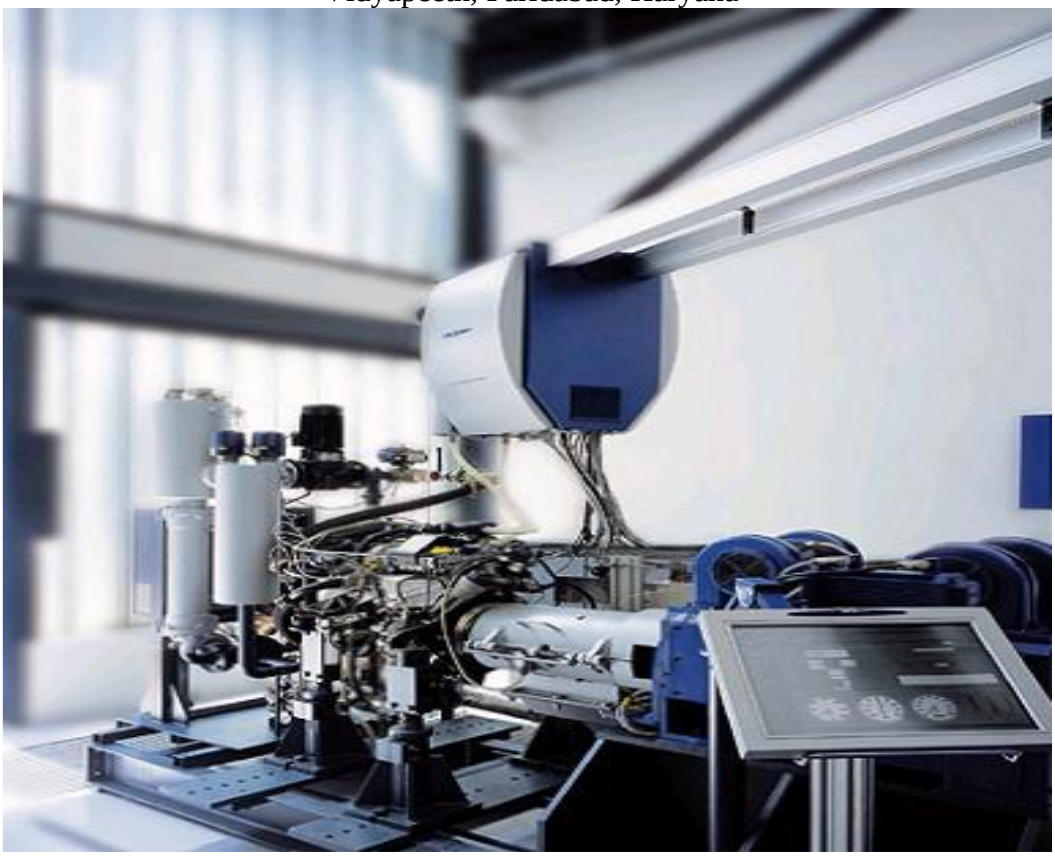
Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024

INTELLIGENT ENERGY MANAGEMENT SYSTEM FOR CONTROL OF AIRWASHER FLOW BY CLOSED LOOP VFD SYSTEM

Mr. Yasin Tirkey Mr. Abhishek B. Tech - Mechanical Enginnering (Evening) Lingayas's Vidyapeeth, Faridabad, Haryana - 121002
Mr. D.K Bhalla- Professor and LEET coordinator B.Tech, M.Tech, PhD, FIE in Lingaya's Vidyapeeth, Faridabad, Haryana



1.1 Introduction

In consideration to the proposal, this document covers the modifications of the air washer and its accessories in the test bench area with respect to energy efficient and energy saving.

1.2 Existing System Description

The existing system consists of an air washer which is manually/semi- automatic operated having capacity of 4200 CMH (Cubic Meters per Hour). The air washer equipped with a blower having flow capacity of 42000 m^3/hr attched with Seimens motor of 15 Kw motor (VFD: non suitable).
Equally distributed air flow through the air-washer via. 12 nos. of ducting for testing of 9 Kw (Heat rejection capacity) engine test benches.
Minor factors have been considered for energy saving, such as idle/stop during lunch time, tea break and shift change.

1.3 Proposed System Modification

This document outlines modifications to the existing system in respect of human comfort and energy savings.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024

1.4 Design Considerations

(a) Heat load Calculation

Descriptions	Value	Unit
Total Load of on bench	9	kW
Total no. of Benches	12	Nos.
Additional load	12	Kw
Total Load of Test Bench area	**120**	**Kw**

(b) Ventilation System Details:

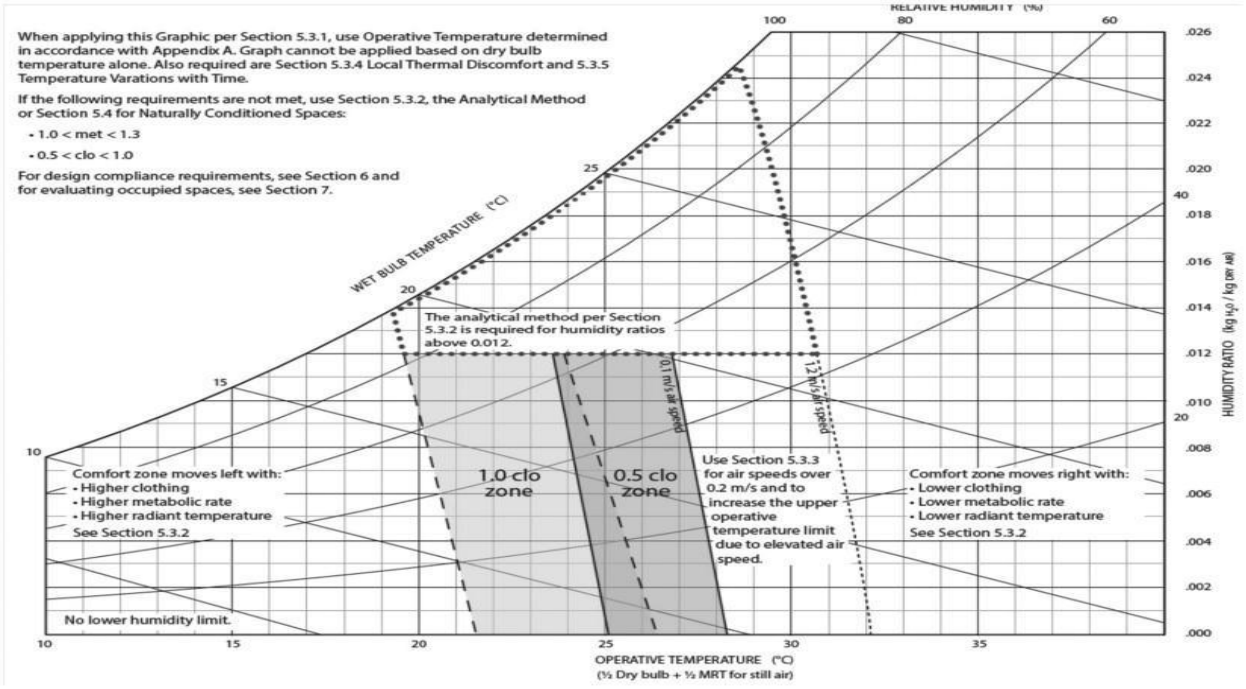
Descriptions	Value	Unit
Existing System		
Air washer capacity	42000	CMH
Type of operation	Constant Speed & Adiabatic Process	
Motor	15	Kw
VFD compatibility	NA	
Proposed System		
Air washer capacity	42000	CMH
Type of operation	Variable Speed & Adiabatic as well as non-adiabatic process	
Motor	15	
VFD compatibility	Yes	

(c) Operation Requirements:

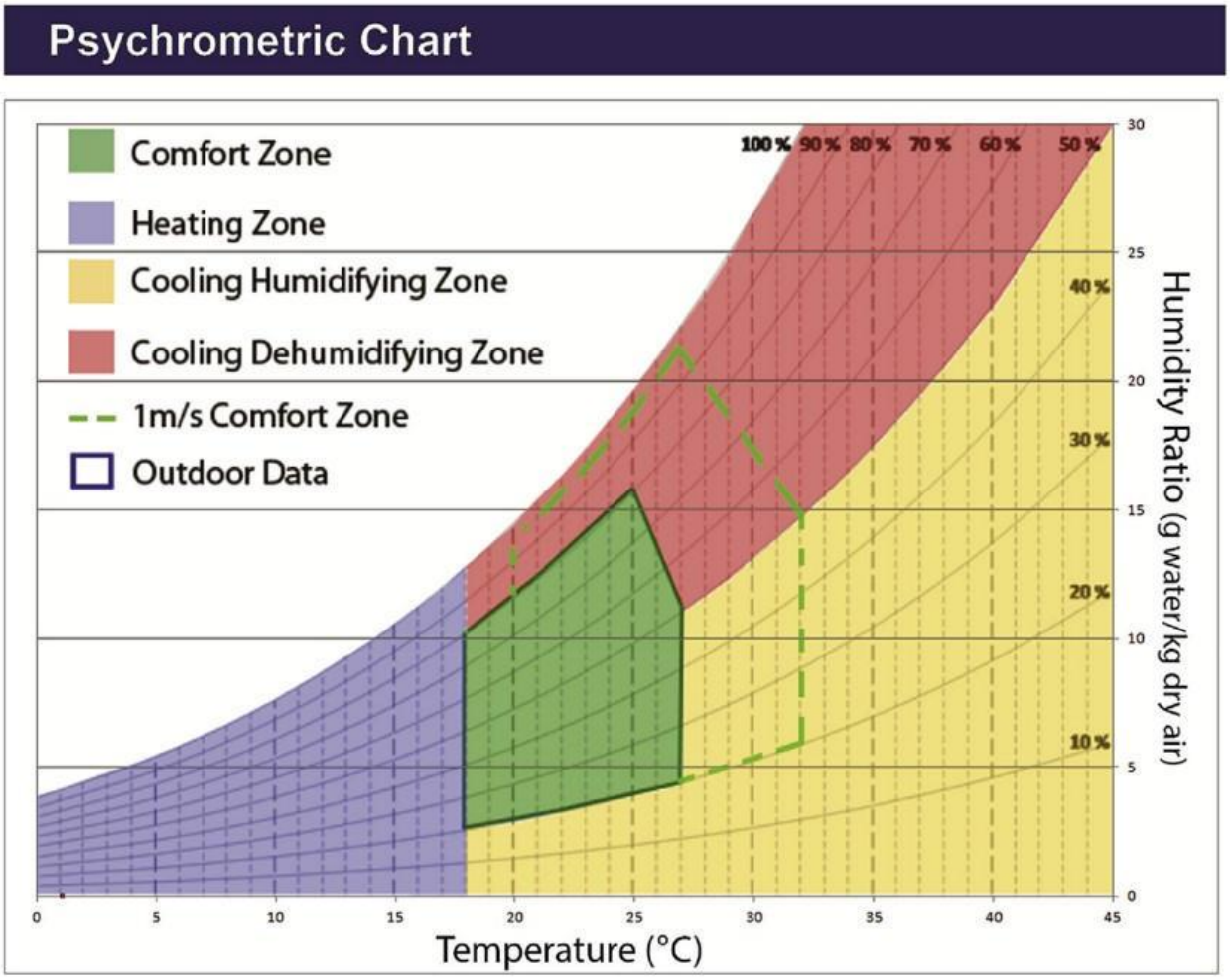
1. The Air washer system will not be operational for the ambient temperature <18 °C.
2. The Relative Humidity range in the area will be 20% to 90%.
3. The operation period will be from mid February to mid November.

1.5 Design Considerations (Standards)

As per ASHRE (American Society for Heating Refrigeration and Air Conditioning Engineers)



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024



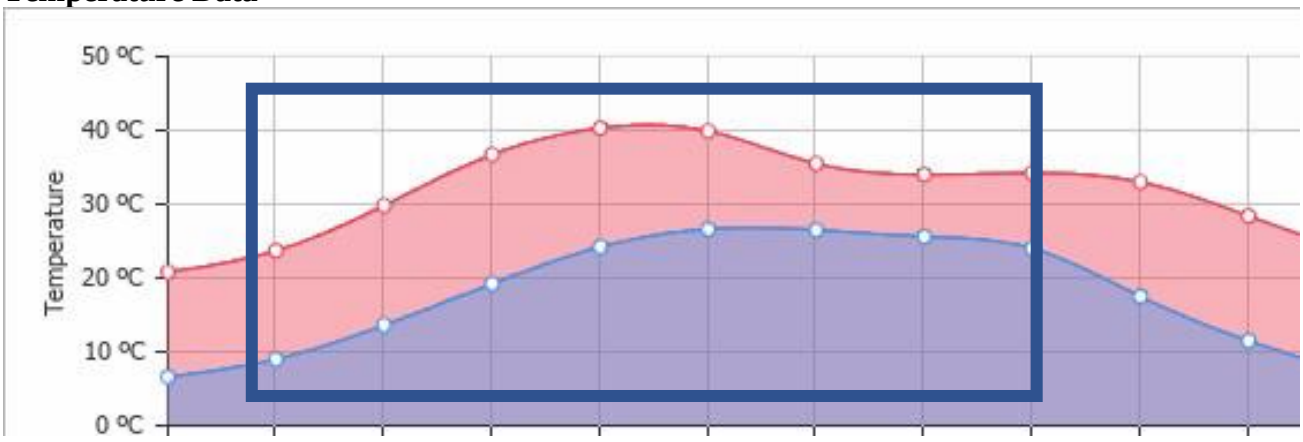
As

Considering the above paramenters for human comfort Zone, the supply air temperature and humidity range is defined.

Outer Weather condition

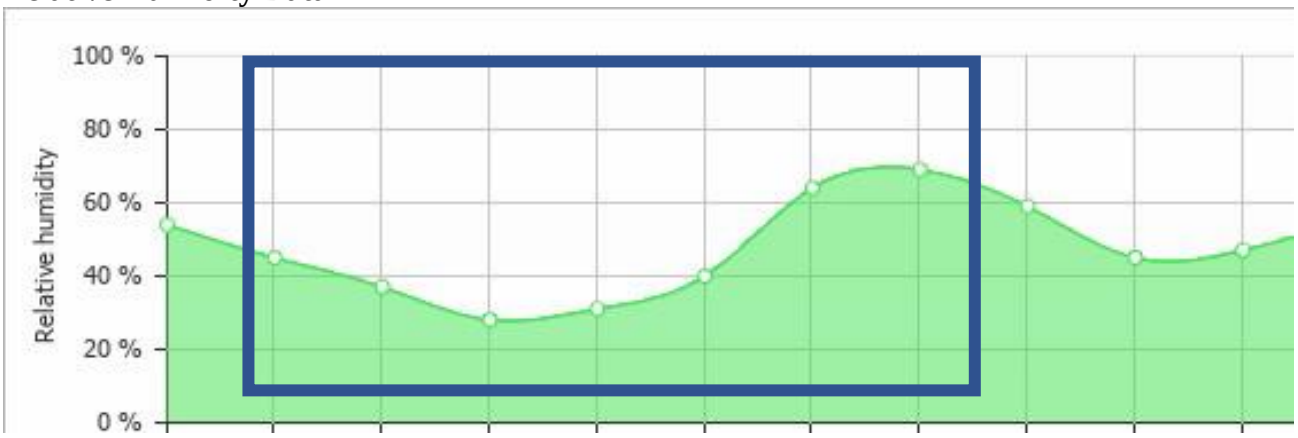
As per the requirements , the working time will be from mid february to mid november.

Temperature Data



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024

Relative Humidity Data



- **NATIONAL BUILDING CODE OF INDIA 2016**

PART 8: BUILDING SERVICES

Section 3 - Air Conditioning, Heating and Mechanical Ventilation

- **6.2** - Design of indoor conditions as per Adaptive Thermal Comfort Model

A) For mixed-mode (MM) buildings:

Mixed-mode buildings, where HVAC is operational only during extreme outdoor conditions, are becoming prevalent in INDIA. The occupants in the mixed-mode building are more adaptive when compared to those in air conditioned buildings and less adaptive compared to occupants in naturally ventilated buildings.

B) Indoor operative temperature=(0.28 x outdoor temperature) + 17.87

Where indoor operative temperature (in °C) is neutral temperature and outdoor temperature is the 30-day outdoor running mean air temperature (in °C). The 90% acceptability range for the India specific adaptive model for mixed-mode buildings is ±3.46°C.

- **Proposed Modifications:**

2.1 The air washer motor for the blower shall be replaced with VFD compatible motor, hence to synchronize the blower with the speed/RPM with 40% to 100%.

2.2 The motor shall be compatible for 4 Pole 415±10% & 50 Hz ±5% with VFD application.

2.3 A temperature (in °C) and Relative Humidity (RH%) transmitter to check and inform the ambient weather condition.

2.4 A duct mounted temperature (in°C) and Relative Humidity (RH%) transmitter to check and inform the supply air environments (TT & RH%) information for testing bench area.

2.5 Modification in existing PLC to control motor RPM/Speed for blower via VFD and ON/OFF operation of Air washer pump motor based on process system matrix.

1.6 System Process Matrix

The system process matrix reflects complete functional details with respect to ambient condition, supply air condition and process description.

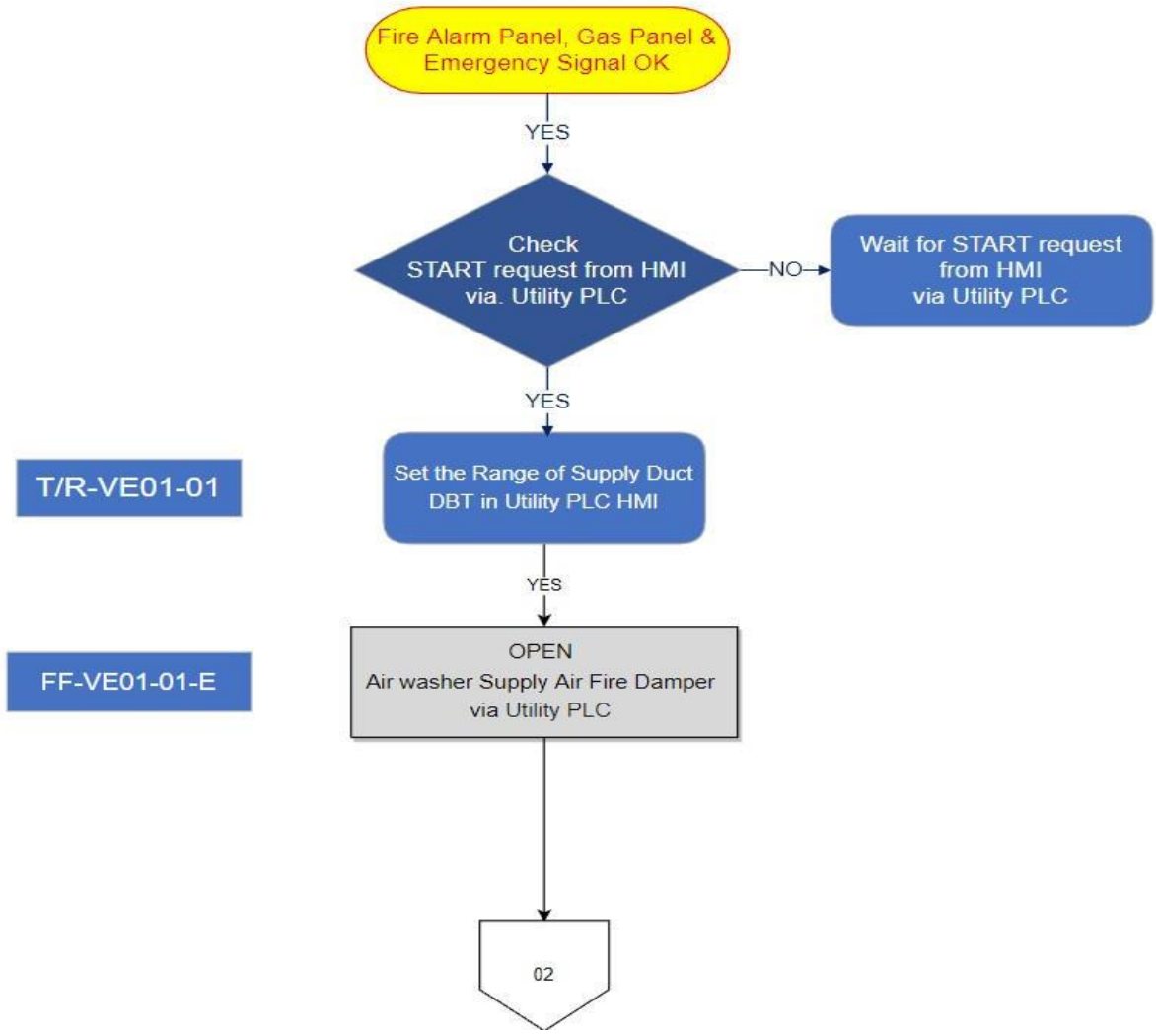
The matrix has been derived in respect to the ambient temperature in conjugation to the air-temperature based approach.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024

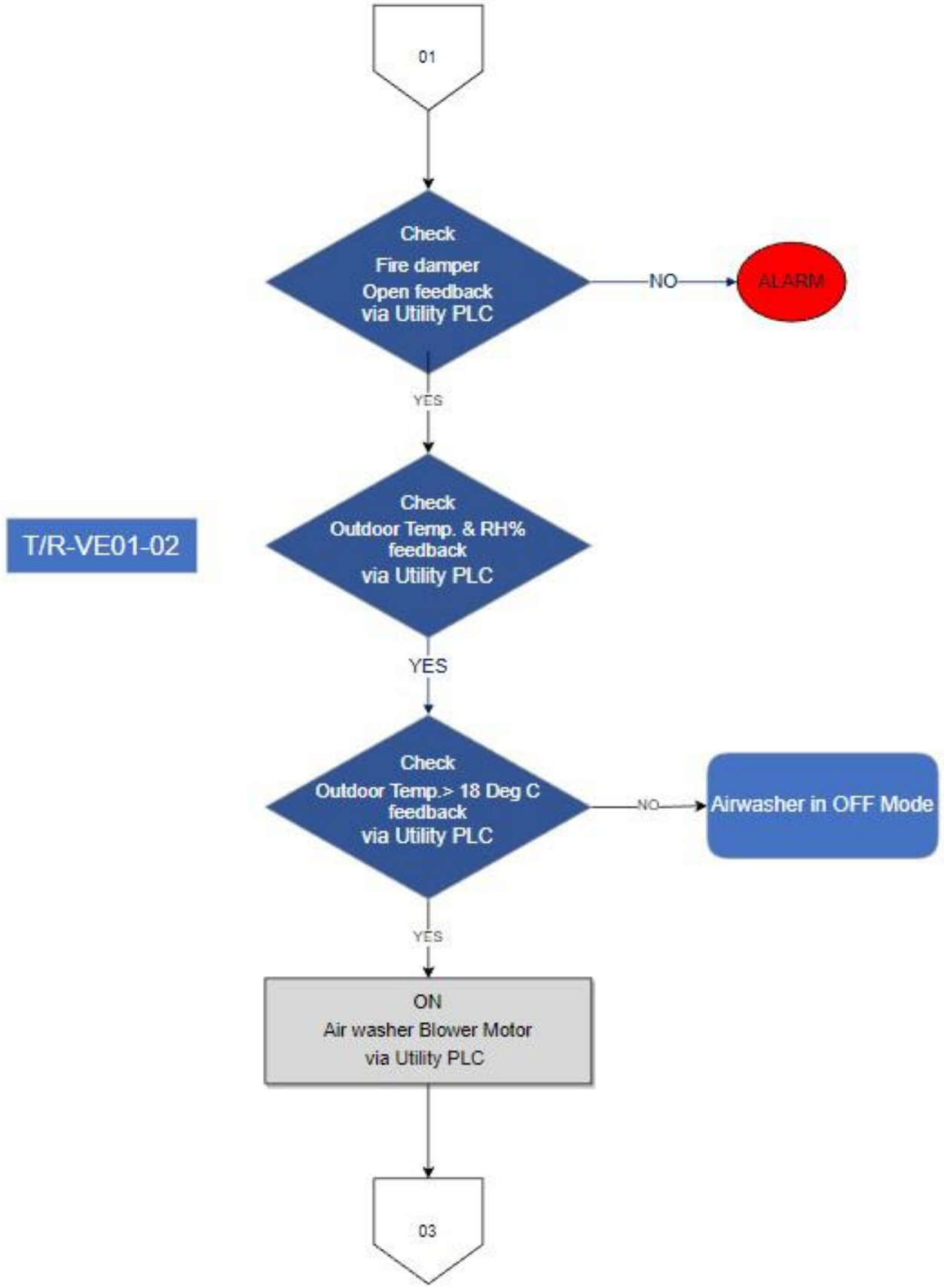
Air-temperature based approach									
Outdoor temp.	Supply Duct Temp.	Max. Return Temp. as per Design	Supply Duct Relative Humidity	Available Supply Air Flow	Required Supply Air Flow	Selected Supply Air Flow	VFD control	Water Pump	Process
(°C)	(°C)	(°C)	(RH%)	m³/hr.	m³/hr.	m³/hr.			
18 19 20 21 22	20 ±3.46	40	same as ambient	42000	19820	18000	48%	OFF	Non-adiabatic Mode
23 24 25 26 27	25 ±3.46	40	same as ambient	42000	27910	28000	67%	OFF	Non-adiabatic Mode
28 29 30 31 32	27 ±3.46	40	60% to 90%	42000	30440	31000	74%	ON & OFF as per requirement	Partial-adiabatic Mode
33 34 35 36 37	28 ±3.46	40	60% to 90%	42000	33320	33500	80%	ON & OFF as per requirement	Partial-adiabatic Mode
38 39 40 41 42	29 ±3.46	40	70% to 90%	42000	36770	37000	88%	ON & OFF as per requirement	Partial-adiabatic Mode
43 44 45 46 47	30 ±3.46	40	70% to 90%	42000	41000	41000	98%	ON & OFF as per requirement	Partial-adiabatic Mode

Towards Adiabatic Mode

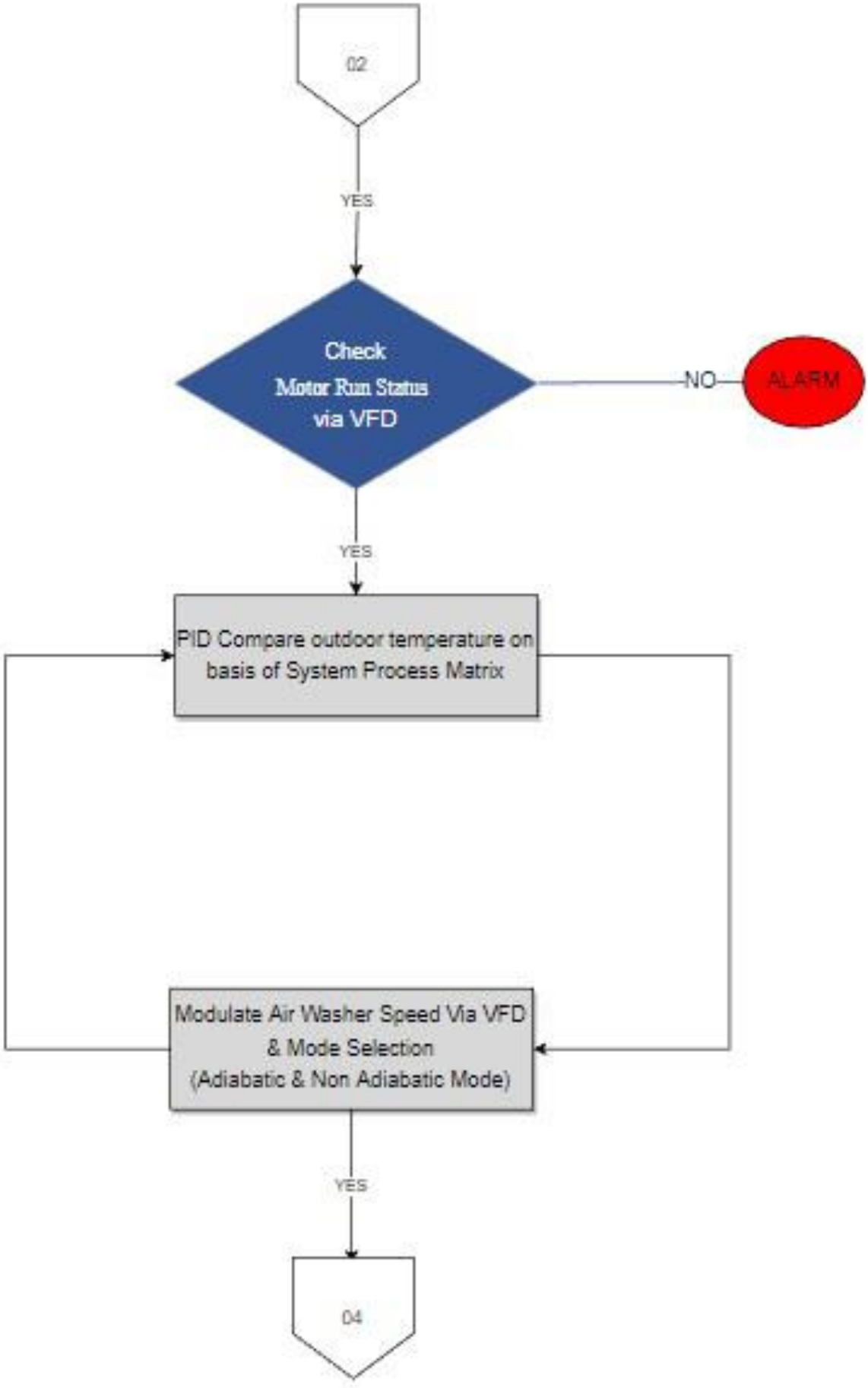
1.7 System Functional Design Specification:



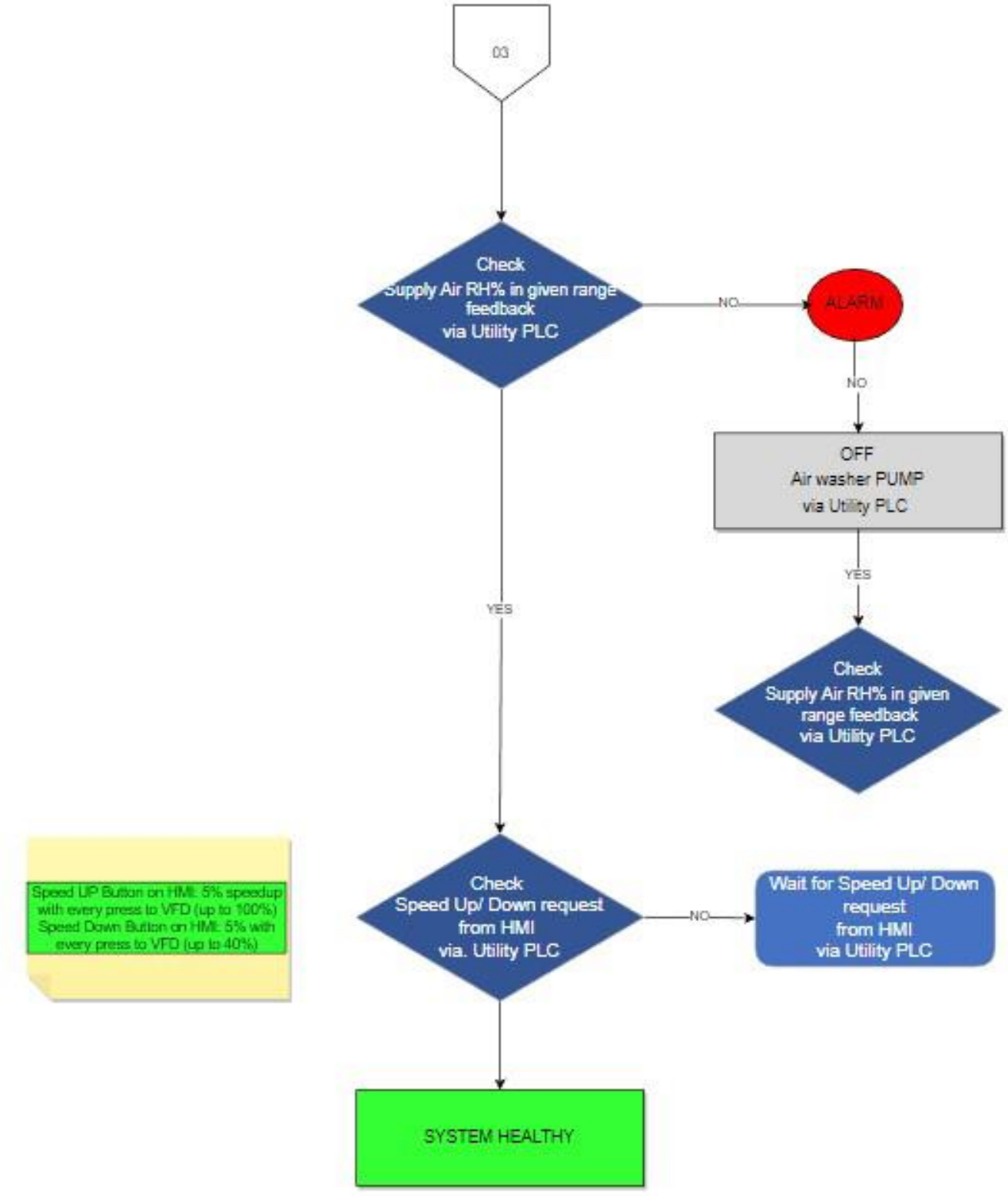
Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024



Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024

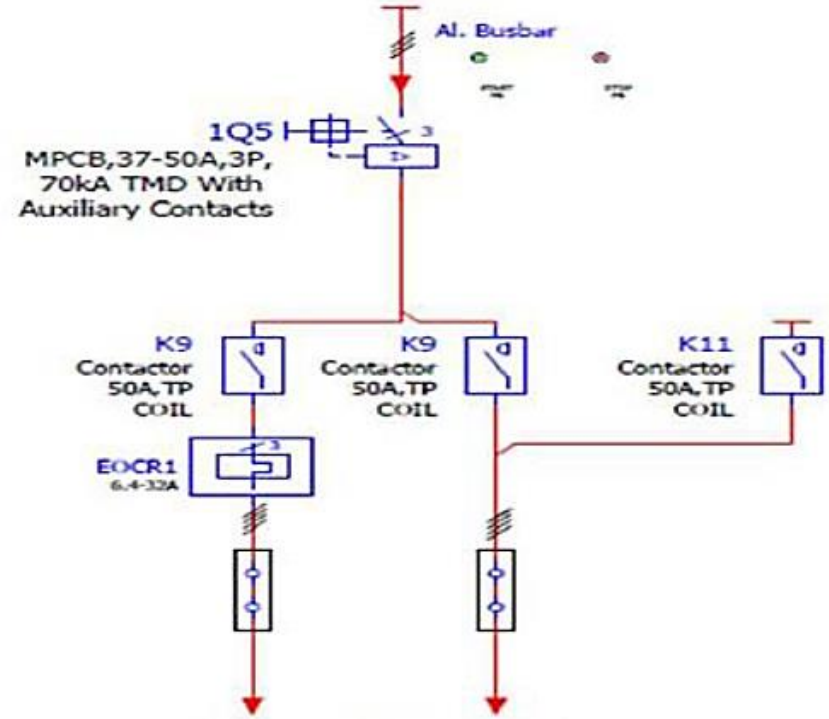


1.8 Conclusion:

➢ **Before : Air washer fan running without VFD**

- In 2W Engine plant, a dedicated air washer is working in test area which is enclosed
- Air washer runs continuously with no control on flow
- Fixed speed of AC motor and constant torque without any control for flow
- There are times in spring & autumn season when air washers are not required with full flow.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 5, No.1, May : 2024

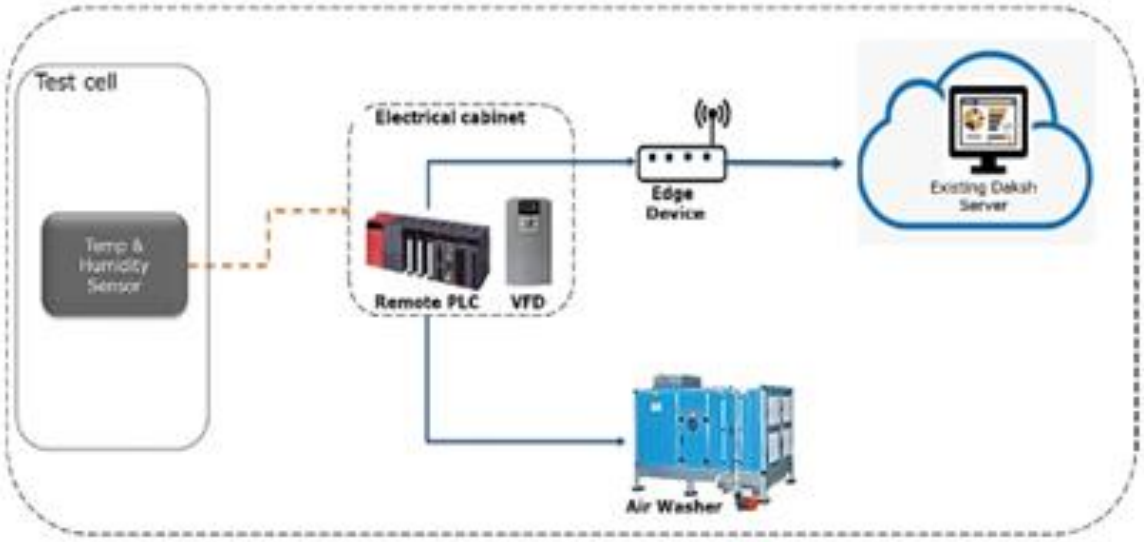


Rating of air washer & pumps(kW)	**18.5**
Running hours in a day (hours)	**16**
Energy consumption/day (kWh)	**296**
Annual consumption (9.5 months running) (kWh) **(A)**	**68,080**

➢ **After: Air washer running with VFD & sensor based IoT system**

• Temperature & moisture inside the test cell being used to set the flow of air washer blower.

• Variable frequency drive(VFD) introduced for flow control by feedback of ambient temperature & moisture levels.



Total energy consumption after introduction of VFD (in KWh)	36,509
Total energy saving (in KWh)	
Previous consumption	68,080
Current consumption	36,509
Savings	**31,571**
Total CO2 saving (in tons)	**~23**

1.9 Challenges and Future Direction:

Despite the benefits, such as initial investment cost, system complexity and operator training need to be addressed to facilitate widespread adoption of **Intelligent Energy Management System for Control of Airwasher Flow by Closed loop VFD System,** the organization can achieve sustainable energy efficiency while maintaining productivity and competitiveness in the market.

1.10 References:

IMD data	IMD data for temperature & relative humidity data for Gurgaon(10 months)
ASHRAE	American Society for Heating Refrigeration and air Conditioning Engineers
ISHRAE	Indian Society for Heating Refrigeration and air Conditioning Engineers
NBC	National Building Code-2016

A comprehensive list of references citing relevant research papers, articles, industry reports and Standards on itelligent compressed air flow control system.

This journal provides a comprehensive overview of intellegent energy-saving techniques with compressed air flow control systems, highlighting their importance, implementation strategies, benefits and prospects.