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Full Length Research Article

Design Optimization And Analysis Of A Single-System Air Handling Unit (Ahu) For Efficient Air Distribution In Commercial Buildings

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Abstract

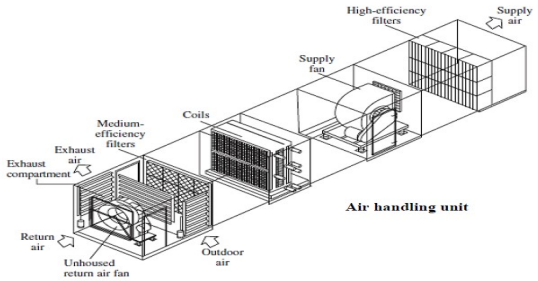
Air Handling Unit (AHU) is defined as a self-contained unit that the conditions of air vary while passing through it and reach to the desired temperature and humidity. To perform variations in weather conditions various processes such as heating, cooling, humidification, dehumidification and mixing are applied. In this research thermodynamic modeling and analysis of air handling units approaching minimum energy consumption is achieved. The objective function for analyzing is pressure drop of air crossing coil per cooling and heating load of the system. This function comprises all thermal and geometrical parameters of the coils such as coil surface area, number of rows, fin spacing and air side pressure drop of the coil. The optimization results are to compose of minimum pressure drop, optimum area, and optimum number of rows and fin spacing. The effects of varying the cooling and heating load, fin efficiency and the surface area of the coil on fan power consumption are investigated as well. A comparison of simulation results to experimental results, gained with a test bed. This method is used to design the unit in modeling tool CATIA, which is simple method as compared with the other design methods. These work gives the combination of theoretical and software tool to provide a comparative analysis in the ANSYS for the Air handling unit.

I - INTRODUCTION

In the present day, as the populace builds the requirement for comfortness additionally increments. The individual needs more comfortness in view of sub-par condition (like light, solid, machine which deliver warm). Sound, light and warmth influence human solace a ton. They may unfavorably influence the human solace decidedly or contrarily. Specialists recommend that, human body is utilized to be agreeable at a temperature of 22ºC to 25ºC. At the point when the temperature of room is lower or higher than this temperature, than the human body feels awkward. This is on account of, the human body is organized in a way that, it ought to get a specific measure of light, inability to which it can cause sunburns and other skin conditions.

1.1 Air Handling Unit (AHU)

Air taking care of unit (AHU), is a gadget used to flow the air as a feature of a warming, ventilating, and aerating and cooling (HVAC) framework. An air taking care of unit is typically a major metal box having a blower, chambers, warming or cooling components, dampers and sound attenuators. AHU by and large associate with a ventilation work ventilation framework that dispenses the cooled air through the house or rooms and takings it to the AHU.



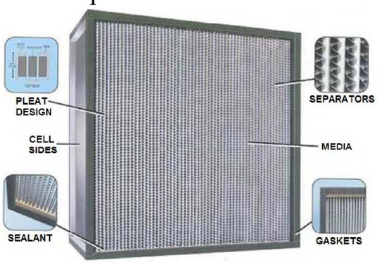
The essential capacity of the AHU is taken in outside air, condition it and supply natural air to a building. All fumes air is released, which anchors a worthy indoor air quality. Contingent upon the required temperature of the molded air, the outside air is either warmed by a recuperation unit or warming loop, or cooled by a cooling curl.

1.2 Air taking care of segments

The principal segment of AHU is given underneath:

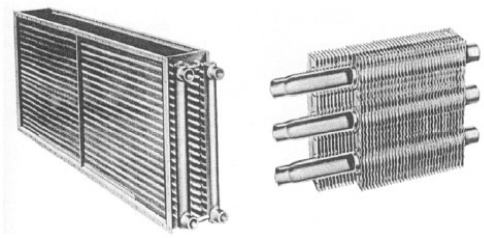
Channels

Air channel is utilized as a part of the AHU with a specific end goal to convey clean earth free air to the house tenants. This air channel is by and large set driving noticeable all around dealing with unit to hold the various contraptions clean.



Warming and Cooling Elements

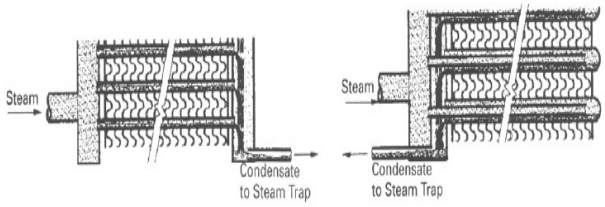
Air handlers need to convey cooling, warming, or both to variety the supply air temperature, and dampness level dependent upon the position and prerequisite. Such molding is conveyed by a warmth exchanger curl. Such loops might be immediate or aberrant in connection to the medium giving the cooling or warming impact.



Cooling/Heating components

Humidifier

Humidification is constantly basic in colder climates where relentless warming will make the air drier, bringing about awkward air quality. For the most part evaporative write humidifier is utilized.



Blower or fan

Air handlers for the most part utilize a major blower, which is driven by an AC age electric engine to exchange the air. The blower keeps running at a steady speed.

II - LITERATURE SURVEY

For over a century, The HVAC people group has seen a quantum jump in the field of plan and esteem included redesigns in Air-Conditioning (A/C) designing. The prime variables to be undeniably considered as the four mainstays of the HVAC framework are, warm solace, Indoor air quality (IAQ), HVAC controls and vitality sparing. In this section, a complete overview of the past examination on the execution of the VAV A/C framework, the VRV refrigeration framework, a correlation of EEV and TXV, and controllers in refrigeration and aerating and cooling frameworks is exhibited.

2.1 Thermal Comfort and Indoor Air Quality

The part played by moistness in the view of warm solace can't be overstated, as minor moves in RH will sharply affect microbial development, specifically, at bring down RH levels i.e. under 30%. Regular reasons for dampness issues like building snugness, entrance and warm extension were recorded with suggestive references being made for constraining contagious development. The evil impacts of diminished and over the top stickiness levels were specified. Investigations of the quantitative distress at various RH settings and related warm solace over a presentation scope of 20ºC, 60 % RH to 26ºC, 90 % RH were expounded bringing up a good blend of parameters.

2.2 Energy Conservation Techniques

The utilization of vitality by HVAC hardware in mechanical and business structures constitutes half of the world utilization (Imbabi 1990). The significant disadvantage of the steady volume frameworks is that they by and large utilize more vitality. Prior to general society was influenced mindful of the vitality deficiency, to individuals perceived that structures expected vitality to give a controlled domain and expanded profitability. Vitality use in ventilating frameworks is viewed as a basic piece of a building's

utilitarian necessities. Since the late 1960s, be that as it may, HVAC engineers have started to investigate different outline ideas to limit vitality use in air taking care of frameworks. Variable volume frameworks bit by bit rose as more up to date, more vitality saving frameworks for building ventilating. Since the 1973 Arab oil ban, there has been a propensity to supplant steady volume frameworks with variable volume frameworks as a superior and more effective utilization of assets.

2.2.1 Variable Air Volume (VAV) System

A standout amongst the most mainstream HVAC applications, the Variable Air Volume (VAV) application, is intended to convey low vitality cost, low support, low warm vitality waste, IAQ and great warm solace execution. The fundamental rule of the variable air volume aerating and cooling framework is to control the volume of supply air into the space to be ventilated because of the space stack. In Constant Air Volume (CAV) frameworks, in any case, a steady volume of air is provided to the molded space and the supply air temperature is differed with variety of room stack. The focal points for the most part ascribed to VAV frameworks are their flexibility in singular zone-controlled space and multi zones. By and large, these frameworks are considered vitality proficient by plan examination.

2.2.2 Variable Refrigerant Volume (VRV) framework

The progressive variable refrigerant volume framework initially showed up in Japan in 1982 and is currently utilized all through the world. It is quick supplanting the customary chilled water frameworks inferable from its waterless task, outright adaptability and vitality sparing highlights. The VRV framework balances refrigerant volume as per limit prerequisites. To independently cool or warmth various regions, the VRV inverter framework controls the limit of units by methods for an inverter blower to coordinate the request of indoor units. William Goetzler et al (2004) portrayed the variable refrigerant volume framework highlights and its retrofit capacity, empowering its joining into practically any building, old or new, with least auxiliary change. They have additionally clarified the VRV framework's outrageous adaptability in the way that, it can have a solitary consolidating unit associated with various indoor units of differing limit and arrangement. VRV frameworks give viable zonal control, which is equipped for killing individual indoor units in areas that needn't bother with cooling or warming while at the same time proceeding to work productively; in this manner, vitality preservation can be accomplished.

2.2.3 Variable Speed Compressor (VSC)

The execution of the variable speed blower used for inverter aerating and cooling applications, has been examined by Shuangquan Shao et al (2004). The guide based technique is used to fit the execution bends of the inverter blower. The model was worked at the fundamental recurrence and the guide condition as the second-arrange capacity of buildup temperature and dissipation temperature. At that point it was revised by the blower recurrence as the second-arrange capacity of recurrence and in real working condition. In view of the test information and reproduction show, the recurrence at zero mass stream rate and power contribution at zero recurrence were examined and the connection amongst COP and blower recurrence was additionally broke down.

2.2.4 Electronic Expansion Valve (EEV)

Thermostatic Expansion Valves (TXV) is normally utilized as a part of refrigeration and cooling frameworks. The proficient and effective mechanical control of the refrigerant relies upon the thermostatic extension valve. The TXV works by estimating and controlling the superheat in the evaporator. Controlling the superheat enables the TXV to meter the best possible measure of refrigerant into the evaporator under all heap conditions and still revent surge again from harming the blower. Likewise, it isn't dependable because of few moving parts and slack reaction. A perfect refrigerant control gadget would be non-refrigerant particular, have a wide load run, have the capacity to be set remotely, and control temperature specifically. Electronically controlled valves would meet these prerequisites and the TXV can be supplanted by the Electronic Expansion Valve (EEV) whose working is like TXV. It reacts rapidly to stack variety and can without much of a stretch set and change superheat setting.

2.2.5 Demand Control Ventilation (DCV)

Generally, the HVAC business has followed ASHRAE guidelines for indoor air quality with steady ventilation, a control that keeps up a coveted ventilation set point in view of the outline inhabitance of the space. Be that as it may, this strategy regularly brings about huge squanders of vitality. Interestingly, DCV utilizes CO2 sensors to supply open air in light of the real inhabitance of the room. All the while, it increments indoor air quality and the spares vitality

typically squandered in ventilating empty spaces. The ASHRAE standard 62-1989 requires an Occupancy Based Ventilation Control Strategy (OBVCS) as a "Ventilation estimation and control" system. The OBVCS looks at a coveted natural air cmm (set point) with the genuine outside air cmm (controlled variable) and courses an acclimation to the outside air damper. The coveted natural air cmm is computed by increasing the cmm/individual necessity by the inhabitance level. The cmm/individual necessity is regularly a steady, for example, 0.567, in light of the utilization of the space recommended by ASHRAE for office territories. The inhabitance can be physically entered or consequently changed in light of a period plan.

2.2.6 Economizer Cycle

An economizer cycle is a choice in an air taking care of framework configuration normally used to spare cooling vitality. The outline plot exploits the cooler outside air in mellow and chilly atmospheres to supplement or fulfill the cooling needs. Inside spaces of a building require cooling year-round. At the point when the outside air temperature dips under the required supply air temperature, the required cooling burden can be met be blending differing measures of cool outside air with return air. Under this condition, the whole refrigeration plant can be closed down. Notwithstanding when the outside air temperature is higher than the required supply air temperature however lower than the room temperature, supplanting the higher-temperature return air with cooler outside air can altogether diminish the refrigeration stack, gave the outside air stickiness isn't exceedingly high. The utilization of an economizer cycle to monitor cooling vitality is very down to earth in colder atmospheres. An economizer cycle can be connected to most focal air taking care of frameworks, and is particularly compelling on single-pipe frameworks.

2.3 Conventional HVAC control strategies

The air-taking care of arrangement of an extensive building must be intended to adapt to an extensive variety of working conditions since the climate and inhabitants' exercises are liable to huge, occasional changes from day to night and from season to season. The control framework has a choosing part in keeping up the indoor condition in the safe place. The control of the HVAC framework ought to fulfill the necessity of warm solace and vitality proficiency. While the advanced control hypothesis permits an abnormal state of complexity in control frameworks outline, traditional HVAC control systems, for example, the two-position controller and the PID controllers are still exceptionally prevalent in view of their minimal effort and generally straightforward structure, which can be effectively comprehended and actualized by and by.

III - OBJECTIVES OF THE PROJECT

The target of this venture work is to effectively build up an outline of an Air Handling Unit for a HVAC System. The procedure is to be warmth or temperature solid, basic, financially savvy and for all intents and purposes attainable.

3.1 Summary of abilities

Catia Elements is a product application inside the CAID/CAD/CAM/CAE class, alongside other comparative items as of now available.

Catia Elements is a parametric, highlight based displaying engineering fused into a solitary database rationality with cutting edge run based plan abilities. The abilities of the item can be part into the three fundamental heading of Engineering Design, Analysis and Manufacturing. This information is then archived in a standard 2D creation drawing or the 3D drawing standard ASME Y14.41-2003.

3.2 Engineering Design

Catia Elements offers a scope of devices to empower the age of an entire advanced portrayal of the item being outlined. Notwithstanding the general geometry instruments there is additionally the capacity to create geometry of other incorporated outline trains, for example, mechanical and standard pipe work and finish wiring definitions. Apparatuses are likewise accessible to help community improvement.

3.3 Analysis

Ansys Elements has various examination instruments accessible and covers warm, static, dynamic and weariness FEA investigation alongside different devices all intended to help with the advancement of the item. These devices incorporate human variables, fabricating resilience, form stream and outline streamlining. The plan streamlining can be utilized at a geometry level to get the ideal outline measurements and in conjunction with the FEA investigation.

IV - WORKING METHODOLOGY

For outlining a legitimate framework, it is important to evaluate cooling load which is utilized to choose the zone and wind stream rate that the channel framework conveys. Once the wind current rate is resolved, the channel framework segment can be set. This incorporates the supply and returns diffusers and chooses to air dealing with unit (AHU) or fan loop unit is useful for that space.

4.1 General guidelines for outline

• Air ought to be passed on as specifically as conceivable to conserve on power, material and shape.
• Sudden alter in course ought to be maintained a strategic distance from.
• Air speeds in pipes ought to be inside as far as possible to limit misfortunes.
• Rectangular pipes ought to be made as about square as could be allowed. This will guarantee least channels surface. An angle proportion of under 4:1 ought to be kept up.
• Damper ought to be given in each branch outlet to adjusting the framework.

4.2 Air Friction Loss

Air erosion misfortune is influenced for the most part by the pipe size and shape, the material utilized, fittings utilized. As indicated by ―Carrier Handbook‖ round excited sheet metal has the least grating misfortune per meter, while the adaptable ventilation work has the most astounding erosion misfortune per meter. The nature of fitting directly affects the general weight drop of a pipe framework, smooth and effective fitting with a low turbulence lessen the channel framework pneumatic stress drop. An immediate course utilizing round pipe with less fitting and size changes can have a less erosion misfortune in examination with the comparable size rectangular framework with a more extended course and size changes at each branch channel.

4.3 Noise Level

The cutting edge AC frameworks require control of commotion level beneath a specific level notwithstanding the control of dampness, temperature and air speed of over the top clamor which causes awkward inclination. The hardware as blowers, humidifiers, engines and numerous others contribute commotion to the aerated and cooled space. The air going through the conduits and flame broils likewise make clamor.

4.4 Heat Transfer and Leakage

Ventilation work that goes through warm or chilly regions can endure warm pick up or misfortune that viably lessen the limit of the cooling and warming gear, result in tenant distress and higher working expense. Spillage in channel additionally influences the limit of cooling gear and may make smells.

4.5 Static Pressure (Ps)

The static weight dependably exists in a channel framework. The weight which is free upon the air development called static weight. This sort of weight pushes against the mass of the conduit. It tends to surge a pipe when its power is more noteworthy than that of barometrical weight and tends to fall when its power is not as much as that of the air. These weights defeat the grating and stun misfortunes as the air is stream.

4.6 Velocity Pressure (Pv)

The speed or dynamic weight is equivalent to the drop in static weight important to create a given speed of stream. As it were, it is equivalent to the expansion of static weight conceivable when speed is decreased to zero.

4.7 Total Pressure (Pt)

It is the arithmetical whole of the static weight and dynamic weight.

$$Pt = = Ps + Pv \ldots (3.1)$$

4.8 Pressure Losses

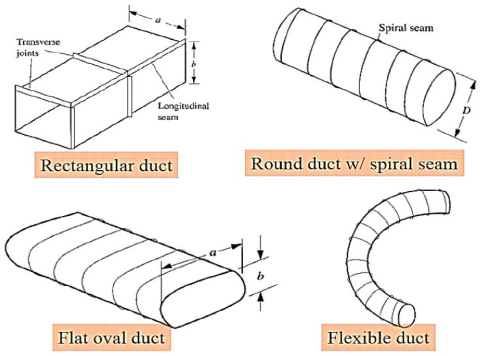
Weight is lost because of grinding between the moving molecule of the liquid and the inside surfaces of a channel. At the point when the weight misfortune happens in a straight channel, at that point this misfortune is known as grating misfortune. The weight misfortune is because of the alters of course of wind stream, for example, twists, elbows and so on and at the difference in cross area of the conduit, this misfortune is known as powerful misfortunes.

4.9 Duct System

As the channel framework for the best possible appropriation of chilly air, costs about 20% to 30% of the aggregate cost of the gear required. Along these lines, it is important to outline the air conduit framework such that the capital cost of pipes and the cost of running the fans is lower.

4.10 Classification of channels

The channel might be named takes after:



Subsequent to concentrate above figures, the outcomes comes that roundabout channel has least contact misfortune when contrasted with the rectangular pipe.

V - DESIGN METHODLOGY OF AIR HANDLING UNIT

5.1 Introduction to CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-stage CAD/CAM/CAE business programming suite created by the French organization Dassault Systems. Written in the C++ programming dialect, CATIA is the foundation of the Dassault Systems item lifecycle administration programming suite. CATIA contends in the top-of-the-line CAD/CAM/CAE advertise with Cero Elements/Pro and NX (Unigraphics).

Modeling of Air Handling Unit in CATIA V5

This Air Handling Unit is composed utilizing CATIA V5 programming. This product utilized as a part of car, aviation, customer merchandise, overwhelming designing and so forth it is great programming for outlining confounded 3d models, uses of CATIA Version 5 like part configuration, get together plan.

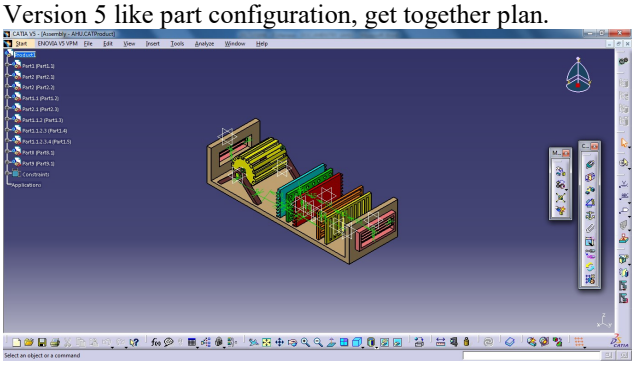


Fig: 5.2: Model outline of Air Handling Unit

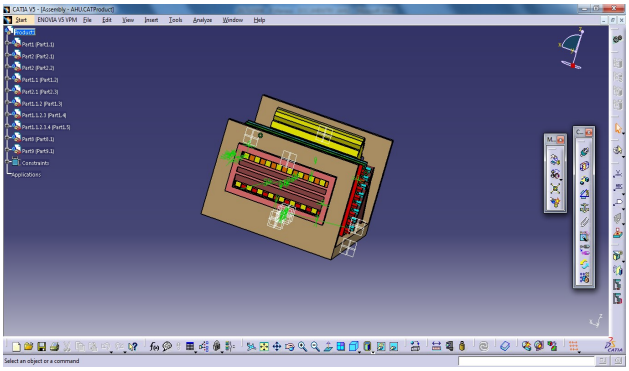


Fig: 5.3: Model course of action of Air Handling Unit in CATIA-V5

5.4.3 Assembly Modeling of Air Handling Unit

In this demonstrating every last part gets amassed together with the methods for limitations, happenstance, contact, balance, point, settle segment, adaptable, control, and so on.

Control: This charge is utilized to control/turn/pivot the part in any required heading according to the need/appropriate requirements are to be connected on the segment.

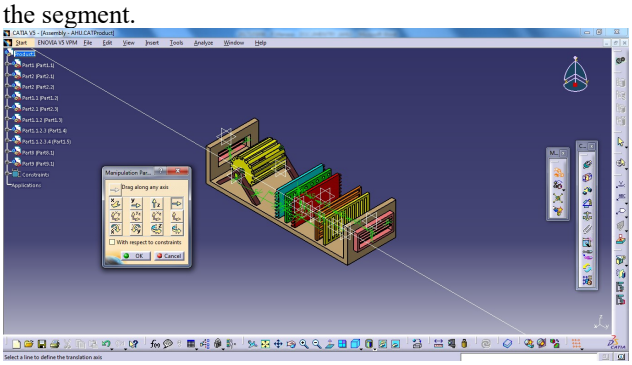


Fig: 5.22: Using Manipulate Command

Multi View: This is the order in which every one of the perspectives of the segment/model can be shown on the screen at a same time, they can be altered under the workbench.

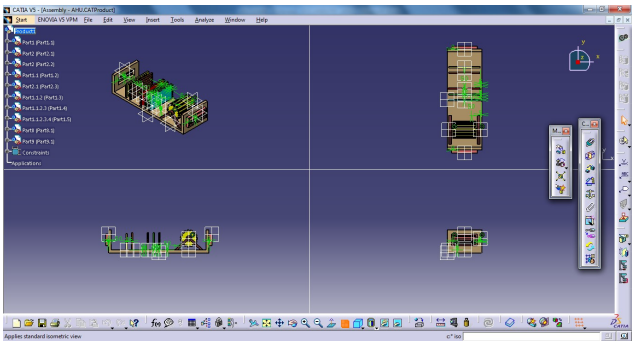


Fig: 5.23: Using Multi View Command

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VI - ANALYSIS OF AIR HANDLING UNIT

6.1 Procedure for FE Analysis Using ANSYS:

The examination of the Air Handling Unit is finished utilizing ANSYS. For contend get together isn't required, is to did by applying minutes at the pivot area along which hub we have to specify. Settling area is base legs of get together machine.

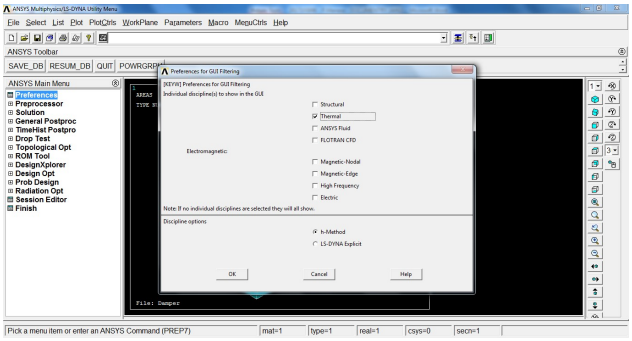
6.2 Preprocessor

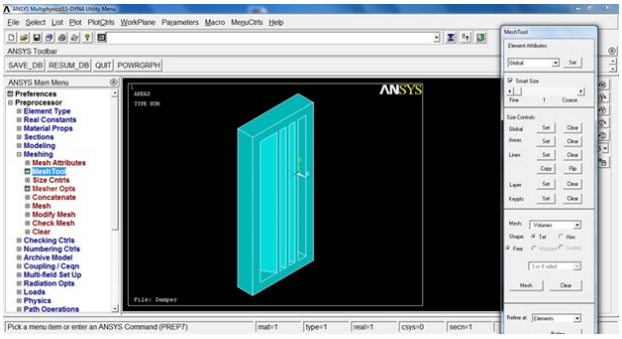
In this stage the accompanying advances were executed:

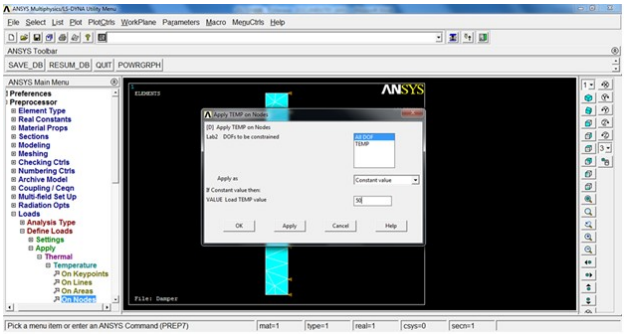
- **Import document in ANSYS window**

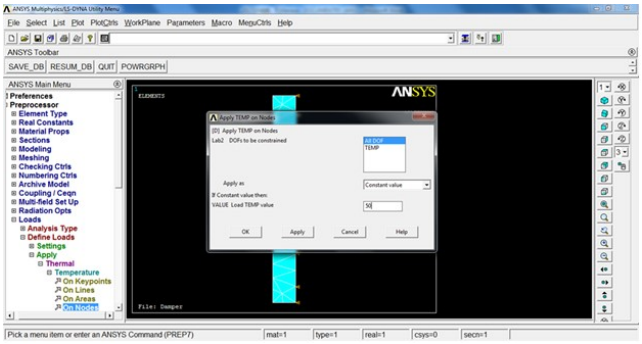
Document Menu > Import> STEP > Click alright for the flew up discourse box > Click

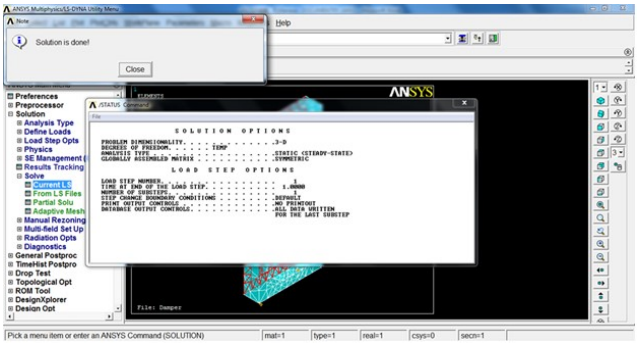
Peruse" and pick the record spared from CATIAV5R20 > Click alright to import the document









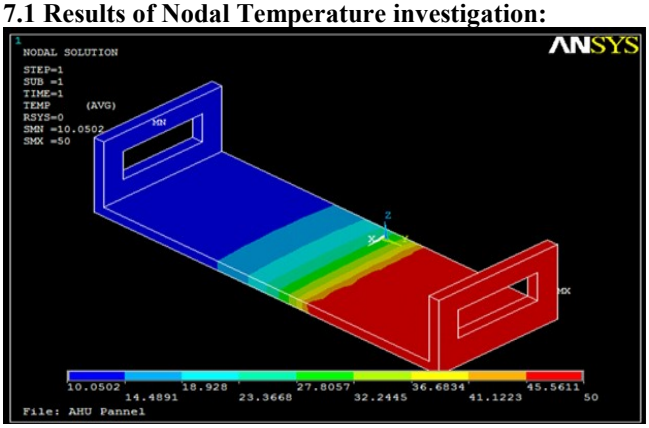


This AHU is demonstrated with 1d component and appeared as above and gathered with contiguous parts. Barely any parts are tackled utilizing Thermal Analysis for checking the pressure and temperature exchanges.

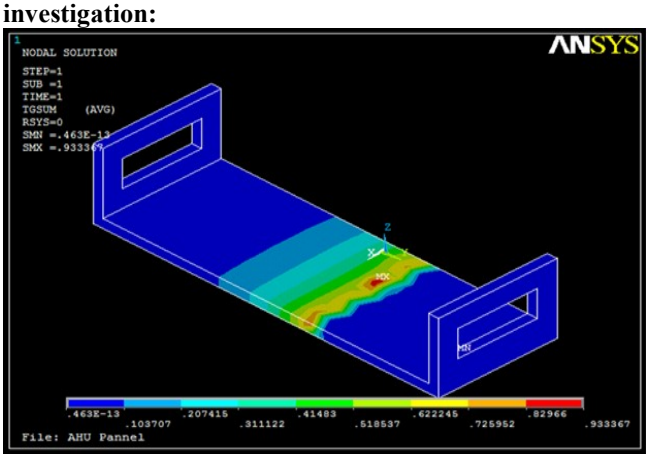
Load is connected and settling at the base key area, was approved in the examination. The material and geometric properties are recorded.

VII - DISCUSSION ON ANALYSYS RESULT

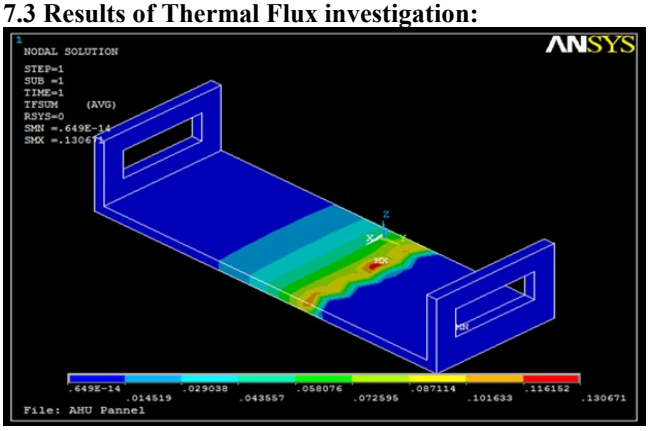
7.1 Results of Nodal Temperature investigation:



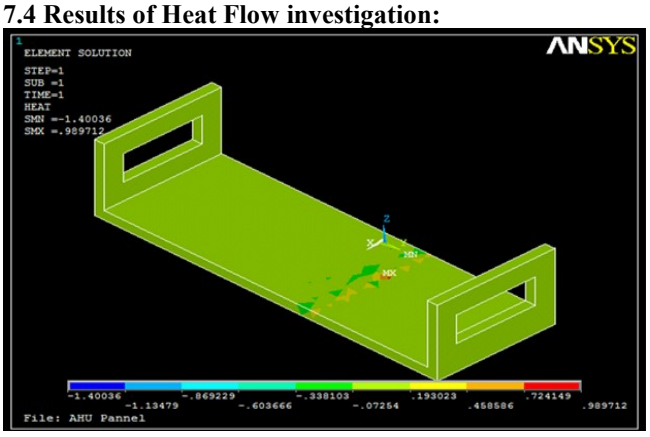
7.2 Results of Temperature Gradient investigation:



7.3 Results of Thermal Flux investigation:



7.4 Results of Heat Flow investigation:



VIII - CONCLUSION

It can be seen from the above results that, our objective to manipulate the temperature of an AHU in a HVAC System has been successful. As shown above figures the temperature of the air is a complete design assembly is manipulated and reached as per the requirement and solved using Ansys and temperature is 10.05°C in AHU system. This is showing us that clearly each component in its thermal analysis.

Thermal Flux is at the location (Minimum Stress which is acceptable). The value is 0.1306 which is very less compared to yield value.

The maximum heat flow is 0.989 coming, this solution solving with the help of Ansys software so that the maximum thermal gradient is 0.9333. So, we can conclude our design parameters are approximately correct.

After studying above, the results comes that circular duct has minimum friction loss as compared to the rectangular duct.

The design of the Air Handling Unit worked flawlessly in analysis as well; all these facts point to the completion of our objective in high esteem.

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