International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

Redesign Ducting System and Calculations for Heat Load

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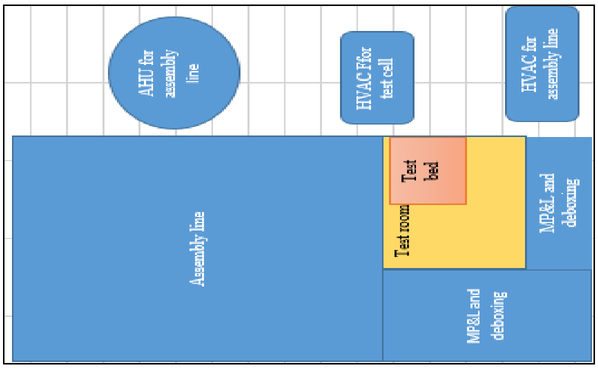
Abstract - *The conventional methodology for cooling a room were window ac, panel ac or Split ac. However, as HVAC has progressed in recent times, we have started making use of chillers and AHU's in order to cool large rooms. The function of a chiller is to cool the water and supply it to the Air handling unit (AHU). The AHU is a blower that blows cool air into the room to be conditioned. Here at the JLR engine assembly plant we are having 3AHU's and 3 Chillers. The plant is divided into three parts 1) Engine assembly 2) Test cell room and test cell 3) MP&L. One AHU is used for the engine assembly while one is common to the MP&L room and test cell room while the third is solely used for the test cell. As the first shift gets over the 1st AHU is turned off while AHU no 2nd and 3rd are continuously running even though there is no one in the MP&L room 2nd AHU must be running to account for the people sitting in the test cell room. Hence as per proposed idea we would use only one AHU that is the 3rd one after 1st shift gets over, we can do so by taking two ducts out of one main duct, one to cool the room and one to cool the panels. This will be taken from AHU no 3. The main aim of this project is to reduce the power consumption by working on the test cell room.*

Key Words: **Set point optimization, Plan Do Check Act (PDCA), Dry Bulb Critical Temperature, Wet Bulb Temperature, Enthalpy, Air Cycle Per Hour(ACPH), Heat Load, Air Handling Unit, Sankey Diagram.**

1. **INTRODUCTION-** Tata motors JLR's Pune engine shop is divided into three parts which are-

1) Engine assembly line
2) Hot test room
3) MP&L and de-boxing



- In which the test room is the room in which a test cell is present as well as an area where tear down occurs.
- In this test cell the engines that are made in the engine assembly line are tested.
- Here various tests like hot test, dyno test occur.
- Hot test runs only for about 2.5 minutes but dyno test there are several tests such as ACRT test, blow by test etc. these tests take 60 hours to get completed.
- In such test around 1500 liters of fuel is consumed be it petrol or diesel.
- These tests are carried out in two shifts.
- There are 3 no of HVAC in the plant and 2 chillers. The work of chiller is cool the inlet water and supply it to the AHU so that it can cool the air and pump it to use the work of the HVAC is to maintain the indoor conditions.
- Here in this setup there is a chiller and an HVAC unit specially assigned only for the test cell and for the occupants in the test room and MP&L there is a common HVAC unit.
- After the first shift gets completed two HVAC's still need to be kept running as one is solely for the test cell and the other one is for the occupants in the test room.
- If the HVAC which is common to the two is kept shut it will save 6000kwh of power.

The specifications of the test cell are given as follows:

• The test cell temperature will be controlled by modulating chilled water flow through the cooling coil by a three-way mixing valve provided in the chilled water return of the coil, in response to a temperature sensor located in the test cell, through a PLC.

• Electrical control panel shall be compatible to operate through BMS system.

• Electrically operated ON/OFF Type Damper with actuator for AC with 30% exhaust mode and 100% supply and 100% exhaust mode.

• All Ventilation ductworks will have an integral fire damper fitted to ensure isolation of the main test tell room in the event of fire. Dampers will be having the correct I/O configuration to the test stand controller.

• If test cell is not running, switch off fan to save energy till hydrocarbon sensor reads 10 % run, then run fan till level drops below 2%, then switch off again.

• Air Damper & Fire Dampers are motorized operator

• Supply Blower & Exhaust Blower supplied will be high efficiency centrifugal and variable speed drive (VSD).

• Return Blower supplied will be high efficiency centrifugal fixed flow.

• The main supply air plenum supply grilles along the test cell ceiling and side walls, preventing hot zones and direction louvers on front of engine and both sides of the engine.

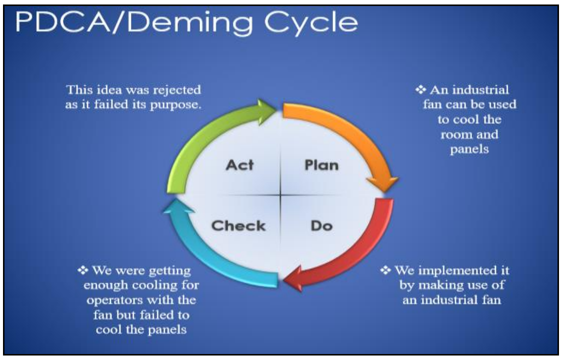
• All Ventilation ductworks will have an integral fire damper fitted to ensure isolation of the main test tell room in the event of fire. Dampers will be having the correct I/O configuration to the test stand controller.

2. Road map to reduce power consumption :

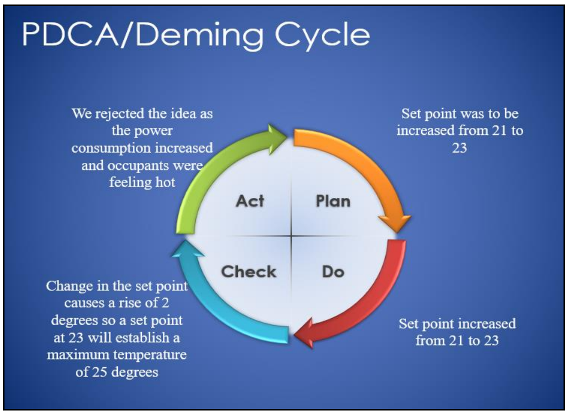
1) **Brainstorming:** We had a team meeting in wich all my team mates gave their inputs to achieve the goal of reduced power consumption.

2)**Validation of idea:** I discussed with seeniors and had a idea congrruency at some ideas which were hereby shotlisted and were a part of plan, do, check and act diagram.

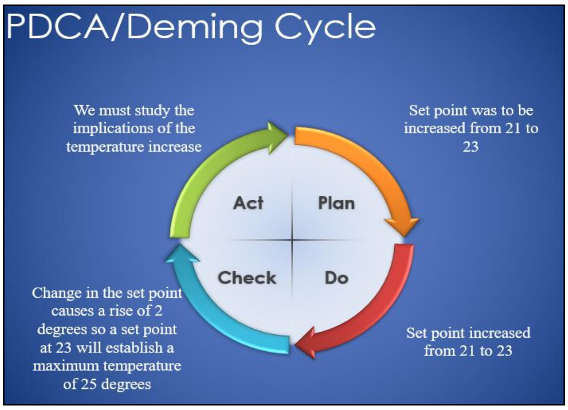
Idea 1: Use of industrial fan:



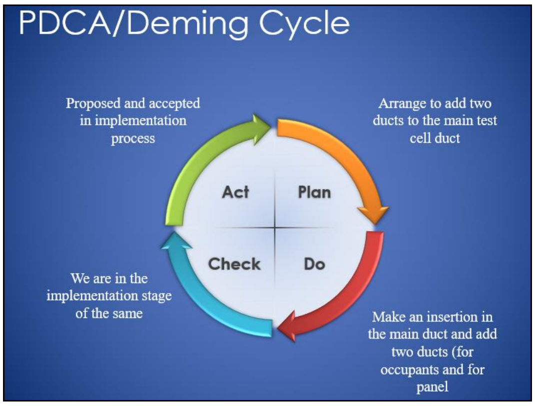
Idea 2: Using panel ac for cooling panels:



Idea 3: Set point optimization:



Idea 4: Modification in the ducts conducted:



3. Calculations

(Basis of design)

Table 1:

Outdoor conditions for Pune:

Factor	*Measured using*	*Value*
Dry bulb critical: - Dry bulb temperature	Using BMS	38.4°C
Mean coincident Wet bulb Temperature	Using BMS	20.5°C
Relative Humidity	Using BMS	18.4%
Enthalpy	Calculated	58.59 kJ/kg
Wet Bulb Critical: - Wet Bulb Temperature	Psychrometric diagram	24.8°C
Mean coincident Dry bulb Temperature	Psychrometric diagram	30.9°C
Relative Humidity	Calculated	61.2%
Enthalpy	Calculated	75.21 kJ/kg
Latitude	Benchmarking	18.53° N

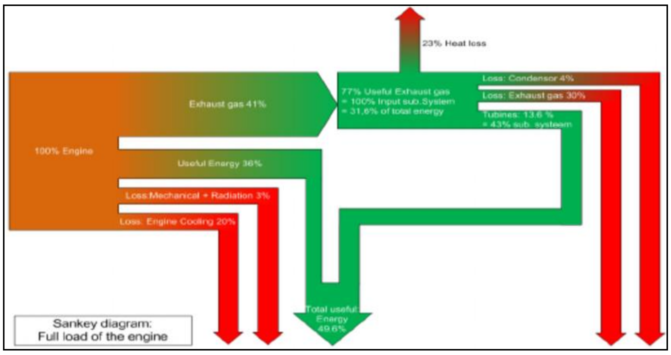
Longitude	Benchmarking	73.85° E
Altitude	Benchmarking	559 m above sea level
Location	Benchmarking	Pune

Table 2:

Indoor Conditions at Test Cell:

Factor	*Measured using*	*Required value*
Dry Bulb Temperature	Using BMS	19°C Min 25°C Max
Relative Humidity	Using BMS	not more than 50%
Test Cell Inside Pressure	Using BMS	- 50Pa (Depression)
Test cell container size	Measured	23.78ft*17.22ft*11.48ft
Occupancy	-	1 nos.
Internal Lighting load	Calculated (measured)	2 Watts/ft^2.
Internal Load	Calculated	150 kW for Test Cell
Test Cell Inside Pressure	-	- 50Pa (Depression)
Noise Level Due To AHU	-	< 75dBA
Hydrocarbon Level	Can be measured using sensor	2% of HC Sensor Read
ACPH	-	~ 60 (Air Change Per Hours)
Engine Power	Calculated	221Kw
Fuel Type	-	Gasoline, Diesel

Heat Load Calculations: -With the help of Sankey diagram, we can establish the heat load as:



Here as we can observe in the diagram above of the 41% exhaust gas only 22% is heat loss hence it is 10% of total engine power that is 10%of 221kw i.e., 22.1kw.

Table 3:

Heat load in the test cell:

Engine Radiation	10	22.1 kW
Exhaust Pipe	30	66.3 kW
Dynamometer AC	15	33.2 kW
Smoke meter	0.7 kW	0.7 kW
Opacimeter	1	1 kW
Filter Panel	1.2	1.2 kW
Lighting (8*100W)	0.8	0.8 kW
Spot Fans (3*300W)	0.6	0.6kW
Cool con	1	1 kW
Fuel con	1	1 kW
F&D tank module	1	1 kW
Pipe (not insulated)	0%	0.0 kW
Wall without acoustic	0%	0.0 kW
Others	1%	2.2 kW
Heat Load		***131.1 kW***

Air Cycles Calculation:

Q= air flow rate

A=area of one duct

V=velocity of air (through ahu duct)

(Here as there are four ducts, we multiply Q by 4)

Q=A*V	Q=299.94*60ft^3/min
Q=4.57*16.4042*4	***Q = 17996 ft³/min***
Q=299.94ft^3/sec	

This gives us the air flow rate i.e. 17996

v=Volume

v=4700ft^3

Air changes per hour =Q*60/v
230

Altered Calculations:

Additional duct dimensions:

Duct 1: 0.82021ft*0.82021ft

Duct 2: 0.984252ft*0.984252ft

Total area of duct (Duct1&2):

$(0.97+0.67)ft^2$

1.64ft²

Alterations in flow:

As we alter the ducts there is a reduction in the velocity at which air leaves the duct. Hence new velocity 14.92ft/sec.

Q=A*V

Q=16.64*14.92

$Q=248.26ft^3/sec$

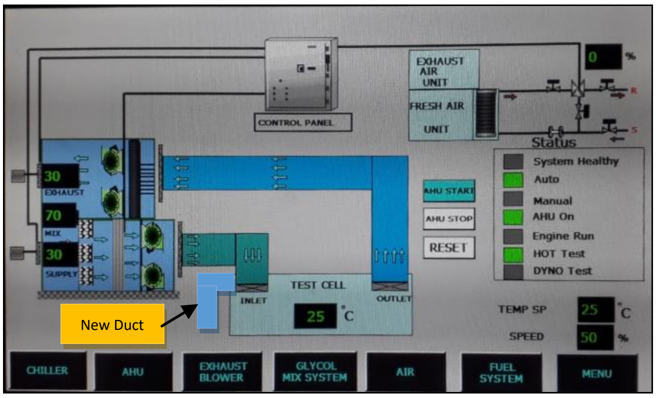
$Q=248.26*60ft^3/min$

Q=14895ft³/min

Air changes per hour =Q*60/v

190.148

4. Proposal for Implementation:



1) This is the proposed new duct is having sizes as follows.

Duct 1: $0.672ft^2$

Duct 2: $0.968ft^2$ respectively.

2) One will be for the occupants in the room while the other will be there to cool the panels.

3) Both will be having dampers to alter the airflow and fins to direct the air blast.

5. Conclusion: -

- Dividing the airflow will result in decrease in the air cycle/changes per hour from 230 to 190 ACPH however it is above 60 i.e., the minimum ACPH that must occur hence safe.
- This will lead to a saving of 6000kwh of power as the second ahu will remain switched off hence it saves the company 60000/-rupees per month as unit cost is 10/- rupees.
- A damper add-on will result in reduction in the airflow, and we can also control it manually and when it is not required can be shut, as it won't be required in the first shift.
- There is also not requirement for additional panel ac which also saves extra cost the company would have needed to incur otherwise.
- The material used to make the extra ducts is also made from in-house material from the TCF shop hence it saves material cost as well as labor costs which would have mounted up to 4.5 lakhs.

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