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Scope of Aluminum Composite materials in Cleanroom HVAC Systems

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Abstract
Cleanrooms are the areas in which the many climatic parameters like Temperature, Relative humidity, Air velocity, Noise level, Odor, Dust particles, Oxygen level and Radiations are controlled and maintained within a required range. Out of all the above said parameters Dust particles and noise levels are considered in this study. Dust particles may enter the cleanroom from the outer un classified region or they may get generated by dust producing sites within the system itself. The dust generating sites may be the components within the cleanroom system start producing dust particles, may be because of wearing and tearing of the sliding surfacesor may be because of rust produced by oxidation of ferrous materials present over there in the cleanroom. The sound level is the next parameter which needs to be controlled within the cleanroom system. The sound may be from outside the system or may be because of the vibrating components present inside the system. The sound which enters from outside can be eliminated by sealing the area properly but the sound which is getting generated because of the moving and vibrating bodies needs to be controlled by proper design and selecting proper materials to produce them. In this study one components (Blower fan) which is present in the cleanroom system and has active involvement is taken into consideration. Blower fan is used in the cleanroom to circulated the air within the system and to maintain required pressure within the duct and cleanroom system. Normally blowers are manufactured by ferrous materials because of easy material availability and machinability and also by considering its low cost. But in this study Aluminum composite material reinforced with E-glass and carbon fibers has been considered to produce the blower fan. It has been considered because the material is light in weight,corrosive resistant,nonmagnetic, abundantly available,good aesthetic look,easy machinability and good thermal conductor. Because of its light weight rotating parts produce less vibration and less noise. Because of its corrosive resistance property, the rusting will not come into picture, if it is not there then the particle generation because of rusting will not come into picture. The only drawback of this material is, it is having low strength. But its strength can be improved with the help of some reinforcements like E-glass and carbon fibers.

Key words: *HVAC systems, Cleanroom Systems, Aluminum composite,E-glass and Carbon fiber reinforced aluminum composite.*

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I. Introduction

We humans always think of our comfort and we want to preserve our daily needs safely for a longer period of time. HVAC is one such technology which creates comfort environment for human as well as it preserves his daily needs and keeps them functional for a longer period of time.

The HVAC field which is related to the human comfort is known as comfort Air Conditioning system and the HVAC field which is used to care of materials and human is called as Clean Room system. Comfort AC mainly used for domestic applications and Cleanroom systems used for industrial applications.

a) **Comfort AC**: - In comfort AC the major intention is to produce comfort environment for human. Human body temperature is between 36.5 ºC -39.5 ºC, heat gets produced within the body because of metabolic activities. The produced heat should be emitted to the surrounding environment. To extract heat from the human body the surrounding environment should be at lower temperature than the human body temperature. If it is more than the body temperature as we know heat never flows from low temperature to high temperature naturally. Hence the use of comfort system is to keep surrounding temperature lower compared to human body so that the body heat can flow to the surrounding environment very easily.

Human being also feels uncomfortable if the surrounding environment relative humidity is higher compared to the required. Because when surrounding temperature is higher the body, it gets cooled by evaporative cooling that is the reason sweat comes out and gets evaporated. To water to get evaporate the moisture concentration in the environment should be minimum else sweat never evaporate.

To design comfort AC system, we should know some parameters, which are a) Human comfort temperature (18-25ºC). B) Relative Humidity (50-65%).c) Outside environmental conditions.
If the outside DBT is less than 18 ºC then heating have to be done if it is greater than 25 ºC then cooling have to be done to the ambient environment. If the outside relative humidity less than 40% humidification has to be done else if its more than 65% then dehumidification have to be done.
b) **Clean room AC system**: - Clean rooms are designed to provide an atmosphere that will protect a products or test materials from a hostile environment. They perform this function by filtering the room air to remove particulates, and by regulating the temperature, relative humidity and Static pressure within the room. The cleanliness level of room - as defined by ISO 14644-1 - is determined by counting the total number of particles larger than a specified size per M3 of air. Table no 1 gives different classes and allowed no of particles/M3.

The temperature of the working area is normally based on personnel comfort values of the workers, with 68° F (being optional for those persons wearing full uniforms (hood, coveralls, boots and gloves). Temperature above 74° F) are inadvisable unless specific processes or equipment require such high levels. The relative humidity in a clean room effects on the creation and Dissipation of static charges and consequent agglomeration of viable and non-viable particles.

There are several types of clean rooms currently in use, including horizontal and vertical laminar-airflow rooms and conventional non-laminar rooms. In addition, Unidirectional Vertical Down flow Clean Air Systems are utilized in place of, and within, larger clean environments. Each of these types has its advantages and disadvantages, which should be considered during initial design and decision is based on operations that are conducted theirin. The most efficient and practical means of maintaining a closely controlled environment for Pharma, Biotech and other industries to meet present technological need is the multi disperse vertical flow method in conjunction with LAF Units for critical areas.

The basic concept or design comprises the use of a modular ceiling system which incorporate high efficiency particulate air (HEPA) filters (each having adjustable air balancing dampers), low level return air risers, also with air control dampers and required prime air moving equipment.

In stringent requirements like Micro Electronics industries, the vertical laminar flow concept, in comparison to horizontal Unidirectional Vertical Downflow Clean Air Systems has a very definite advantages in that the filtered air is constantly being distributed downward. Consequently, the possibility of creating a "downstream" contamination problem is eliminated. This of course applies only when there are no special cases of forced cross-flow or heat convection columns disturbing the flow patterns. These are employed for rooms better than ISO Class 5. When particles are being generated directly above a clean work area, it must be considered special, and, seriously must be "dealt" with during design. The use of Unidirectional Vertical Downflow Clean Air Systems is often advisable above critical work areas. They can also provide a clean environment for small items that do not justify the installation of a full clean room, and can be placed within a class ISO 7 or 8 clean room to provide localized class ISO 5 conditions. The major drawback is that the working space, being so confined, is subject to contamination by particles injected against the airflow by workers approaching a bench or merely walking past it. For this reason, placement of machines and movement of materials and personnel should be strictly controlled.

CLASSIFICATION OF CLEANROOMS

Level (or the process of specifying or determining the level) of airborne particulate cleanliness is applicable to a Clean room or clean zone, expressed in terms of an ISO Class N, which represents maximum allowable concentrations (in particles per cubic meter of air) for considered sizes of particles.

ISO classification number(N)	Maximum concentration limits (particles/m3 of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with equation (1) and in 3.2)					
	0.1 µm	0.2 µm	0.3 µm	0.5 µm	1 µm	5 µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1 000	237	102	35	8	
ISO Class 4	10 000	2 370	1 020	352	83	
ISO Class 5	10 0000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7				352 000	83 200	2 930
ISO Class 8				3 520 000	832 000	29 300
ISO Class 9				35 200 000	8 320 000	293 000
Note : Uncertainties related to the measurement process require that concentration data with no more than three significant figures be used in determining the classification level						

Table .1

ISO Classification Number:
Airborne particulate Cleanliness shall be designated by a classification number N. The maximum permitted concentration of particles. Cn, for each considered particle size, D is determined from the equation :
Cn = 10N x { 0.1/D } 2.08
Where:
Cn - is the maximum permitted (in particles per cubic meter of air) of airborne particles that are equal to or larger than the considered particle size. Cn is rounded to the nearest whole number, using no more than three significant figures.
N-is the ISO classification number which shall not exceed a value of 9. Intermediate ISO classification numbers may be specified; with 0.1 the smallest permitted increment of N.
D-is the considered particle size, in micrometers.
0.1 is a constant, with a dimension of micrometers.

Class 5 areas are required for manufacturing Sterile Products. In this case the air filtered through HEPA (High Efficiency Particulate Air) flow either horizontally or vertically with a clean sweep in a straight-line flow without any turbulence in the air flow (Laminar Air Flow) now called unidirectional airflow.

Proper designing of Clean Rooms is very important in order to maintain the desired room conditions. The basic data require for the design of Clean Room viz. Products to be manufactured, process flow and conditions, capacities, utilities required. HVAC requirements, room finishing, any product related specific condition etc., shall be provided by the process and engineering personnel for designing the layout.

II. Scope of Aluminum composites in Cleanroom HVAC Systems

HVAC cleanrooms required a material which should have a) Good aesthetic look, b) light in weight c) Corrosive resistant d) High strength to weight ratio e) Nonmagnetic f) Easy to fabricate g) Long life.

Reason to have above said properties

a) Good aesthetic look:Cleanroom is the man maid environment where all the air properties and physical appearance of the system are controlled according the requirement of user and the products which exist in the system. Creating Cleanroom environment is mainly due to improve the person performance and maintain and regulate the quality of the product produced in the cleanroom system. Comfort environment always improves the performance of the person who working in the cleanroom like sensitive areas. And also the required quality of the product can be maintained. To make person comfortable within the cleanroom system the system aesthetic look should be good enough to keep him active and performing. Aesthetic look leaves positive impression on the person's mind and keeps him motivated and active perform well.

b) Light in weight: Cleanrooms are installed after civil work, when infra is ready. In the building Civil structure holds the entire weight of components of Cleanroom system, Plumbing system, Electrical system, Firefighting system etc. If a structure carries more weight for some time the stresses starts inducing into the structure material, and it may lead to viscoelastic creep. Creep is a type of material failure and depends on the amount of load which is responsible for it. More the load more will be the failure if lesser the load lesser will be the failure. Here the Cleanroom system adds some load to the Civil structure. It can be minimized by using lightweight materials to construct it. The major cleanroom components are Air Handling Unit(AHU), Duct system to carry air, Chilled water piping System to carry chilled water from Chillers to AHU and AHU to Chiller, Cold and hot water pipe from cooling tower to chiller and from chiller to cooling tower. AHU mainly contains blower, filters, mist eliminator cooling coil etc. Blower is having rotating impeller which produces vibration and noise because of load imbalance and random hitting of air on impeller blades. This problem can be solved by using light weight impeller blades. Only light weight is not enough it should also have strength to function well during its life cycle.

c) Corrosive resistance: Corrosion particles are the rust particles formed on the surface of material because of oxidation, Corrosion can be seen on ferrous materials. If such materials are used in constructing cleanrooms, then the rust particles may contaminate the cleanroom air and hence may spoil the products which exist in the system. To avoid this problem corrosive resistant materials, have to be used to construct cleanrooms. All the materials which are open to the cleanroom environment should be corrosive resistant materials. If otherwise they act as a particle generating sites.

d) High strength to weight ratio: Using lightweight materials is for reducing creep failure of the structure material. But strength should not be compromised. Forexample, the AHU is having a bower which circulates the air within the system. The blower is having impeller mounted on shaft. If the impeller weight is more it may create more vibration and more noise because of weight imbalance which exist normally in the rotating objects (Because of Centre of gravity may not coincides with the rotation axis). If the weight of the rotating object is much less, then the mass imbalance also reduces and hence amount of vibration and noise level goes down. In process of reducing weight strength of material should not hampered, hence some composite materials are preferable for this application.

e) **Nonmagnetic**: Magnetic materials may attract some radiations or they may repulse depending on their polarity. If the cleanroom facility is for testing facility, then the magnetic materials may hamper the final results of some tests conducted in the cleanroom facility.

f) **Easy to fabricate**: Erection of the cleanroom with such materials should be easy, so that the fabrication time and cost can be reduced effectively.

g) **Long life**: Cleanrooms are the costliest facilities. Once fabricated should be functional for long period of time.

After observing all the above points, it becomes evident that the aluminum composite materials much preferable materials in cleanroom systems because of its good aesthetic look, it is light in weight, it is nonmagnetic, easily it can be fabricated. But strength and life of the aluminum can be increased by adding some reinforcements like carbon fibers and E-glass which have much more tensile strength than the aluminum.

III. Conclusion

In cleanroom HVAC application the aluminum composites are much suitable materials because of their matching properties with the required properties. Incleanrooms for example if impeller fan is made of heavy materials then it may generate more vibration and noise because of mass imbalance due to the distance between center of gravity and axis of rotation. Instead of using heavy ferrous materials to make impeller fan if light aluminum composites are used then certainly the mass imbalance will reduce for a given distance between the axis of rotation and center of axis. Hence it reduces the noise and vibration in the system. After adding reinforcements like carbon fiber and E-glass to the aluminum matrix material, theprepared composite functions well for a long period of time.

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