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HVAC Design of Air-Cooled Chiller by Revit Tool and Power Consumption Analysis when Different Compressors are used for an Office Building

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Abstract: ***Air-conditioning of mercantile building found to be important criteria; contemporarily efficient design and the reduced power consumption are also two of the major factors that has to be considered in to an account, for which chillers are found to be the best air- conditioning units so far like air-cooled and water-cooled chillers among which water- chillers found to be much efficient than the air-cooled chillers. But, what if there is no adequate availability of water at the desired place where water-cooled chiller has to be installed? And also, compressors are the major component of chiller systems if not selected appropriately would increases the energy crises and consumption drastically. This project mainly describe about the power consumption when different classified compressors are used for an air-cooled chiller also it describes about the design of (HVAC)Heating ventilation and air-conditioning using Revit tool- a BIM (Building Information Modelling software) which helps an individual to clearly visualize the model of building and various services that are installed such as HVAC, Electrical and Plumbing and also it helps a design engineer to outfit the MEP services within time that involves in designing the services by the other CAD designing tools like Auto CAD, duct designing softwares like Eductulator or McQuay-duct-sizer etc. High power consumption requirements are being demanded by the air-cooled chillers because they are the units which use the 25% of the electricity of a commercial building. Therefore, it is uttermost importance to analyse the different parameters such as energy consumption, performance coefficient in order of reducing power consumption for a mercantile buildings.. In air-cooled chiller we direct air across the condenser coils with the ease of a fan whereas in water-cooled vapor refrigerant is condensed by passing water over the condensing coils. Air-cooled chiller has specific power (input) consumption up to 1.51KW/Ton where as water-cooled chiller has 0.56-0.8KW/Ton. Operating cost is also as important as energy consumption, as air-cooled chiller is preferred because of its lower maintenance cost as it doesn't require a cooling tower, pumps, and condensing water by chemicals action as well. But water-cooled chiller has comparatively low condensing temperatures than the air-cooled chillers.***

I. INTRODUCTION

A. Centralised Air-Conditioning Systems

Whenever large space or volumes are wanted to be cooled, this is recommended to refer centralised air conditioning and chilling system in which only a sole outdoor compact generally called chiller and many indoor compacts are stationed for different space or volumes to be conditioned.

A centralised air conditioning and chilling system is used for cooling building space or volumes like hotels, airports, shopping malls etc, are wanted to be conditioned comprehensively.

B. Chilled Water Central Air-Conditioning System

When the no. of floors of a building is to be conditioned at the same time setup of chilled water system is recommended. There are two categories of cooled water systems are used they are:

1) *Air-cooled chiller system*
2) *Water-cooled chiller system.*

Here for this project we are going to discuss about air cooled systems only

The refrigeration cycle of an air-cooled chiller includes two activities:

a) The dissipation of the fluid refrigerant in the evaporator which retains warmth and brings down the temperature of the chilled water system.
b) The build-up of the refrigerant vapor realisable all around cooled condenser and dismissal of warmth to the environment.

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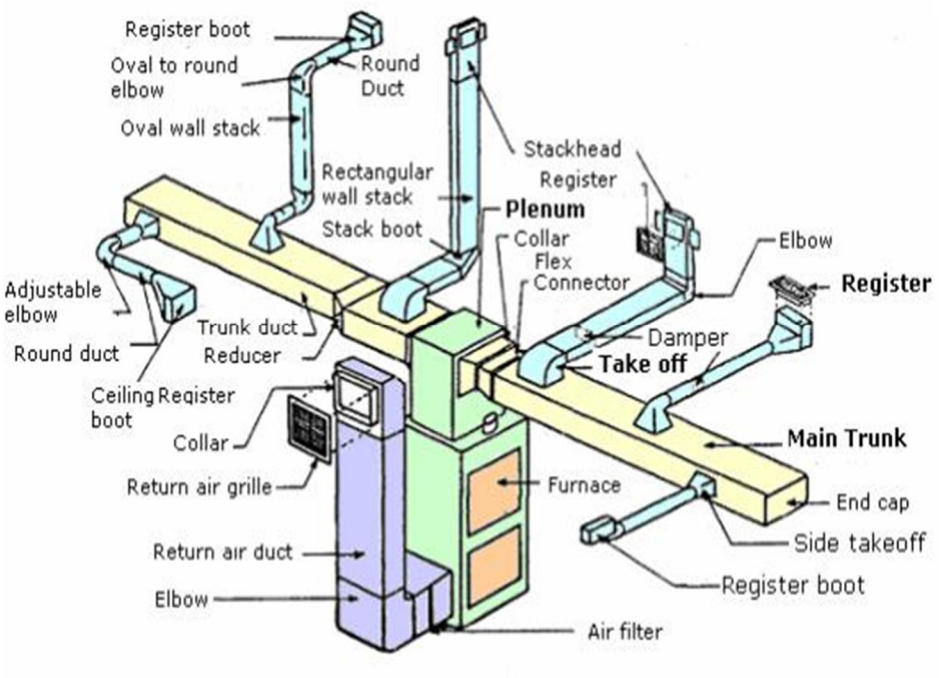


Figure1 simplified diagram of different hvac components

II. REVIT

Revit MEP is the Construction data demonstrating plan and documentation programming for MEP (Mechanical, Electrical and Plumbing).

To get over the tool Revit it is of uttermost importance to have clear idea about the Construction information modelling abbreviated as BIM.

A. BIM

The Construction Information is a gathering of information that is organized such that the data can be shared. The BIM is a digitalized model of a working in which information about the task is put away which can be 3D, 4D (time), 5D (cost)… … .nD (a term that covers some other related data). Subsequently, for the exhaustive data of the task BIM has an tentative adaptability and potential which is useful for a MEP and the other Engineer to find the thoughts however much and soon as could be expected.

B. Services offered by BIM

a) Revit architectural services.
b) Revit structural services.
c) Revit MEP services.
d) BIM 3D, 4D modelling, drafting, coordination, family creation, simulation services, cost estimation.
e) Revit BIM services, clash detection, quantity take off.

How the BIM has been used in this project is explained below with the help of revit software this below shown figures was made:

C. Engineering Design stages with BIM

1) LOD: 100 conceptual Geometry - simplified design.
2) LOD: 200 Approximate Geometry - Basic design.
3) LOD: 300 Precise geometry - Detailed design (bidding model).
4) LOD: 400 Fabrication - construction documents.
5) LOD: 500 AS-built - AS-built.

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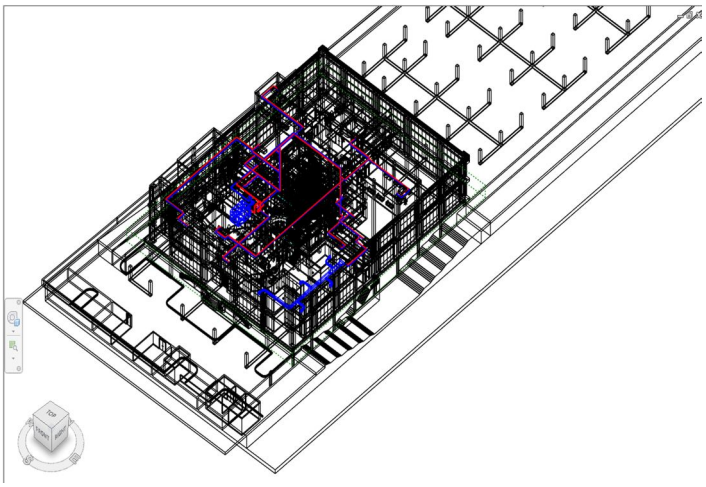


Figure 1- level-1 contains overall amount

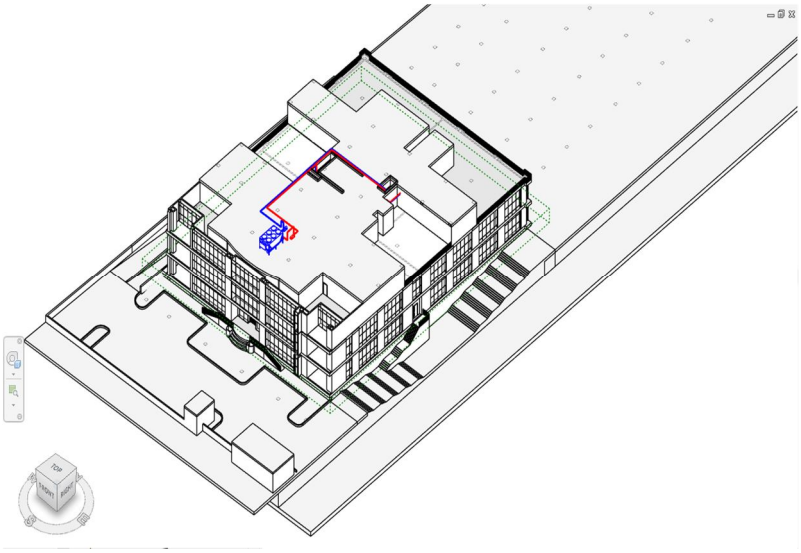


Figure 2- level-2 contains shell with openings



Figure 3- level-3 basic architectural details but no surface finish

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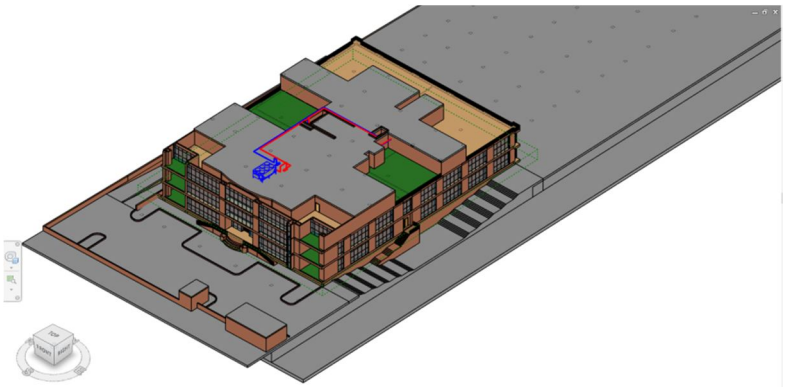


Figure 4- level-4 detailed architectural and structural details



Figure 5- level-5 accurate architectural and structural details.

III. COMPRESSORS

A. Introduction to Refrigerant Compressors

A refrigerant compressor is a machine used to pack the refrigerant vapor to high weight refrigerant vapor keeping in mind the end goal to expand its weight and reaches to the immersion temperature with the end goal that the temperature is more than that of cooling medium. It is the main segment in flowing the refrigerant all through the cycle of refrigeration for which work must be finished amid the dissemination action. It requires a prime mover to work the cycle. Compressor is thought to be the most imperative segment and furthermore the greatest power consumer.

In this undertaking, we have consider distinctive sorts of compressors for the power utilization investigation for that it is vital to experience the investigation of various kinds of compressors.

B. Types Of Refrigerant Compressors Used In HVAC

1) Based On The Method Of Compression: Reciprocating compressors, Rotary compressors and Centrifugal compressors.

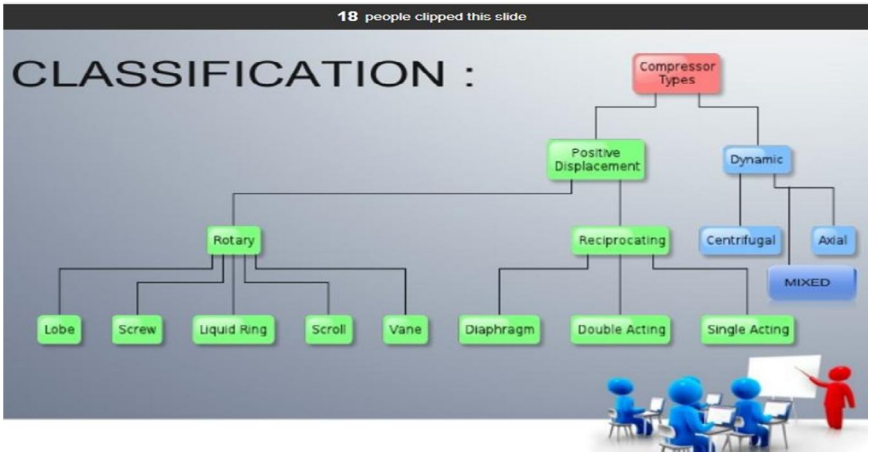


Figure-6 different compressor types

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Now we shall discuss each of the compressors in brief.

a) *Reciprocating Compressors:* On the off chance that the vapor refrigerant is compacted by the piston activity of Backward or forward i.e. reciprocating activity then the kind of compressor is called reciprocating compressors.

b) *Rotary Compressors:* In this kind of compressor rotary activity is performed on the working medium with in a limited chamber, the activity might be by screw or scroll, hence rotating compressors are of two sorts they are revolving screw and rotational scroll compressors.

IV. STATEMENT OF PROBLEM

Experimentation strategy was being utilized amid the ordinary outline of the system or past experience was being considered while planning structure, which was never been done professionally has lead for the experimental estimation and results.

In a refrigeration cycle compressor part is in charge of the power utilization and furthermore modify of COP for the better productivity of the structure. We are happy and regarded for such a superb chance to break down the power utilization on various compressors introduced in an air-cooled chiller.

In this task we have considered the plan of the ducting structure in BIM programming (Revit) for its better adaptability of investigation of load and other re-enactment highlights and examination of the power utilization is done on various compressors as this should be possible by intensive audit of various compressors indexes which was extremely useful for us to experience the particular power utilization at various load like ¼ stack, ½ stack, ¾ load and full load.

V. HEAT LOAD CALCULATION

A. Introduction to HAP

Hourly analysis program is a HVAC tool helps an engineer in designing the heat load and also helpful for the selection of an air-conditioning system based in the load obtained.

There are two major functions of HAP they are:

1) To calculate design load and

2) Energy simulation.

It is so flexible that an individual can put the input data and can get the output as quick and accurate as possible, as it follow the code and standards of ASHRAE 62.1.2007

B. Outside conditions

For summer

1)	Dry bulb temperature-	:	106^0F.
2)	Wet bulb temperature	:	76^0F.
3)	Daily range	:	14^0F.
4)	Latitude	:	17.86^0N.
5)	Longitude	:	-72.6^0E.
6)	Elevation	:	1788 ft.
7)	Maximum temperature- ranging months:		May to July.

C. Building Details

The locale of the site is at Hi-tech city, Hyderabad, Telengana. All the four sides are exposed to sunlight. The front face is facing towards north-east direction. Glass glazing is outfitted to the outer wall made of 8in. light weight concrete with 50mm as air gap is outfitted between glass glazing and 8in. Wall.

The office construction is consisting of basement, ground floor, first floor and the roof floor.

Area of basement is 68780 ft^2. Area of ground floor is 18565 ft^2. Area of first floor is 18585 ft^2. Area of roof floor is 18585 ft^2.

The details are required to input in the weather tab of HAP as shown below

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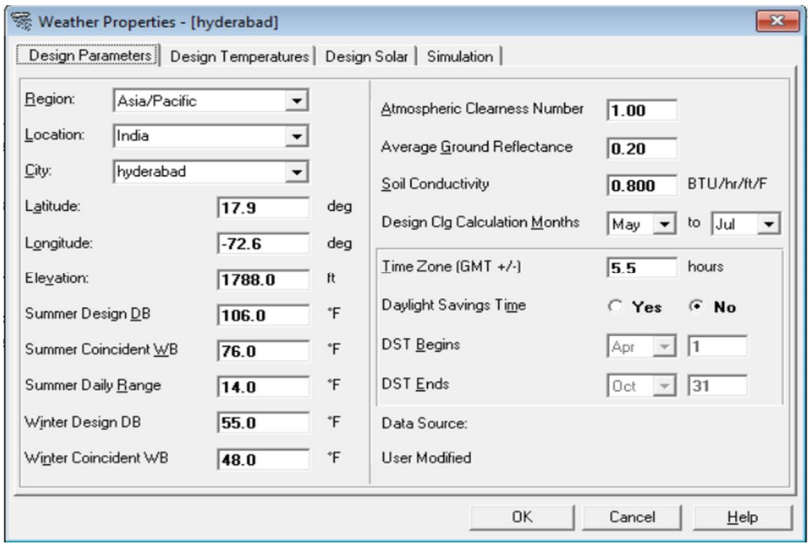
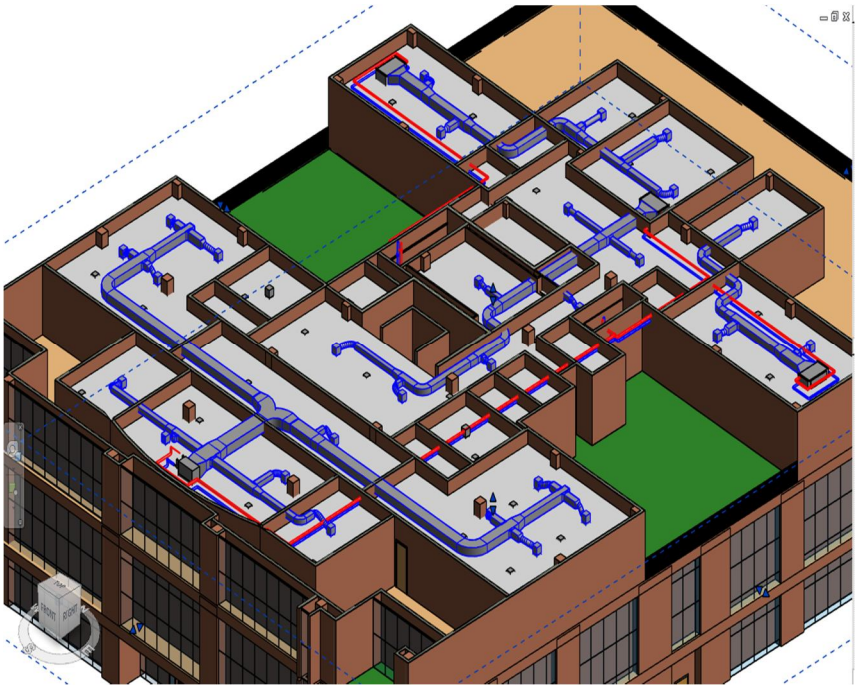


Figure 7- weather data in HAP


Figure 8- Sample of the Revit tool in 3D.

VI. RESULTS

After going through the various catalogues of Hitachi for different compressors the estimated, specific-power consumption for different compressors like screw, scroll and reciprocating air compressor when NH_3 (Ammonia) R717 as refrigerant the following results have been collected they are as follows:

If the compressor is operating at different loads such as quarter, half, three quarters and full load then specific-power consumption for different compressor are recorded from the catalogue outfits from Hitachi. From the graph shown in the figure outfits the characteristics curves of the different compressors at different loads are show.

By interpretation we can say that screw compressors are best for the load if it is operating at full load else scroll compressor would be preferred operation is for all the loads. When it comes to rotary compressor it is not nominated for its high specific- power consumption and vibrations and noise at full load operation.

Now total power consumption at different load of different compressors are shown below in the table

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Table-1 Results of total tonnage of various compressors at various loads

	Quarter ¼ load	Half ½ load	¾ load	Full load
Screw compressor	36.822 KW	57.038 KW	83.746 KW	87.640 KW
Scroll compressor	39.707 KW	59.922 KW	91.688 KW	101.79 KW
Reciprocating compressor	58.476 KW	70.025 KW	98.185 KW	135.009 KW

Note: Total tonnage obtained after the heat load estimation for the entire construction is

A. 72.2 TR.

The above obtained results are from HAP and this data is used for the modelling of the HVAC services in Revit.

After extracting the results of different specific-power consumption values of different compressors at different loads the following are nominated:

Better to choose Air-cooled-Screw chiller of capacity 75 TR for this project as the total load calculated to be 72.2 TR, because it operates with better performance at three quarter ¾ and full load and with very less noise whereas air-cooled-scroll chiller operates with better performance as close to the air-cooled screw chiller but it produces noise and vibrations during its operation.

VII. CONCLUSION

By observing the present market, there are lots of engineers would get bewildered at the selection of a compressor which would be cleared by putting the factor of space or volume i.e. for the small space or volume it would be a better idea to select reciprocating compressor and for the space or volumes it is preferred to select rotary compressors like screw and scroll and for the extremely large centrifugal compressor found to be the most suitable.

After going thoroughly through the study of different compressors we have the following conclusion points:

1) Design of HVAC system was so flexible by using the software of BIM (Construction information modelling) like Revit.
2) There was a feasibility to calculate the heat load through Revit as well as HAP but preferred HAP as it outfits accurate results.
3) Duct sizing and pipe sizing of chilled water piping was done by the Revit software itself and found to be user friendly than AutoCAD.
4) After extracting the results of different specific-power consumption values of non-identical compressors at different loads the following are nominated

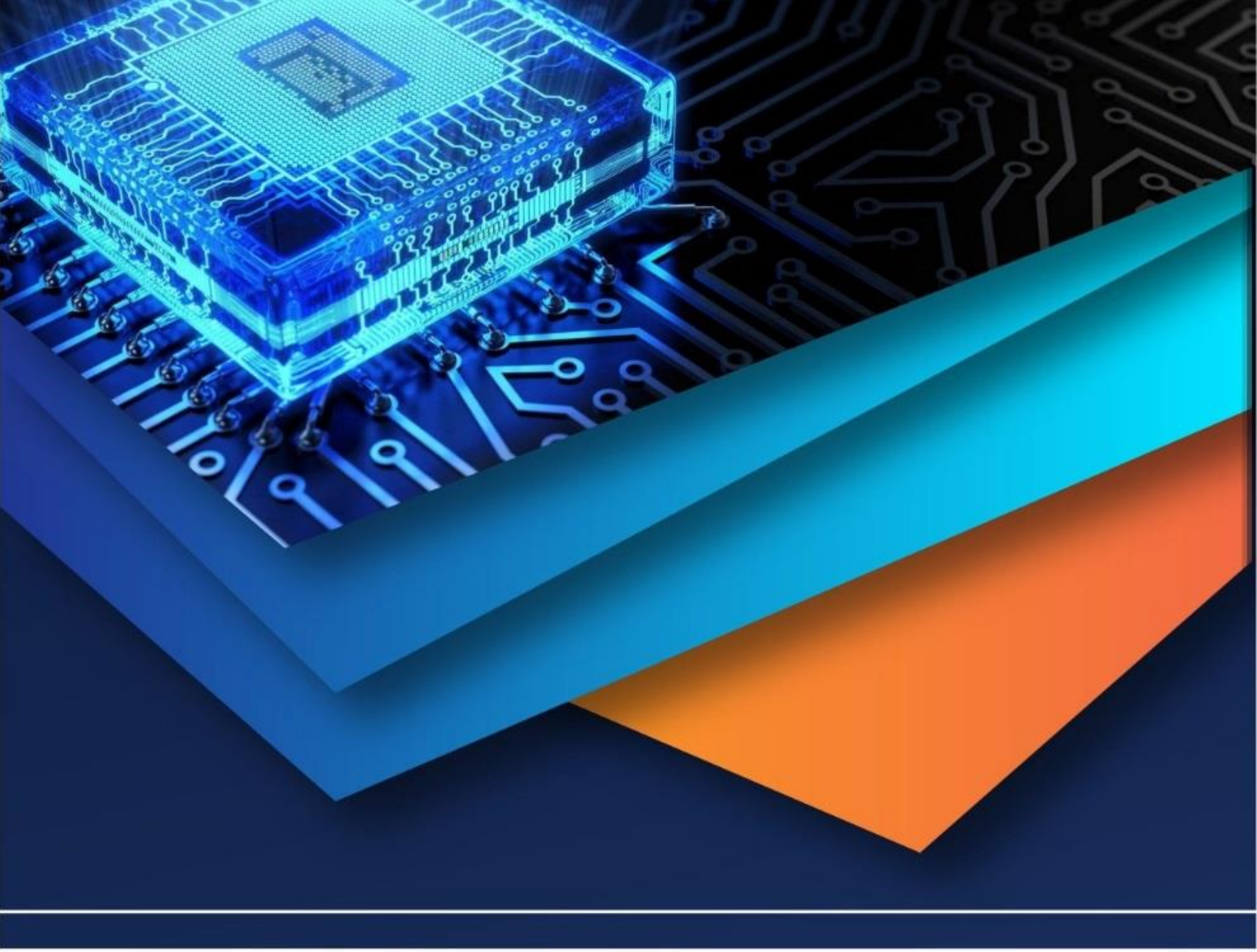
A. Scopes

This project could be used as a referral for the student for their project in the future. It outfits information about the different compressors used and their power consumption for the student which would be helpful for them to get thought of moving on to creative ideas and their implementations, Thus, helping an individual in going through the various compressors behaviour. It outfits the information of power consumption when it is operating as at different part loads. It outfits an idea how flexible is it if one uses Construction information modelling software like Revit.

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