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A GLANCE ON RADIANT COOLING TECHNOLOGY FOR HEATING AND COOLING FOR RESIDENTIAL AND COMMERCIAL BUILDING APPLICATION

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INTRODUCTION

In this modern era the use of energy is more because the growth of population is increases day by day. To reduce the energy consumption is most challenging. The commercial and residential building uses energy, as compare to this both buildings the commercial buildings are uses more energy because of air-conditioning devices are used to provide thermal comfort to people inside the building. The EU says that cooling and heating applications uses more than 40% energy from total energy which required for building [1]. The target is to reduce the energy consumption and give better thermal comfort to peoples; the use of Radiant Cooling is good. Radiant cooling is alternative air-conditioning systems it is having cooling panels to provide the cooling to buildings [2, 3]. D. Petras is researcher who researches that radiant cooling uses less energy and give more thermal comfort [4].By using the radiant system local discomfort and draft rate reduced [5]. To check the thermal comfort by using radiant cooling there was a tremendous research done considering the risk of condensation [6-7].

This article describes all the information regarding to radiant cooling. Many more authors are researched that the temperature during radiant cooling process could be perceived up to 2^0C lower than with mixed air system process [8]. According to study the ISO standard 7730 is applicable for radiant cooling system [9]. Radiant cooling system has two types which are chilled slabs and ceiling panels. There is a no noise and less air distribution during process for radiant panels [10]. Radiant cooling is a capacity to take individual cooling loads and due to which the thermal comfort is improves [11]. As compare with other ventilation systems the radiant cooling has higher temperature cooling source and due to which it has higher coefficient of performance [12]. The ceiling radiant cooling panel is most important type of radiant cooling system [13]. For determine the convective and radiative heat transfer coefficient more work has been done [14]. To determine the performance of radiant ceiling panels there are some models developed and

after studying on this models its conclude that the temperature of panels are depended on their particular application, material to be used to make the panels and configuration [15]. According to the research it is clear that temperature of supply air goes up to 24^0C to 18^0C, it increases the indoor air temperature by 26.5^0C. Due to which the energy is saved up to 13% and more for water chillier [16]. For the heat load calculations, designs, principals for radiant cooling the ASHRAE standard handbook is used [17].

- **TYPES OF RADIANT COOLING SYSTEM-**

1. Embedded surface system [18, 19]-

In this system the pipes are distributed within a layer like walls, floors, ceiling etc. This pipes structure is isolated with the building construction. The Figure 1 shows Embedded surface system.Thermally activated ceiling system [18, 19]-

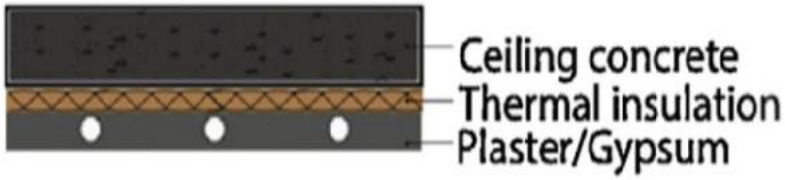

Figure 2: Embedded surface system [20]

In this system the pipes are distributed into main building structure also in the walls, ceilings and floors. The Figure 1 1 shows thermally activated ceiling system (TABS).

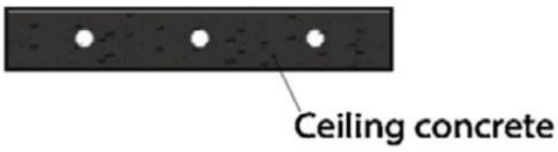

Figure 1 2: Thermally activated system [20]

2. Radiant Panel System [17, 19]-

   In this system the panels are used and in these panels the pipes are distributed. The Figure 1.2 shows the Radiant panel system.

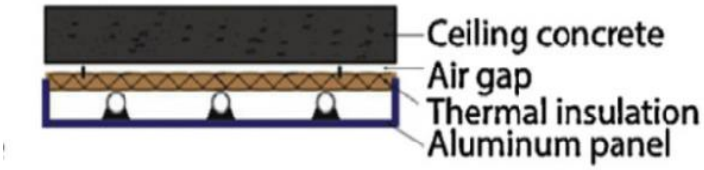

Figure 1.2: Radiant Panel System [20]

- **COMFORT FROM THE RADIANT HEATING -COOLING SYSTEM-**

It is very important to study about thermal comfort which the people get from the radiant cooling system. According to study the utilization of the heat transfer between the radiant surface and human body is important. At lower air temperature the human body realizes thermal comfort during radiant heating and at higher air temperature the human body realizes thermal comfort during radiant cooling [18, 21]. Within the space radiant cooling system provides stable thermal environment to human body [22]. It has vertical radiant cooling and heating temperature gradient [23]. The temperature 17^0C to 29^0C is sufficient for floor surface according to ASHRAE standard 55 & ISO 7730. For floor cooling the temperature is not less than 19^0C. Due to radiant heating system the indoor air quality is get improved and helps to reduce the dust transportation compare to other heating system. Peoples feels better indoor air quality in the presence of radiant heating system because of lower air temperature inside the indoor environment as compare to conventional system. For displacement ventilation system guaranties that high indoor air quality in chilled ceiling system. Mixing ventilation is also combined with radiant cooling system for better thermal comfort.

- **ENERGY SAVING BY THE RADIANT HEATING-COOLING SYSTEM-**

For the radiant heating and cooling system water is used as a thermal medium, during heating and cooling the water flows through the pipes and absorbs the heat. Water has capacity about 3500 and more to absorb the heat. So, the transportation of the energy is reduced as compare to conventional systems. In this both systems the lower temperature is required to heat the surface and higher temperature for cooling the system. The system provides acceptable thermal comfort level by utilization of heat transfer and large surface for the heat transfer. According to this principal the system maintain air temperature lower for heating and higher for cooling. So, its results to reduce the energy consumption for ventilation system as compare to conventional system. According to these principles for radiant cooling system the electricity is saved up to 25% of the original value. It has been proved that 50% cooling capacity of chiller can be reduced by the installation of thermally activated ceiling systems. If it is possible to run pumps at night time which results to reduce the energy peaks and electricity cost.

CONCLUSION

It is conclude that in this modern the demand of energy and supply is increases day by day. Due to which the energy consumption rate is increases rapidly. In this study we conclude that the commercial and residential buildings both utilizes more energy but the commercial buildings uses more energy because of heating and cooling applications to maintain the thermal comfort in indoor environment and feels better to peoples. The heating and cooling systems in buildings consumes 40% of energy from the total energy consumption. To overcome this problem and get better thermal comfort the Radiant Heating and cooling system is beneficial for both the residential & commercial buildings. Radiant heating and cooling systems has three types and according to that there construction is discussed. Thermal comfort is a main thing which human being required so, the radiant heating and cooling system gives good thermal comfort as compare to conventional systems. Also, we conclude that according to principal we can save the energy for chiller and improve the overall efficiency of the system. It is proved that the radiant heating and cooling system has good coefficient of performance as compare to other ventilation systems. As we discus that the cooling load calculations by using analytic studies and heat

transfer study. Overall we conclude that the Radiant Heating & Cooling is better solution to reduce the energy consumption and gives good thermal comfort to peoples as compare to conventional systems.

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A REVIEW ON PROPERTIES AND SCOPE OF NANO-PHASE CHANGE MATERIAL FOR LOWER TEMPERATURE APPLICATIONS

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INTRODUCTION

Thermal energy storage systems for both heat and cold are necessary for good performance of many industrial processes [1-2]. High energy storage density and high power capacity for charging and discharging are desirable properties of any storage system. TES could be the most appropriate way and method to correct the gap between the demand and supply of energy and therefore it has become a very attractive technology. It is well known that there are three methods of TES: sensible, latent and chemical heat storage.

1. **Sensible heat**

The energy storage density in sensible heat storage is determined by the specific heat capacity of the storage media and the temperature changes of the material. This temperature change (ΔT=T2-T1) depends on the application and is limited by the heat source and by the storage system. The sensible heat stored in any material can be calculated as follows:

$$Q_{sensible} = \int_{T_1}^{T_2} C_p \cdot dT$$

Where Qsensible is the sensible heat stored, Cp the specific heat of the material, and ΔT the temperature change.

2. **Latent heat**

Another means of storing energy is by using phase change materials (PCM). The energy density could be increased by using PCM, having a phase change within the temperature range of the storage. Considering the temperature interval (ΔT=T2-T1) the stored heat in a PCM can be calculated as follows:

$$Q_{latent} = \int_{T_1}^{T_{pc}} C_{p,s} \cdot dT + \Delta H_{pc} + \int_{T_{pc}}^{T_2} C_{p,l} \cdot dT$$

Where Q_{latent} is the sensible and latent heat stored and ΔHpc is the heat of fusion at the phase change temperature ΔTpc.

The use of PCM in different applications is presented, differentiating those ones that are already in the market from those ones that have been studied by researchers. PCM offer the possibility of thermal protection due to its high thermal inertia. This protection could be used

against heat and cold, during transport or storage. Protection of solid food, cooked food, beverages, pharmaceutical products, blood derivatives, electronic circuits and many other is possible. Some of the different applications for cold storage presented are the following ones:

- Cooling: use of off-peak rates and reduction of installed power, ice bank.
- Thermal protection of food: transport, hotel trades, ice-cream, etc.
- Medical applications: transport of blood, operating tables, cold therapies.
- Industrial cooling systems: re-gasification terminal. [3]

Phase change heat storage materials; divided as organic and inorganic materials. Organic materials are further classified as paraffin and non-paraffins (fatty acids, eutectics, and mixtures). Experiments (melting and freezing cycles) using these materials showed that they crystallize with little or no sub cooling and are usually non-corrosive and very stable. Inorganic materials are further classified as compounds and eutectics. A eutectic material is a composition of two or more components, which melts and freezes congruently forming a mixture of the component crystals during crystallization. Eutectic nearly always melts and freezes without segregation, leaving little opportunity for the individual components to separate. Eutectic mixture melts almost at constant temperature. Main inorganic materials are salts, salt hydrates, aqueous solutions and water. The selection of a salt hydrate as a PCM can be eased by a good. The thermal conductivity of nanomaterials plays a vital role in enhancing the conductivity of PCMs. Nanoparticles were commonly used for incorporation in PCM which improves their thermos-physical properties like thermal conductivity, diffusivity, specific heat and latent heat capacity.

Properties of phase change material,

1. Thermodynamic:

- Melting temperature in desired application range.
- High latent heat of fusion.
- High density.
- High specific heat for additional Sensible storage.
- High thermal conductivity.
- Congruent melting.
- Small volume changes during phase transition.

- No super cooling.

2. Chemical:

- Chemically stable over long periods.
- Non-corrosive to container materials.
- Non-flammable, non-toxic and non-explosive.

3. Economic:

- Low cost.
- Available in large quantities.

Preparation of Nanofluids

Preparation of nanofluids is the first key step to synthesize fluids with improved thermal conductivity. These nanofluids are obtained by suspending nanoparticles in the range of 1–100nm in conventional regular fluids in suitable volume fractions. Theoretically, when solid particles with high thermal conductivity are added to fluids, the overall thermal conductivity is improved due to the change in flow, heat, transport, and heat transfer features of the liquid [4]. The single-step method involves the preparation of nanoparticles and dispersion of them in the host or base fluid simultaneously. The nanoparticles can be directly prepared via physical vapor deposition technique or liquid chemical method. In the two-step method, which is the most widely used method for preparing nanofluids, the nanoparticles, nanotubes, nanofibers, or nanorods are first produced by chemical vapor deposition, inert gas condensation, or any other technique as a dry powder. The second step involves dispersing this nanopowder into the base fluid with the help of intensive magnetic force agitation, ultrasonic agitation, high shear mixing, homogenizing, and ball milling. The two-step method is more economical than the one-step method to produce nanofluids commercially. The main disadvantage of this method is that, due to the high surface area and surface attractively, the nanoparticles tend to agglomerate. [5].

Stability of Nanofluids

Agglomeration of nanoparticles has severe ramifications ranging from clogging of micro channels to reduction in thermal conductivity of nanofluids. Sundry of methods have been developed to assess the stability of nanofluids and the simplest of all is sedimentation method. The nanofluids are said to be stable when their concentration remains constant. Physical

inspection by naked eyes is also usually considered one of the methods for observing stability of nanofluids. Below, some methods are described for analyzing stability of nanofluids. [6]

1. Zeta Potential Analysis: The electric potential difference between the dispersion medium and the stationary layer of fluid is termed as zeta potential. This potential is crucial for depicting the stability of colloidal suspensions. The higher zeta potential is, the more stable colloidal suspension will be and vice versa.

2. Spectral Absorbency Analysis: Spectral absorbency analysis (SAA) is another efficient way in addition to zeta potential analysis in order to assess the steadiness of nanofluids. Generally, there exists a linear relationship between concentration of nanoparticles in fluid and the absorbency intensity. If nanomaterials, which are dispersed in base fluids, possess characteristic absorption bands in the wavelength range of 190–1100 nm, then stability of nanofluids can be evaluated by using UV-vis spectroscopy reliably. Nano-PCMs with their combined benefits from latent heat storage of PCMs and high thermal properties of nanomaterials have found applications in modern energy systems to improve their system performance, power savings and contribution towards reduction of global gas emission. [7]

II PROPERTIES OF PCM AND NANOPARTICLES USED FOR COLD CHAIN APPLICATIONS

Table 1.Thermo physical properties of Phase Change Materials

Authors	**PCMs**	**Thermal conductivity "k"in (w/mk)**	**Density in (kg/m^3)**	**Specific heat capacity"c_p"in (J/kgK)**	**Latent heat of fusion "L_h" in (J/kg)**	**Melting temp "T_m" in (k)**
A.A. Altohamy et al. [8]	Water	0.561	999.84	$4.182x10^3$	334×10^3	273.15
S. Yu et al. [9]	Bio-based PCM	0.2	860	---	$149.2x10^3$	301.28
Shuying Wu	Paraffin	0.2699	900	$2.95x10^3$	$205.6x10^3$	329.333

et al. [10]						
C.J.Ho et al. [11]	Water	0.62	997	$4.17x10^3$	$333x10^3$	273.15
	Microencapsulated PCM	0.31	961.4	$2.13x10^3$	---	309.55
S. Mossaz et al [12]	THERMINOL66	117.6	1007.1	$1.6269x10^3$	---	---
O. Sanusi et al. [13]	n-tricosane	0.2(Solid)	796.9	$156.7x10^3$	$2.2x10^5$	329.15+2
X.L. Wang et al. [14]	C-L Acid matrial code (C0.14)	0.375 (Solid) 0.372(liquid)	870.8	$1.853x10^3$(Solid) $1.891x10^3$(liquid)	$100.1x10^3$	---
A. Zabalegui et al [15]	Paraffin	0.21(Solid) 0.12(liquid)	900(Solid) 780(liquid)	1888(Solid) 2272(liquid)	$1.8x10^5$	326
R. Hossain et al. [16]	Liquid Cyclohexane	0.127	779	$1.763x10^3$	$32.557x10^3$	---
B. Rajabifar[17]	Nanoencapsulated n-octadecane	0.18	815	$2x10^3$	$244x10^3$	---
A.B.S. Alquaity et al. [18]	Nanosizedlauric acid PCM Particle	0.147	1007	$1.76x10^3$	$211x10^3$	---
R. Pakrouh et al. [19]	Paraffin RT44	0.2	780	$2x10^3$	$255x10^3$	314.15-318.15
M. Karthikeyan et al. [20]	Nanoencapsulated paraffin	---	---	---	$74.2x10^3$	337.45
Kin Yuen Leong et al. [33]	Paraffin Wax	0.305	---	---	---	60°C – 62°C
C. L. Saw et al. [36]	water	0.226	976.5	1838.0 (solid) 2086.0 (liquid)	160.3 (liquid)	59.6
IoanSarbu et al [38]	Ice	---	920	---	333	0
	Na-acetate trihidrate		1300		250	58

	Paraffin		770		150-240	-5-120
	Erytritol		1300		240	118

Table 2 Thermophysical properties of Nanomaterials

Author	**Nanao materials**	**Bulk density (Kg/m^3)**	**Thermal Conductivity (W/m K)**	**Specific heat capacity (J/Kg K)**
S. Wi et al. [21]	xGnp	$5.3X10^{-6}$-$1X10^{-5}$	2-300	710
A.Sciacovelli et at. [22]	Cu (Avg.dia. 15mm)	8954	400	383
H. Peng et al. [23]	Al (Avg. dia.20mm)	2688	237	905
A.Adil et al [24]	Sio_2 (Avg. dia.12mm)	2200	1.38	773
	Tio_2 (Avg. dia.20mm)	1156	8.4	692
Ilone J [25]	SWCNT	2600	6600	425
L. Fan et al. [26]	CuO	6310	18	540
Elgafy et al. [27]	CNF	2260	1950	---
Wei Yu and	MgO	2900	48.4	---

HuaqingXie [39]	TiO_2	4100	8.4	---
	ZnO	5600	13	---
	Al_2O_3	3600	36	---
	SiO_2	2600	10.4	---

CONCLUSION

The present paper gives a comprehensive review of the properties of phase change material and nanoparticles related to the application of thermal energy storage system. PCM combined with Nanoparticle benefits latent heat storage of PCMs and high thermal properties of nanomaterials, has found applications in modern thermal energy storage systems. The use of PCMs with nanomaterials will improve thermal properties, power savings, and contribution towards the reduction of global gas emission. Water, paraffin, and Bio-based PCM were commonly used PCMs in engineering. Nanomaterials like Al, Cu, SiO_2, TiO_2, Carbon nanotubes (CNT), Carbon nanofibers (CNF), Al_2O_3, NaOH KOH, etc. In thermal energy storage systems (TES) PCM and Nano-PCMs with Nano-particles were successfully employed and achieved good system performance. The nanoparticle plays a very important role in enhancing the thermal conductivity of the base PCM. The addition of nanoparticle increases the dynamic viscosity of the fluid which requires more pumping power. Nano encapsulated PCM with good fluid properties could solve the additional pumping power requirements. The use of Nano-PCM is a composite in cement and food storage packing for investigation. Despite the numerous researches work investigated on the nanoparticles and their enhancement of the thermal performance parameter of the thermal energy storage base materials. More investigations are needed to understand the distribution and encampment of the nanoparticles in the base materials. Further research should be directed towards using a mixture of more than one nanoparticle to increase the thermal performance and efficiency of thermal energy storage system.

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A STATE OF ART: GRAPHENE RESEARCH WITH THEIR PROPERTIES AND APPLICATIONS

ShivaniHogade, Rohit S. Dayma, Sanket S. Bapat, Abhishek K. Bhagate, Manas V. Patil, HrutujaMadake

INTRODUCTION

Graphene, a single layer Graphite, having extraordinary properties, has made an irreplaceable imprint, when it comes to its wider range of applications. Its unique two dimensional structures, superior thermal conductivity, room temperature quantum Hall Effect, magnificent electron mobility, exceptional mechanical strength, high surface area etc. has affirmed its individuality. Several graphitic materials such as fullerenes, carbon nanotubes, and graphite, those are widely applicable in most of the sectors can be synthesized with the help of Graphene. Graphene is a one-atom thick planar sheet of sp2 bonded carbon atoms packed in a honeycomb lattice structure [1]. In other way Graphene can be defined as the two dimensional sheet of sp2 hybridized carbon. Other Graphitic allotropes can be easily derived from the basic structure of Graphene such as its wrapping with produce 0D fullerenes rolling will create 1D nanotube (CNT), and stacking will cause 3D graphite. Long-run π-conjugation in graphene yields phenomenal mechanical, thermal and electrical properties which have for some time been the enthusiasm of numerous hypothetical investigations and all the more as of late turned into an invigorating zone for experimentalists [2].

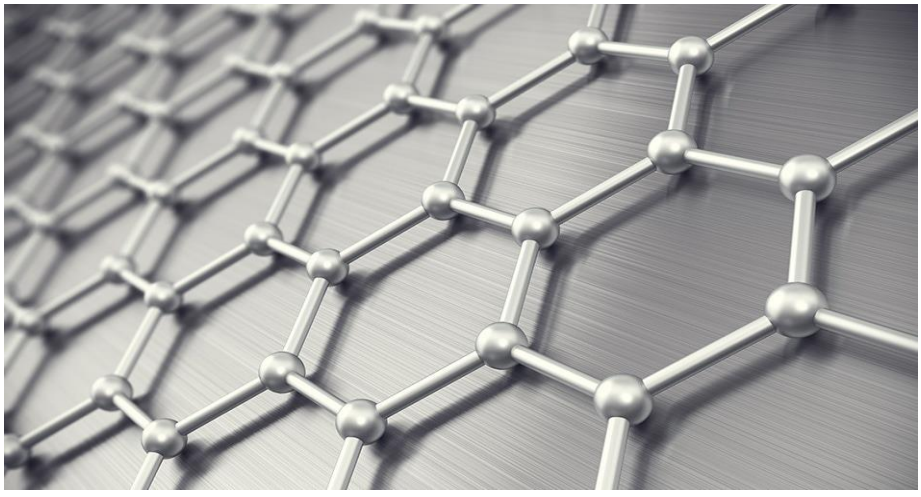

Figure 1: Basic Hexagonal Structure of Graphene

The other phenomenal properties of the same related to optical, electrical and chemical sectors are caused due to its ability of stacking of two layers. The characteristic of it, of absorbing 2.3% white light, assures its transparent nature. It suits most of the electronic applications due to its 2D hexagonal structure and presence of charge carriers which behaves like massless particles. The infinite plane of perfect graphene has a zero electronic band gap and even the electrons have zero effective mass, which signifies its electronic properties. It can conduct electricity better than copper and even diamond and. Graphene is categorized one of the strongest material due to the fact that carbon-carbon bond length is 0.142 nanometre which gives tensile strength of 130 GPa, Young's modulus of Graphene counts 1TPa., which is experimentally proved. The carbon atom of an aliphatic compound such as methane has a longer covalent single bond radius as in diamond. [3]. Though being summarized as one of the hardest material, it is very light in nature. It weighs about 0.77mg/m^2. Another property of Graphene, which attracts most of the physicists to it, is that it is the thinnest material that can be imagined ever measuring thickness of about 0.345nm thick. Graphene has an astonishing ability of self-healing holes in its sheets while exposed to containing carbon molecules such as hydrocarbons. The infinite plane of perfect graphene has a zero electronic band gap and even the electrons have zero effective mass, which signifies its electronic properties. Apart from this, Graphene ranks excellent while it comes to the thermal properties. Its thermal conductivity ranges from 3000-5000 W/m.K which is much higher than that of copper as well as diamond at room temperature. Specific heat of the same is about 700J/Kg.K which is found experimentally. There are various methods to produce Graphene and most of them are available at low cost and much easier to carry out. These methods include Chemical Vapour Deposition, Mechanical Exfoliation, Electrochemical Exfoliation, some chemical methods such as Hummer's method etc. One of the above methods can be selected by considering the cost, time required and product to be obtained etc. It is available in diverse forms mainly Graphene, Few Layer Graphene (FLG), Multilayer Graphene (MLG), Graphene Oxide (GO), Reduced Graphene Oxide (rGO), Graphene Nanoparticles etc. All of them have wide area of applications. These forms either alone or in coalescence with other materials have reached a milestone due to its applications. All of the above parameters are the reasons why Graphene has attracted most of the sectors including mechanical, electrical, electronics, medical etc. towards it. In recent days, most of the articles related to Graphene have been published, but very few of them cover integral information about each and every aspect of the same. In this review paper, we aim to glance through the historical

background, synthesis methods, applications in various sectors as well as challenges faced in practical implementation of Graphene and Graphene based materials.

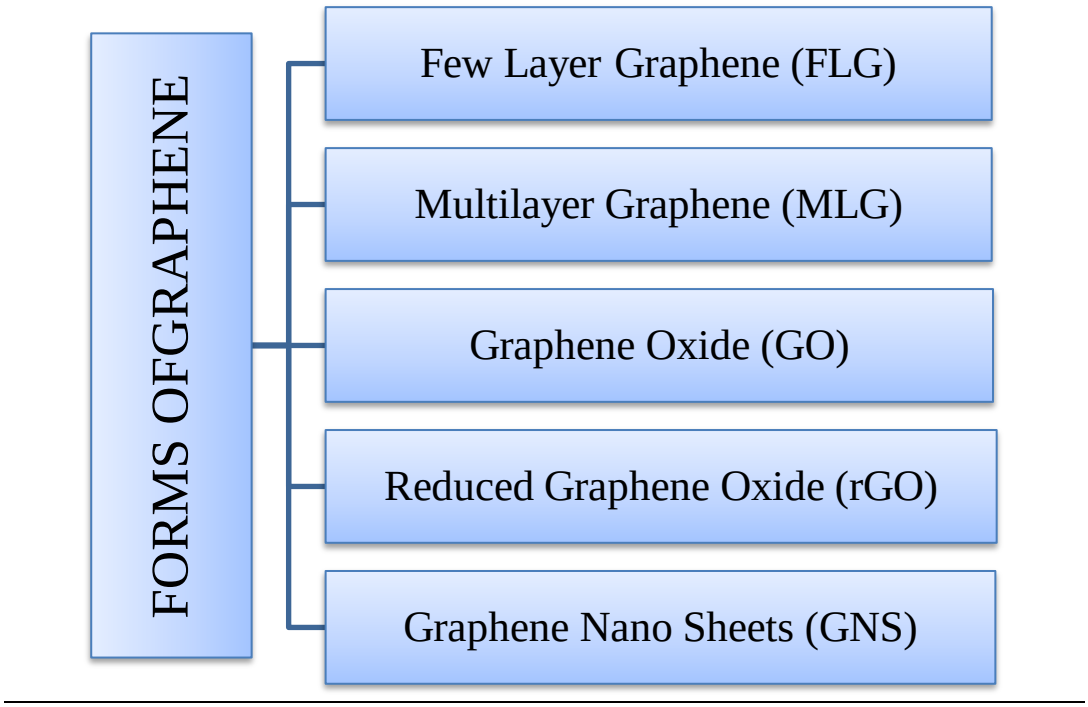

Figure 2: Forms of Graphene

HISTORICAL BACKGROUND

Graphene was already studied in 1947, though theoretically as a textbook example for calculations in solid state physics by P.R. Wallace, National Research Council of Canada [4]. He not only predicted electronic structure but also derived the linear dispersion relation. He predicted the electronic structure and derived the linear dispersion relation [5]. R. Ruoff and others tried and suggested a process for Graphene extraction [6]. The very first method which was mechanical exfoliation technique was suitable for extracting thin layers of Graphene from Graphite. Konstantin S. Novoseloy and Andre K. Geim from University of Manchester, UK were felicitated with Nobel Prize in Physics in 2010 for their "ground breaking experiments regarding the two dimensional material graphene". They had succeeded in not only producing, isolating, but also identifying and characterizing Graphene.

SCOPE OF REVIEW

Graphene and Graphene based other forms have attracted a large number of sectors towards it due to its magnificent properties. Graphene alone and even in conjunction with other materials have enhanced not only optical, mechanical and electrical but also thermal and material

industry. This review paper focuses mainly on the properties, synthesis methods and applications of the Graphene. The whole paper is divided into number of parts such that first part discuss about the basic introduction and historical background of the Graphene. The next part contains information about the synthesis methods. The third part focuses on the important properties of the Graphene that have overwhelmed the all sectors. Then the forth part includes information about the applications in various industries. The conclusion part discusses about the whole scenario of Graphene research.

METHODS OF PREPARATION

There are multiple methods available for the Synthesis of Graphene. The selection of the exact method should be done on the basis on number of parameters. Some of the common methods of Graphene Synthesis are explained below.

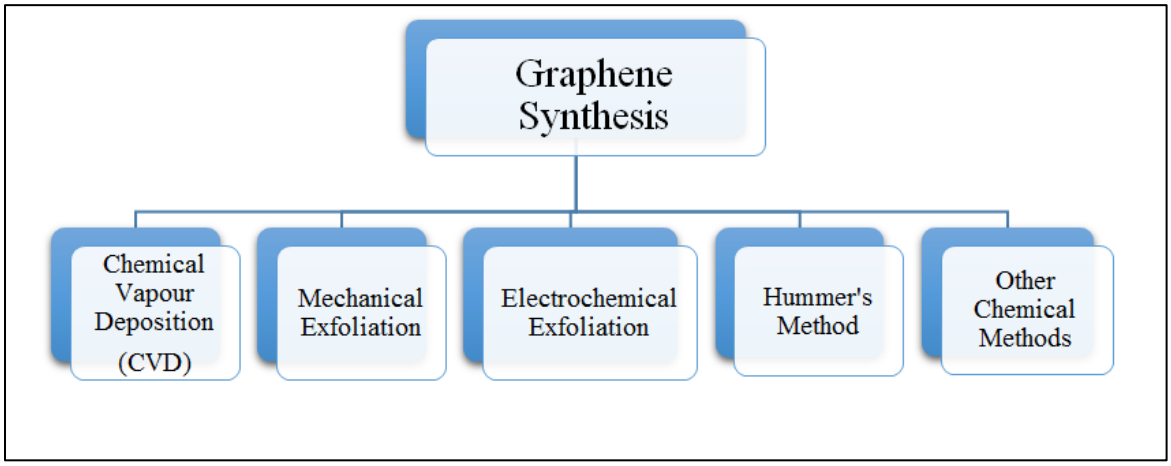

Figure 3: Synthesis of Graphene

1. Chemical Vapour Deposition (CVD) Method:

Chemical Vapour Deposition (CVD) is one of the cheapest and easily available methods for preparation of Graphene. The principle of CVD is connecting and depositing molecules of volatile gas onto a transition metal substrate. There are 2 types of CVD graphene growth as conducting through surface catalysis or carbon segregation ways depending on the metal, respectively, at high and low temperatures in the process [7]. This growth is self-limiting due to the low solubility of carbon in metal. In case of segregation, graphene is produced by way of the diffusion of carbon that is dissolved within the majority metal to the metal surface, which usually happens upon cooling for the reason that the solubility of carbon is lower in metals at lower

temperatures. The quantity of graphene layers is synthesized by segregation depending upon numerous factors: the quantity of dissolved carbon and also the cooling rate [8].

2. Mechanical Exfoliation:

This method is also called as micromechanical exfoliation. This is the most prior technique of Graphene preparation in history of Graphene. Graphene films of about 5-10 micrometre can be produced of superior quality can be produced with this method. The production cost of this method is much higher than the other ones because of the fact that low yield and rough thickness of layers. Graphite is a stack of mono-atomic graphene which can be separated into individual sheets of graphene by overcoming van der Waals forces [9]. Graphene sheets of various thicknesses can be produced through mechanical exfoliation or by stripping off layers from graphitic materials, for example, highly ordered pyrolytic graphite, so-called HOPG, natural graphite, or single-crystal graphite [10-13].

3. Hummer's Method:

1. Graphite flakes (2 g) and NaNO (2 g) were mixed in 50 mL of 3 H_2SO_4 (98%) in a 1000 mL volumetric flask kept under at ice bath (0-5°C) with continuous stirring.
2. The mixture was stirred for 2 hrs at this temperature and potassium permanganate (6 g) was added to the suspension very slowly. The rate of addition was carefully controlled to keep the reaction temperature lower than 15°C.
3. The ice bath was then removed, and the mixture was stirred at 35°C until it became pasty brownish and kept under stirring for 2 days.
4. It is then diluted with slow addition of 100 ml water. The reaction temperature was rapidly increased to 98°C with effervescence, and the colour changed to brown colour.
5. Further this solution was diluted by adding additional 200 ml of water stirred continuously.
6. The solution is finally treated with 10 ml H2O2 to terminate the reaction by appearance of yellow colour.
7. For purification, the mixture was washed by rinsing and centrifugation with 10% HCl and then deionized (DI) water several times.
8. After filtration and drying under vacuum at room temperature, the graphene oxide (GO) was obtained as a powder [14].

PROPERTIES OF GRAPHENE

As we have already discussed, Graphene has several magnificent properties that should be considered so as to understand its utility on a larger scale. Following are some properties of Graphene:

1. **Structural Properties:**

Graphite is a 2- dimensional network of carbon atoms. It is a one-atom thick planar sheet of sp2 bonded carbon atoms packed in a honeycomb lattice structure.[15] These carbon atoms are bonded within the plane by strong bonds into a honeycomb array comprised of six- membered rings.By stacking of these layers on top of each other, the well-known 3- dimensional graphite crystal is formed.It has C-C bond length is about 0.142nm**.** Graphene can self- repair holes in its sheets when exposed to molecules containing carbon such as hydrocarbons.Bombarded with pure carbon atoms the atoms perfectly align into hexagons completely filling the holes. Each atom has four bonds, one σ bond with each of its three neighbours and one π-bond that is oriented out of plane. It stability is due to its tightly packed carbon atoms and a sp^2 orbital hybridization – a combination of orbitals s, p_x and p_y that constitute the σ-bond. The final p_z electron makes up the π-bond .

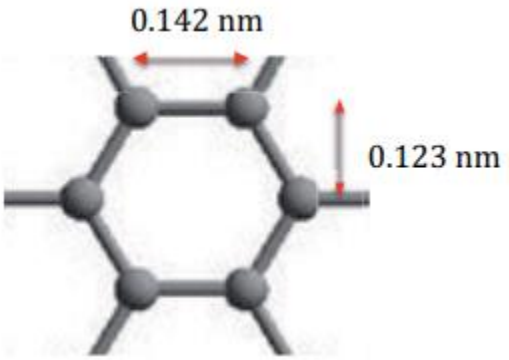

Figure 4: Bond Length of Graphene [2]

2. **Mechanical Properties:**

Stiffness, strength and toughness, are some of the impressive mechanical properties of graphene, which is one of the reasons that make graphene stand aside from the other materials. They are caused by the stability of the sp2 bonds that form the hexagonal lattice and oppose a variety of in-plane deformations.

Stiffness-

The breaking force obtained experimentally and from simulation was almost identical and the experimental value of the second order elastic stiffness was equal to 340 ± 50 N/m. This value corresponds to a Young's modulus of 1TPa, assuming an effective thickness of 0.335 nm.

Strength-

Defect-free, monolayer graphene is considered to be the strongest material ever tested with a strength of 42 N/m-, which equates to an intrinsic strength of 130 GPa.

Toughness-

Fracture toughness, which is a property very relevant to engineering applications, is one of the most important mechanical properties of graphene and was measured as a critical stress intensity factor of 4.0 MPa.m^(1/2) [16].

3. **Thermal Properties:**

Thermal conductivity-

Thermal conductivities of the Graphene and Graphene based materials depends upon also the synthesis methods through which it is derived. Pyrolytic Graphene measures thermal conductivity of about 2000 W/m.K. at room temperature. The CDR method can produce Graphene of thermal conductivity of about 1500-2500 W/.m.K at room temperature. All these values prove that Graphene is a very good conductor of heat and is even better than Copper and Diamond [17].

4. **Chemical Properties:**

The one atom thick sheets of the Graphene are more reactive than that of the thicker ones. Graphene has proved that it is the most reactive form of carbon. Due to its unique 2D structure

and being form of Carbon, each and every unit atom is in exposure for chemical reaction from two slides. The edge carbon atoms in Graphene sheets have special thermal reactivity. The burning point of Graphene is quite lowering valued up to 350 degree Celsius [18].

APPLICATIONS

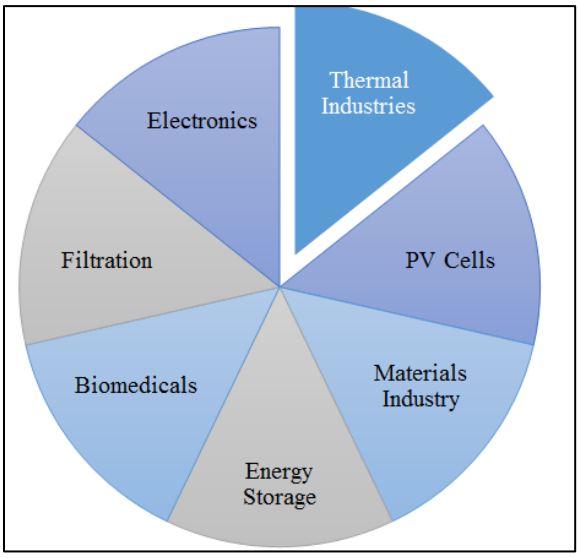

Figure 5: Diverse Areas of Application of Graphene

1. Thermal Applications:

Graphene, being world's best heat conductor, it can be implemented in most of the thermal management applications. It can be applied in the heat conducting coating, heat dissipation films and heat sinks applications. Not only is this, but also thermal management of electronic devices or components possible with the help of Graphene. As electronic devices have become more complicated and working at higher speeds, large amount of heat is generated within them. Heat spreaders, Polymer composites can be implemented in order to achieve optimum temperature range of the device.

a. Graphene in Thermal and Infrared Vision-

Graphene lenses have ability to allow thermal and infrared vision. This is the great advancement in Graphene's history. The graphene allows manufacturing such ultrathin devices with a built-in camera which can give user infrared and thermal vision.

b. Graphene in Thermoelectric:

A thermoelectric effect, occurs when heat is applied to one of the two dissimilar electric conductors or semiconductors to move electrons from the hot part to the cooler part and produce electricity. Though the energy generated by this process is very small in the range of microvolts, it has number of applications. Graphene can be added to the semiconductor in order increase Seeback Effect. It can increase this effect almost by 5 times.

2. Photovoltaic Cells:

As we have previously discussed, Graphene can absorb only 2.3% of radiant light, it offers high electron mobility. This suggests that it can be easily used as an alternative for the silicon or ITO for PV Cell manufacturing. Graphene based cells are not only potential but also due to the fact that Silicon cells are expensive, they should be preferred.

3. Graphene-enhanced composite materials:

Two or more materials with diverse properties are conjunct with each other in order to produce another material with unique characteristics. Graphene based composite materials have many advantages, as they can be made to be lightweight, strong, corrosion free and more according to the specific needs. The presence of Graphene in those materials increases its conductivity, strength of bulk materials and other superior qualities. Graphene can be added to polymers, ceramics so as to make them conductive, resistant and light weight. Graphene composite materials can be used in mobile phones so as to make light, flexible and durable casing.

4. Energy Storage

One area of research that is being very highly studied is energy storage. While all areas of electronics have been advancing over a very fast rate over the last few decades the problem has always been storing the energy in batteries and capacitors when it is not being used. These energy storage solutions have been developing at a much slower rate. The problem is this: a battery can potentially hold a lot of energy, but it can take a long time to charge, a capacitor, on the other hand, can be charged very quickly, but can’t hold that much energy (comparatively speaking). The solution is to develop energy storage components such as either a super capacitor or a battery that is able to provide both of these positive characteristics without compromise.

5. Biomedical Applications:

As we have already discussed, Graphene possess a large surface, which makes it stand apart from most of the other carbon based materials. This allows it to be an outstanding platform for drug delivery. Also, some researches have shown that Graphene composite with polymer can be used to develop sensitive electromechanical sensors, and it will be a milestone in brain surgeries.

6. Corrosion Resistant Coating:

It can also be used as a very important metallurgical tool. Corrosion-resistive coatings can be made from Graphene which could protect important building and machinery elements from corrosion. It can help in doing so by conducting the charges responsible for corrosion of a material [5]

CONCLUSION

In this article, synthesis process, mechanical properties, thermal properties structural properties and its application of graphene have been reviewed. It had been studied for over a hundred years but Geim and Novoselov found how to isolate it to be graphene and some application for its use, Graphene is more beneficial material due to its 2D nature and strong Bonds. Graphene is Biodegradable. Thus, it becomes worthy of making sensors, electronic circuits, transparent and flexible. It shall introduce new ear of devices of electronics, space, bio medical and energy harvesting. Graphene is a new material, which is the first one atom thick and 2d material that has been isolated. Graphene has novel like high mechanical strength, high thermal and electrical conductivity. These properties have made graphene an exciting proposition in the research world. Graphene is a new encouraging material for new types of devices, circuits and for system where several processes can be combined in to single sheet. And this material shows a wide range of applications in areas like electronic components, electrical, solar cells, energy storage devices and in also biomedical sector. Currently there is a critical issue with the large scale use of graphene in electronics and manufacturing.

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VARIOUS METHODOLOGIES FOR AC DUCT CLEANING

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Roshan M.Kanwade,ManojP.Karanjkar, Vishal J.Kesharwani, SanketChikhale

INTRDUCTION

IAQ is one of the most serious environmental concerns along with lead poisoning and hazardous wastes[1]. In large cities, the indoor air quality has been reported to be as much as five times worse than the outdoor air quality[1,2,3]. Possible causes of indoor air quality concerns include installation and design of the cooling and heating equipment, building design and construction, number of occupants, activities of the occupants, airborne pollutants and human physiological factors [4, 5]. HVAC units can become sources of mold, fungi and other microbial pollutants. Dirt, dust and fibrous material can accumulate inside the ductwork. One way of keeping the indoor air quality of a residential house good is to clean its HVAC unit and ductwork on a periodic basis [6]. Air conditioners are machines that alter the characteristics of surrounding air to condition more comfortable for humans by lowering temperature, eliminating humidity and distributing it to the required places. Nowadays As its need is increasing exponentially; the distribution process has also become diversified leading to the entire system as HVAC system. These distribution channels require inspection at regular intervals to maintain its high efficiency and to lower the losses of effects produced by the air conditioners [7]. The HVAC system ina building plays a crucial role in not only maintaining thermalcomfort in the indoor environment of a building but also contribute significantly to the IAQ.There is evidence that under normal operating conditions,ventilation ducts within the HVAC system can be contaminated with dusts and serve as reservoirs for microbes to proliferate [8]. AC ducts are at the position of structure

where we can’t clean it manually. We need to use vacuum or cleaning robot to perform the task. If we do not clean the ducts then it leads to serious problems in the sense of air quality,health issues and also it will effect on the maintenance of the system. We require the good and feasible solution to clean the ducts. Also it is requirement here that we have to sanitize the ducts as there is production of fungi, microbes due to collection of dust. Hence there should be integration of the sanitation process with cleaning of ducts. Lack of maintenance and cleaning of the air ducts can expose the users of the system to biologic, physic and chemical contamination. The personnel involved in the maintenance of these systems have a higher exposure to these agents, which pose a threat to the respiratory health. Fig. 1 and Fig. 2, illustrate common situations found in these type of systems.[9]

Fig. 1. Air duct accumulated with dust

Fig. 2. Presence of insects in the air ducts

CONCERN FOR INDOOR AIR QUALITY

Studies abroad have shown that 70% or more of all IAQ problems involve the HVACsystem and that most are due to inadequate care and maintenance of the system. The airducts, which are the "lungs" of a building, can accumulate deposits of construction dirt,dust, cigarette tar, smoke, insects and other air borne pollutants. Dirty air ducts can alsobecome an ideal breeding ground for mold spores, mildew, pollen, bacterial colonies and other health - threatening microorganisms. The air that occupants of such buildingsconstantly breathe is exposed to all this dirt inside the duct as well as growths of fungusand mold inside the coils and drain pans of the air handling units. [10]

Conclusion

In this review paper the various types of AC duct cleaning methodologies are mentioned. AC duct cleaning has become a need as the serious and adverse effects of not cleaning it concerned. The review consists of all the different types of robots and methodologies which are used to clean the AC ducts. The ducts maybe cleaned by the conventionalbut there are adverse effects on the individual working on it. Hence there should be use of proposed robotic systems for cleaning it. We can use different type of brushes and robots with respect to size and type of the robot. From research reviews we found that we can add so many advance techniques and features to optimize the cleaning process. After going through all this research reviews it can be concluded that the duct cleaning is essential factor and we can achieve it by using various types of robots.

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CENTRALIZED SANITIZATION AND DISINFECTION SYSTEM

Santosh ChidanandShivpuje, Rupesh Sanjay Ingale,HrishikeshGajananrao Mane, Rohan Mahesh Patil, Nikita Mane

Introduction:

We have come up with the Innovative Smart Disinfection and Sanitization System to Minimize Human Interference and to Cover Large portion in less time. At a time we can sanitize whole Building. Disinfection of Hospital after respective time will be done by Automation and Especially in Offices Sanitization will be done before and after working time. For using it into Public Places and Societal Community Areas by making different Single Unit. Disinfection is characterized as a cycle of complete end or pulverization of all types of microbial life (both

vegetative and spore structures), which is done by different physical and chemical methods. Actually, there is decrease ≥106 log colony framing units (CFU) of the safest spores accomplished at the half-season of a customary cycle. [1]

Problem Statement:

Currently various Machines are used for Sanitization with great Human Interference. Some are Hand operated spraying Machines which are not capable to cover each portion in less time and some are Huge and Bulky machines which consumes more energy and labour efforts, which requires high Investment and also they are difficult to Handling and Maintenance.

Solution:

- The Centralized Disinfection and Sanitization System will minimizes Human Interference and Cover large portion in less time
- Fixed design and installation of solution carrier pipes by automatic mixing principles
- Installation of Centralized common system instead of many Machines
- System can fix at one location and transfer solution at Specified Area for Sanitization in specific time

Technical Description:

In our Project we used various Technical Parameters to get Efficient Solution for Sanitization such as, Compressed Air, Disinfectant Basaloid, Material and Type of Nozzle. After considering Technical Parameters we made list of Components required for trials and Completion of project. We studied a lot from taking number of trials by altering Components, Material of Parts, and Location of Parts. Finally we got expected Results at output then we fixed the Structure and Technical Components for our Working Prototype. We used following components,

1) Air Compressor (Pressure 1-2 Bar) [2]

2) Centrifugal Pump (1/2 HP)

3) Multipoint Brass Nozzle (4 Openings, Connection Size: - 12 MM, 3.5 Bar Pressure Capacity)

4) Flexible Hose Pipe (Diameter: - 12 MM)

5) Y-Connector

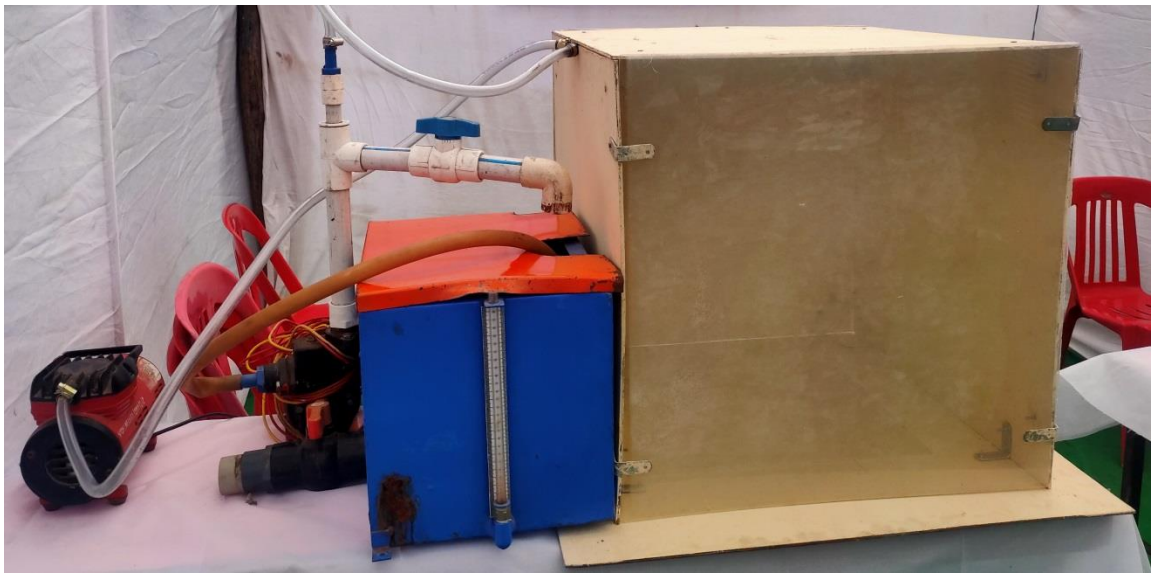
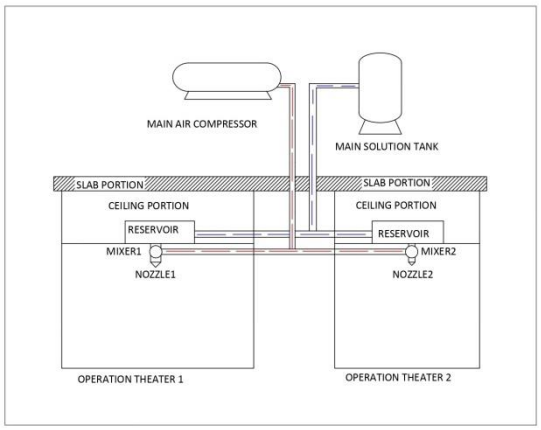


Fig 1: Working Prototype

Working:

The compressor generates a compressed air. This air is flows towards to one of the connector end through hose pipe under high pressure. In the solution tank the Bacilocid is diluted with proportion amount of water in it. The Centrifugal Pump which sucks the diluted Bacilocid solution from the solution tank. The high pressurized solution is enters at one end of connecter. In connector the compressed Air &Basillocid solution is mixed with each other under high pressure. Then this mixture is transported towards nozzle inlet through rubber hose pipe, the nozzle will converts high pressure energy into kinetic energy which increases its velocity at the outlet of multipoint nozzle. When this Pressurized Mixture passes through Nozzle then it optimized into Small Particles which will further spread in a Specified Area to sanitize for

Microbiological Decontamination and Kill Viruses. In such way our Project will help in this Pandemic Situation and post Pandemic Situation too.



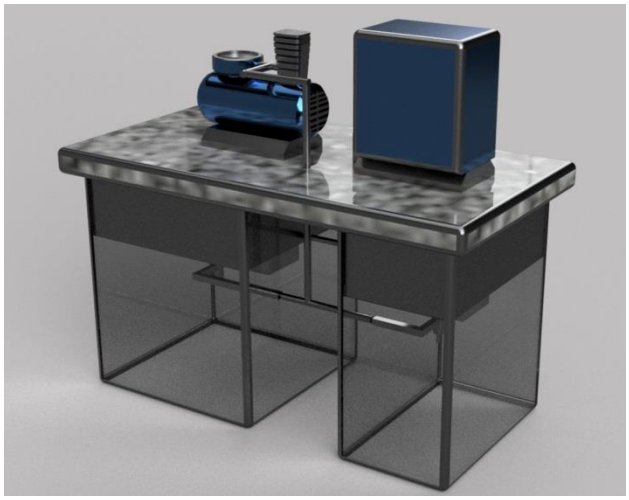


Fig 2: Proposed 2D Design ***Fig 3: Proposed 3D Model***

Advantages of Centralized Sanitization and Disinfection System over Available Alternatives:

- Centralized System
- Cover large portion in Single Spray
- Efficient Energy Consumption
- Less Maintenance is required
- Product Cost Effectiveness
- Innovative way of Sanitization

Conclusion:

The Result shows that the Microbiological Quality of Air and Surfaces with low Bacterial contamination rate. The project will definitely helpful for Multi-floor Hospitals, Corporate Offices and Malls, Public Places, Industries, Societal Communities, Apartments and Complexes to Sanitize in greater extent. Also it reduces overall Power Consumption and the Human efforts too. Overall commercial performance of project results in efficient & effective operation of the system. After going through all Research reviews it can be conclude that, this project is one of

the significantfactors in COVID-19 Pandemic. Also its effective Design is developed to increase the Efficiency and Performance of system.

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DEVELOPMENT OF ECONOMICAL SOLAR TUNNEL DEHYDRATOR FOR APPLE DRYING

Nikita Mane, AmrutaAdamapure, Abhishek Patil, Khalid Pirjade, SanskarPatil, PrathameshPatil, Saeed Shaikh, SanketChikhale

I INTRODUCTION

Drying removes the water from foods so that the growth of micro-organisms is inhibited. It also reduces the weight and bulk of foods which cuts down on transport and storage costs. Sun drying is the simplest and cheapest method of drying. It is used for high volume foods such as grain, rice, sultanas and raisins. The disadvantage of sun drying is that the processor has very little control over the drying conditions and the quality of the dry fruit [1]. India ranks second in the world (production of 45.91 mmt), next only to China (production of 72 mmt), when it comes to fruit production. India contributes 9.54% of the total fruit production of the world. In spite of the India's strong hold on the production of fruits it is alarming to know that India processes just 2% of the total fruit production with an alarming loss of around 35%. Only 20% of the production of processed fruits is being exported. India's share of global exports of fresh fruits and processed fruit products is quite meager when we compare the same with other major fruit producers of the world, i.e., China, Brazil, USA, Italy, Spain, Mexico, Iran, Philippines, Turkey and Thailand (in the same order). The imports and exports analysis of this particular industry in India has been made using secondary data that was available. This data is then analyzed to know the per cent contribution of each fruit and each processed fruit product towards total imports and exports and CGR of the imports and exports of the same. The effort was made to know the causes for the particular pattern of imports and exports along with recommendations on policy front to elevate Indian fruit processing industry to international standards [2].

Making of dried fruit can be a fun family activity with a tasty end product. Dried fruits are a portable snack and it also can be used in recipes.Dried fruits are tasty, nutritious, lightweight and easy to store and use. The energy input is less than what is needed to freeze or can, and the storage space is less than that needed for canning jars and freezer containers. Proper and successful drying produces safe food with good flavor, texture and color. Whenever you

preserve foods, choose the best quality fruits and vegetables. As with other food preservation methods, drying does not improve food quality [3]. The sun powered drying framework utilizes the sun oriented vitality to warm up an discuss and to dry any nourishment substance which is stacked, which isn't as it were useful but too it decreases wastage of rural items and makes a difference in conservation of agrarian items, but it moreover makes transportation of such dried item effectively and advances the wellbeing and welfare of the individuals. Drying implies conservation of nourishment, natural products and vegetables for long time with great quality. It is a process of moisture removal due to simultaneous heat and mass transfer. Agricultural products, especially fruits and vegetables require hot air in the temperature range of 45–60˚C for safe drying. When any agricultural product is drying under controlled condition at specific humidity as well as temperature it gives rapid superior quality of dry product [4].

II ROLL OF SOLAR DRYING TECHNOLOGY IN POST-PROCESSING PROCESS

Nourishment is one of the critical needs of human being within the globe. India is agrarian prevailing nation in south Asia locale, India create assortment of grains, natural products, vegetables, verdant commodities. The world as a entirety more than 25-30 % food grains and 30-50 % vegetables, natural products etc. is harmed some time recently they reach to the shoppers. In south Asian nations, sun drying is the preeminent commonly utilized technique to dry the rustic materials grains, nourishment items and vegetables. The rate of drying on diverse parameters such as sun arranged radiation, including temperature, wind speed, relative stickiness, and starting moistness substance, sort of crops, trim absorptive and mass of thing per unit revealed locale. [5]

Top 5 fruits Producing States

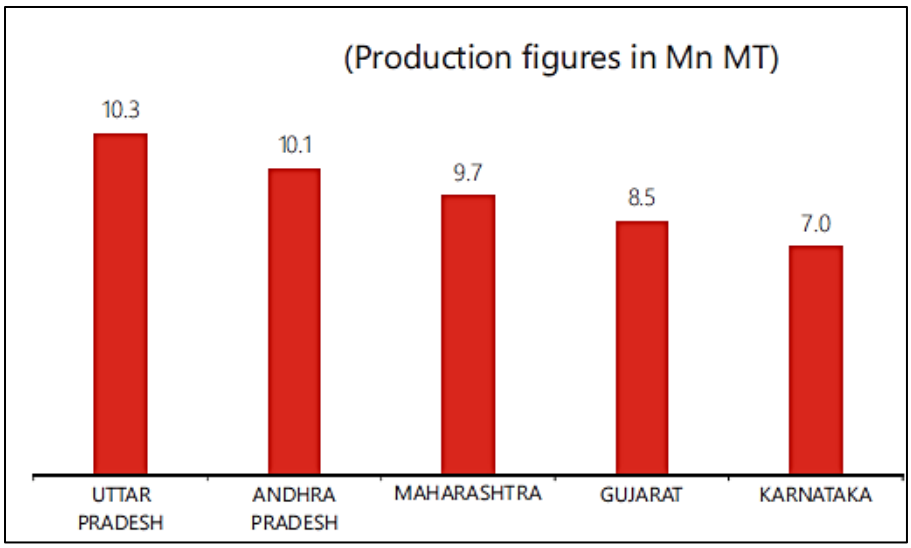

Figure 1 Top 5 fruits Producing States (SOURCES: Department of Agriculture Cooperation and Farmers Welfare)

Top 5 Vegetables Producing States

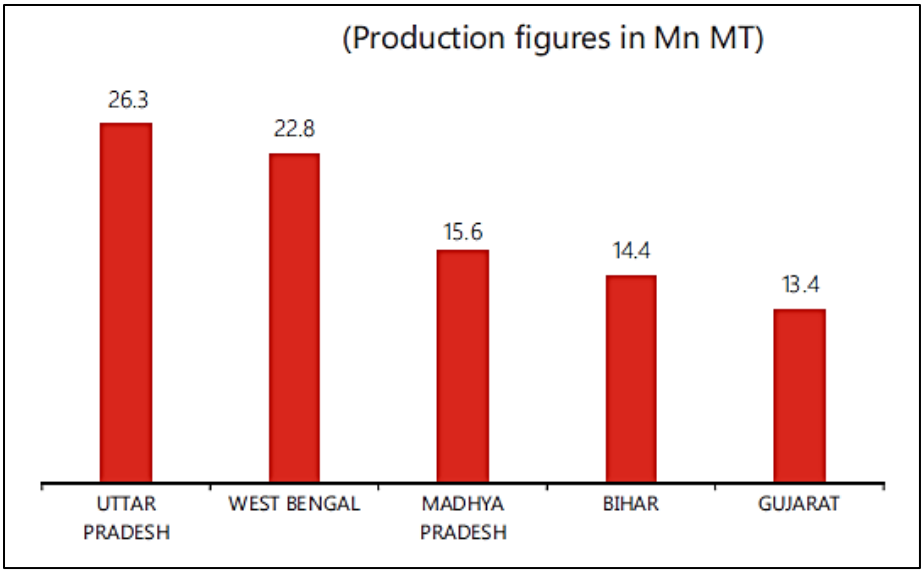

Figure 2 Top 5 Vegetables Producing States (SOURCES: Department of Agriculture Cooperation and Farmers Welfare)

India witnesses nearly 4.6-15.9% wastage in fruits and vegetables annually, due to lack of modern harvesting practices and inadequate cold chain infrastructure. Figure gives facts about top five state fruit and vegetable production. Uttar Pradesh, Andhra Pradesh, Maharashtra, Gujarat and Karnataka are the leading producers of fruits in India, having a combined share of around 51% in the total fruits production. For vegetables, major producers include Uttar Pradesh, West Bengal, Madhya Pradesh, Bihar, and Gujarat, together accounting for around 55% of the national production. [6]

Types of solar drying system

1. Direct type dryers: In direct or natural convection type dryers, the agricultural product is placed in shallow layers in a blackened enclosure with a transparent cover. The solar radiations are directly absorbed by the product itself. The food product is heated up and the moisture from the product evaporates and goes out by the natural convection/circulation.

2. Indirect type dryers: In these dryers the food product is placed in a drying chamber. The air is heated in solar air heaters and then blown through the drying chamber. In some of the designs, dryers receive direct solar radiations and also heated air from solar air heaters. In these dryers manipulation of temperature, humidity and drying rate is possible to some extent.

3. Forced circulation type dryers: In these dryers, hot air is continuously blown over the food product. The food products itself is loaded or unload continuously or periodically. These kind of dryers are comparatively thermodynamically efficient, faster and can be used for drying large agricultural product. These dryers can be of Crossflow type,

Advantages of Solar drying system.

The higher the temperature, movement of air, and lower humidity, increases the rate of drying. Dryers are waterproof so the product is protected against flies, rain and dust; product can be left in the dryer overnight or during rain. The quality of the product is better in terms of nutrients, hygiene and colour, It permits early harvesting and reduces the field losses of the products, It permits better planning of harvesting season, It reduces spoilage in storage drastically, It permits the farmer to sell his product at better price during early period of harvesting season, Quality of the product gets enhanced significantly and hence farmer gets more money for his product, and Transportation is easy with dried product. [7]

III OPORTUNITIES IN FRUIT DRYING AND EXPERIMENTAL SET UP

Drying is one of the most seasoned strategies of nourishment conservation. It is still utilized broadly to protect foods for domestic utilization and for deal. Dried natural products are one of the foremost well known items made by small-scale processors. Drying expels the water from foods so that the development of micro-organisms is restrained. It moreover diminishes the weight and bulk of foods which cuts down on transport and capacity costs. Sun drying is the best and cheapest strategy of drying. It is utilized for tall volume foods such as grain, rice, sultanas and raisins. The impediment of sun drying is that the processor has exceptionally small control over the drying conditions and the quality of the dried natural product. An apple is an edible fruit produced by an apple tree (Malus domestica). Apple trees are cultivated worldwide and are the most widely grown species in the genus Malus. One reason may be that apples contain soluble fiber the kind that can help lower your blood cholesterol levels. In one large study, eating an apple a day was linked to a 28% lower risk of type 2 diabetes, compared to not eating any apples. Even eating just a few apples per week had a similarly protective effect. What's more, the same serving provides 2–4% of the RDI for manganese, copper, and the vitamins A, E, B1, B2, and B6. Additionally, one study in women reported that eating apples was linked to lower rates of death from cancer. There are two main forms of dried fruit- semi-moist and dried fruits. Semi-moist fruits, such as grapes contain naturally high levels of sugar which means they can be preserved with higher moisture content than most other dried fruits. Semi-moist fruits can have moisture content as high as 25% and are consumed as they are without rehydration. The sugar content of other fruits can be

increased by soaking the fruits in sugar solution prior to drying. These fruits are known as osmotically dried fruits.

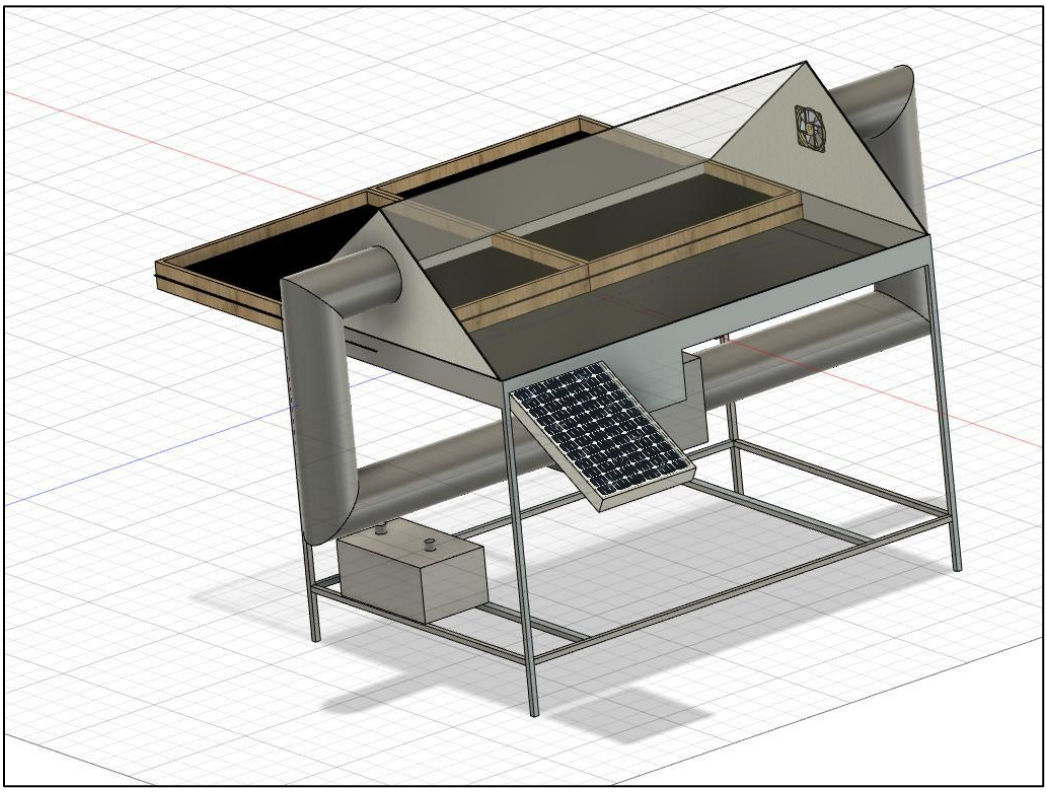

Figure No 3 Experimental Set up

Conclusion:

The financial up gradation of a farmer is possible by providing him the modern, automatic and low-cost fruit drying unit. The natural drying process has many drawbacks, such as requiring more time, large investment on space requirement and infrastructure for drying process, which cannot be afforded by a middle- class farmer. Solar dryer is less in cost which is beneficial for rural life. Low Space is required because of multi-layer compartments. During experimentation care is taken to maintain the Nutritional proportion of product as per the market requirement hence they are exportable and affect to increase the economy level. Similarly, apple and pineapple it required 10 hrs in solar dryer whereas conventional method required fifteen to 18 hrs.

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DEVELOPMENT OF IOT PRIMARILY PREDICATED OBSERVANCE SYSTEM FOR HOME QUARANTINE PERSON THROUGHOUT COVID-19

Rohit S. Dayma, Sanket S. Bapat, Abhishek K. Bhagate, ManasPatil, KomalChakote

I INTRODUCTION

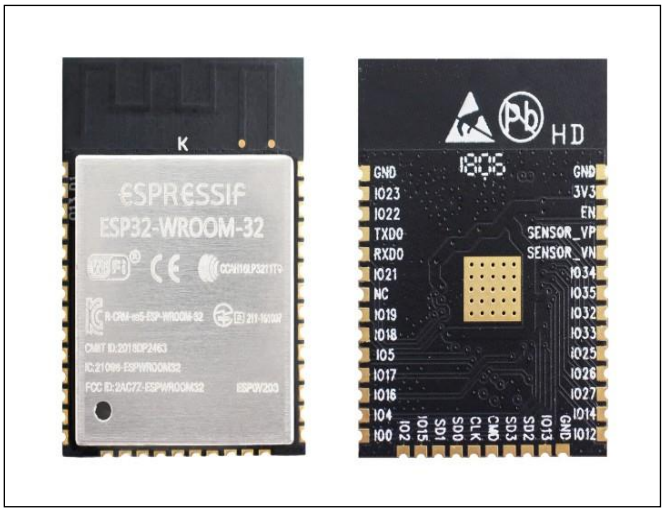
The well-known virus COVID-19, originated in Wuhan, has spread all over the world too rapidly. It has become an international concern of and produced anarchy in the medical health due to its rage form. All CoVs have crown-shape palmers with 80-160 nanometres in size and 27-32 kb positive extremity. The virus has an ability to spread widely through the respiration, sneezing, coughing and personal human contact with the prior affected people. The droplets from their saliva and respiratory discharge have ability to transmit the virus on a large scale. The virus is considered more dangerous due to its long duration of showing symptoms to the patient. The majority of the individuals influenced due this infection recuperate with no extraordinary treatment yet those fundamental clinical issues like cardiovascular disease; diabetes, chronic respiratory sickness, and malignancy are bound to create genuine disease. Scientists are trying at their best to develop a vaccine that can protect the human survival from the virus. As per the Indian Situation Update Report, COVID-19 has affected in 29 countries,

with 3577 confirmed cases and 83 deaths till 5th April 2020. In Maharashtra and Telangana more than 400 cases have been recorded till date. World Health Organization (WHO) has declared high risk assessment for the India. Day by day, situation in India as well as worldwide is getting worse. Chloroquine and Hydroxychloroquine has shown some promise in treatment of COVID-19. The Government of India is coming up with quick financial packages for improving the infrastructure and procuring more number of testing kits and developing more number of testing labs. Also Prime Minister of India has declared 21 days lockdown from 25th March 2020, as a prevention measure over the further transmission of the virus. Within this lockdown, people are strictly allowed not to get out of their houses in order to achieve Social Distancing. This is because; Social Distancing can be only effective way to control the increasing chain of the COVID-19 virus. It will break the further increase in the number of affected people due to the break in social contact of the people. Currently the people those are affected due the COVID-19 are totally isolated and those who have travelled from abroad recently, are strictly warned to stay Home-quarantined. Doctors have marked stamp of Home-Quarantine on their hands. Those are not allowed to make any social contact with any other person unless and until their test report comes out to be negative. But still due to the lack of awareness among people, they are roaming outside in the society in order to buy Grocery, Fruits and Vegetables, as well as Medical stuff even in the lockdown period, by breaking the rule. To stop this, a better solution is found. This paper proposes and implements the Quarantine patient location tracking system which is easy to implement. An IOT based module is developed in order to continuously locate the quarantine patient. This system gives the exact location of the quarantine patient to the doctor and cops, so that his monitoring becomes easier than to keep constant eye on him. The system helps doctor and cops to view the present and the past positions recorded of a patient on Google Map through the internet. The quarantine patient is provided with a GPS module which he is warned to keep in a stable internet connection. This GPS module is in connection with the ESP32 module, which is required to connect with the Arduino. As an output, through this system the doctors will get the latitude and longitude in the form of numbers and that should copy it to the browser window. It will give the exact location of the patient, so that his monitoring will become easier than the traditional methods. Also an android application is developed in order to record the data of the individual patient. The quarantine patient has to login into the application through his email address, in the login window. After that, he has to put all the personal as well as health related data into it. The health related data will include the information such as whether he is underlying some medical treatments, whether he is going through the problems like diabetes, blood pressure,

cancer or any other disorder. Also he has to mark the symptoms, if he is observing within himself with the help of checkboxes provided. Along with it, he has to mention the places that he had visited within last couple of months. After submitting this information, it will be collected by the main server and doctor can easily go through it. After analyzing the information provided by the patient, they will make a report of it and send it to the patient again so that he will be aware about what precautions he has to take within this quarantine period. If the condition is more serious, then the doctor will take necessary actions required to take so that he can get the treatment as soon as possible. Also a sensor is attached to the patient's body which senses whether any other person comes in contact with him and gives an alarm in the form of sound. So that another person will get a notification of not to make any contact with the quarantine. It will help to break the chain further due to the success in maintaining social distancing. In this way, this system will increase the efficiency of both the doctor and cops by reducing their efforts.

Components of technology:

1. **ESP32 Module:**



This is a basic ESP32 module with the ESP32-D0WDQ6 chip on board 1``1 ESP32-S2. It is a general purpose development board, embeds ESP32-S2- WROVER, 4 MB flash, with pin header.

2. **GPS Module:**

III WORKING AND IMPLEMENTATION

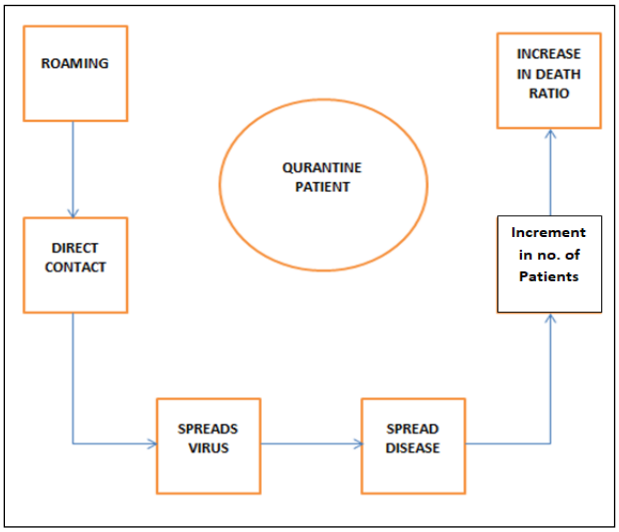


Figure 1: Problem Statement

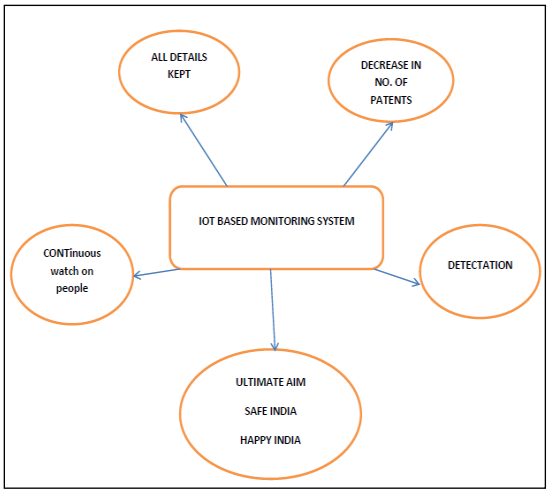


Figure 2: How to Overcome

An android application is developed, that should be installed on the Home Quarantine persons' smartphone. In this application, the patient has to login with his E-mail address. After successfully logging in, through the next windows patient has to fill all the personal information such as name, contact number, residential and professional details etc. Then with the help of next window, he has to fill information about his travel history within last two months. Also he has to mark weather he is underlying any medical treatments such as diabetes, blood pressure, heart diseases or pregnancy etc. Also with the help of checkbox window denoting the symptoms of COVID-19, he has to mark those ones which he is suffering from. This information, after clicking on Submit button, will be collected by the main server which is located near to the doctor. The doctor will go through this information, analyze it and then make a report of it. This report will consist of the data such as weather the patient is affected by the COVID-19, or have any chances of getting affected in future. Also it will include the necessary precautions that should be taken by the patient in order to avoid further spreading of the virus.

When the doctor will input the name of the quarantine patient to the experimental setup, it will give the exact location of the patient to the doctor. There will be an ESP32 module and that module in connection with the GPS module through the wires which has a GPS antenna with it.The Arduino software will debug the code from the in ESP32 module. The module connection will be given to the GPSMOD. When the doctor will ask for the location from ESP32, we will get latitude and longitude of current location as an output. This output in the form of latitude and longitude, should be copied to the available browser which in turn will give the exact location of the patient as an output.If he tries to go out from home, strict action will be taken by the cops.

Another sensor system is implemented with the same GPS module to the quarantine patient. It will sense if another person comes in contact with the quarantine one, and raise a sound alarm so that, another one will get notify not to make any contact with the same person. Our main focus is to detect the location home quarantine person and reduce COVID-19; we apply GPS module and ESP32 module technology to overcome it. When home quarantine person will go to the doctor there will be checkup taken by him and doctor will note down all the information in the application that we are going to provide. The application will contain following type of information: Name, Personal Information, Travel history, Symptoms, Start date of quarantine, End date of quarantine.

After taking the information doctor will fill in the application and at that time. Also he will provide E SP32 module with GPS and which will stick to him. He will restrict him to keep it with him so that continuously they will locate. If doctor wants to see the location of that person he will open the application select name, then there will be an input given and through the GPS module there will be location on Google Maps. Basically, the ESP32 module is debugged code through Arduino and ESP32 and GPS module are connected with the jumpy wires. When he will locate the GPS module with GPS antenna range 1575.42MHz gets connected automatically to the satellite and provides the information to satellite and in return gives location to doctor. The whole setup required for the tracking should be wear by the patient in his hand, so that they can be tracked easily. Each quarantine person should be provided with a single setup.

As the person is restricted to stay at home due to sharp increase in COVID19 patients, in case if he breaks the rule and goes out of house then the cops will catch the patient and he will be isolated in hospital for 20 days. It will help in breaking the COVID19 chain. So as there will be decrease in patients, all we can move towards a healthy life.

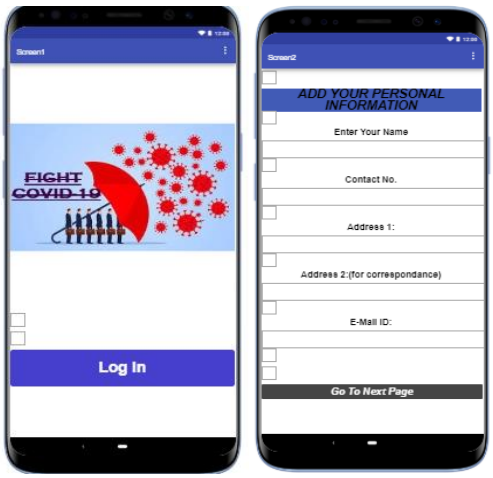


Figure 3: Application Windows

Fig 4: Latitude and Longitude values as an output from the software

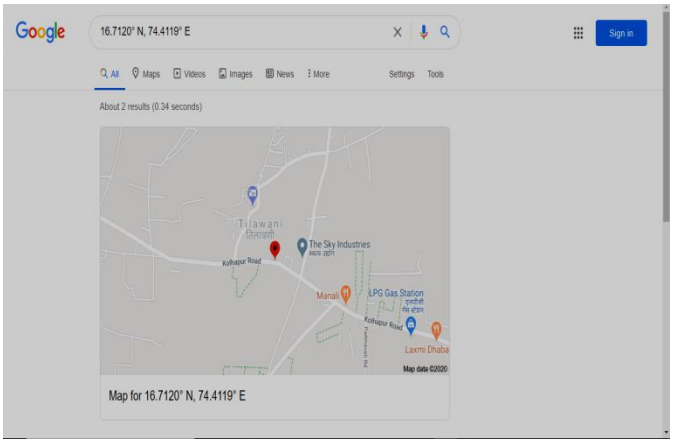


Fig 5: Location of patient as an Output after copying Latitude and Longitude values

The above figures 4 and 5 show the output windows of the system. When the doctor will input the name of the patient of which the location is to be found out, the GPS antenna will provide the latitude and longitude values as an output after code debugging in the software.

These obtained values should be copied to the browser such as Google chrome, Google maps etc. so that it will provide the location of the patient as shown in Fig.5.

Benefits:

As far as the benefits are concerned, this system is very is useful in the areas where COVID-19 has spread widely due to human interaction through social contacts. Due to the large population of the COVID-19 patients, they are facing too much problems for getting tested regularly. Traditional methods of collecting patient data and reporting health officials are costly as well as time consuming. In this case, the developed application will help us to gather all the information at a single place. So it will reduce the efforts required to collect the data. Also the IOT based system will give the exact location of the quarantine patient. It will help doctor and cops to check whether the patient is following the rules strictly or not, so that necessary actions can be taken immediately. The sensor system will sense and raise a sound alarm whether the quarantine patient comes in contact with any other person or not. So that the further spreading of the virus.

CONCLUSION

This paper represents live tracking system for COVID19 suspects. The combination of IOT and GPS helps to provide continuous and real time tracking of a person. The IOT and GPS combination is one of the important systems to track and locate person in real time. At the end the authorities can track every detail of the person. In this paper the solution is given to find the live location or travel history of the COVID19 suspect while the person is home quarantined by the authorities, and to look if the person obeys the rules of home quarantined suspect patient. This paper concludes with the solution of tracking of COVID19 suspects in very effective way and without consuming much time and manual work. Finally this solution or idea can be used in many other fields.

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DIRECT AND INDIRECT EVAPORATIVE COOLING STRATEGIES: AN ANALYSIS

Snehal Mali, ShitalBhore, Akshay Shah, AmrutJadhav, DhawalkumarAlase, Sameer Attar

INTRODUCTION

In evaporative cooling technology, air is cooled by vaporizing the water it is at variance from usual A/C systems based on vapor-compression or absorption refrigeration cycles. For evaporation of 1kg of water into the atmosphere, energy of 680W is needed. This energy for steam humidifiers is supplied either from electricity or gas which is utilised for boiling the water. Conversely, this energy in case of cold water humidifiers is occupied from the air as heat leading to decrease in temperature of air. A large marketable cold water humidifier in addition to increasing humidity, supplying 1,000kg of moisture in an hour to an atmosphere is providing evaporative cooling of 680kW. Since few humidifiers are capable of operating on as low as 0.3kW of current, their prospective for supplying low energy and low cost cooling is significant and this potential can be utilized in HVAC systems. Therefore digging deep into direct, indirect and hybrid evaporative cooling systems to understand them better for commercial application is the need of the hour.

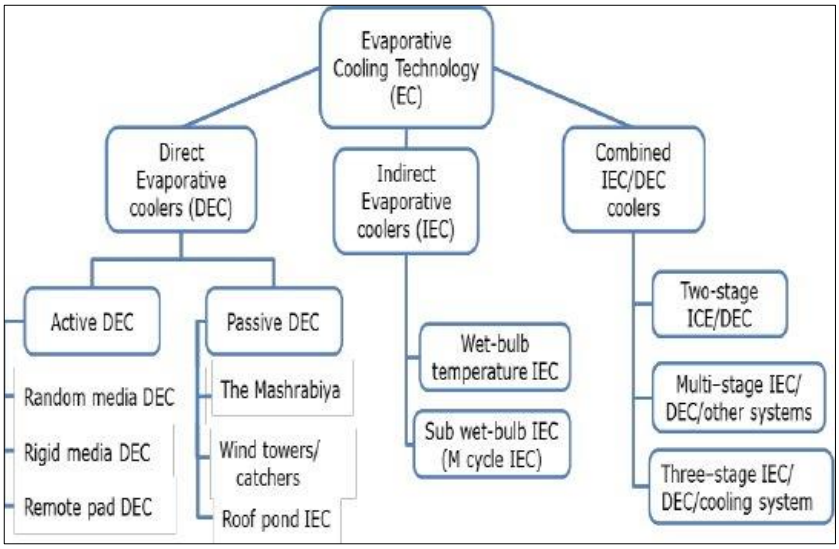
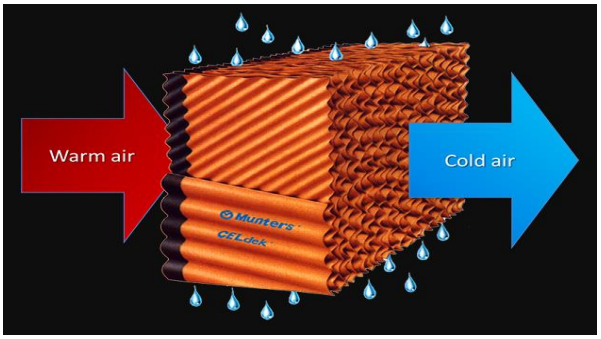


Fig.1: Arrangement of Evaporative cooling systems in cooling the houses [13]

Direct Evaporative Cooling systems

Direct Evaporative Coolers are the systems in which water is vaporized into the air through an engineered pad to deliver adiabatic cooling. Indirect Evaporative Coolers are the systems in which vaporizing water is used to decrease the temperature of outgoing airstream travelling via H.E. and thereby retaining same dampness of treated air.Direct as well as indirect evaporative cooling systems are enormously energy efficient, refuting the requirement of compressors in the cooling cycle. Data Centers, Factories, Livestock and Greenhouses can be benefitted with the application of this technology.



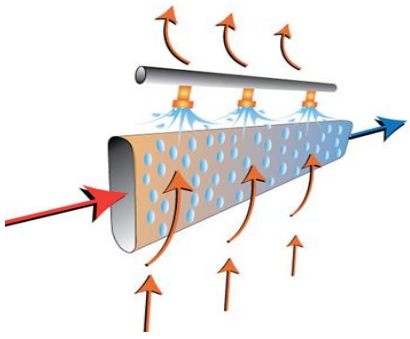


Fig.2. Direct and Indirect Evaporative Cooling [14]

Indirect Evaporative Cooling

Indirect evaporative cooling operates on similar concept as direct evaporative cooling reducing temperature of air by vaporizing the water. The foremost modification in an indirect system is for cooling the air delivered to the living space, a heat exchanger is used. The evaporative cooling sequence happens in heat exchanger.

Hot air from outside is carried using a heat exchanger and it is provided along with water. A design consists of sequence of metal tubes which is made damp on its exterior sides. These tubes are cooled as hot air flows over them thus evaporating the water and cool air thus produced is supplied to the building interior without attaining any extra humidity.

Indirect evaporative cooling offers cooled air to inside spaces which is less damp from direct evaporative cooling thus increasing its suitability for regions where surplus humidity isn't desired for inside air. But it consumes more electricity since it uses two fans as compared to direct evaporative cooling.

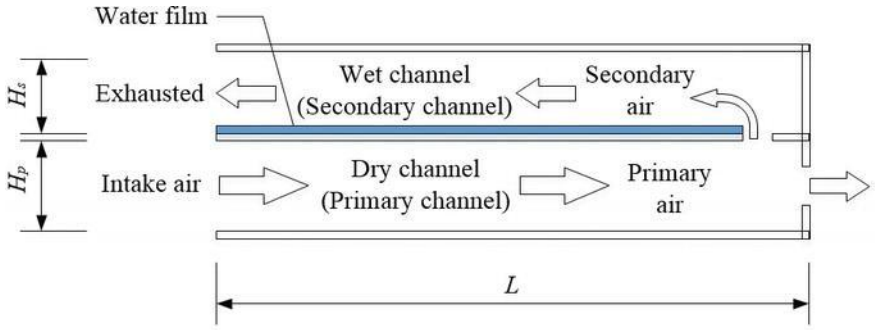


Fig 3: Representation of an indirect evaporative counter-flow regenerative HEX [5]

Advantages of evaporative cooling system over VCRS

The evaporative cooling system possesses these benefits in comparison to VCRS: [1, 2, 3, 4]:

- Curtailing energy consumption
- Reducing costs
- Dropped peak power requirements

- Zero CFCs;
- Subsiding pollutant discharges
- Easy merger with current systems

Limitations of conventional EHX:

- Direct evaporative cooling systems leading to uneasy thermal atmosphere for people in room due to increase in air moisture content.
- Less cooling efficiency of indirect evaporative cooling system.
- Speculative final temperature for cooled air is the wet-bulb temperature.

Energy efficient and novel hybrid evaporative cooling system

Use of indirect evaporative cooling system bids disadvantage of low efficiency and also by using direct evaporative cooling system, the temperature of air to be supplied once cooled would be on the verge of ease and by the time it is passed through the spaces, it might go up by few points to perhaps go outside the comfort zone. Hybrid cooling system augments the usage of the dual cooling technologies in distinct operational systems. [11]

In this kind of system, the air is first cooled without addition of any moisture to it, in binary stages. In the principal stage, air-to-air sensible HE is utilised to decrease air DBT. In next stage, air is furthermore cooled sensibly by a cooling coil which is supplied water through a cooling tower. After that the air is passed via DECS to attain a lesser temperature. Subsequently, in hybrid evaporative cooling system (HEC), lowermost temperature that could be achieved can be lesser than the WBT of the outside air.

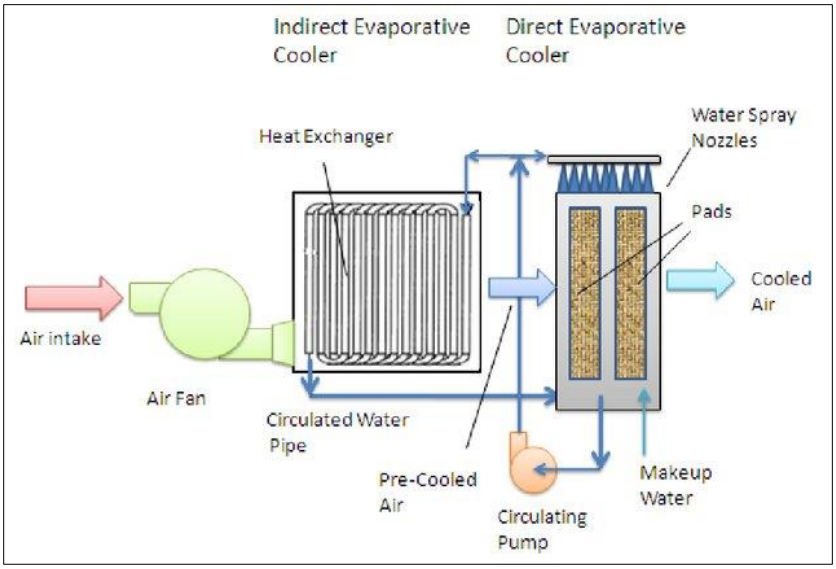


Fig 4: Indirect-direct evaporative hybrid cooling system [12]

Conclusion

Most of the study is done on types of evaporating cooling systems, types of flow in heat exchanger, types of heat exchanger and the cooling agent used. Besides studies are focused on simulation and types of evaporating cooling system and explained the variations in performance according to climatic conditions. Researchers mostly concentrated on parameters such as increment in performance, component reduction, designing according to climatic conditions, development in design in easier and economical way and reduction in electricity consumption. Subsequently reviewing all these international and national research, we found that the direct or indirect evaporative cooling system alone is unable to offer effective human comfort and cooling effect so integrating these two to develop hybrid system could be a way out to overcome the disadvantages of both and augment the benefits. Also counter flow HE in place of parallel flow HE can be used for incrementing the COP. The direct or indirect evaporative cooling system alone is incapable to offer effective human comfort in variable climatic conditions, but this hybrid system is able to provide required human comfort.

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EXPERIMENTAL INVESTIGATIONS OF VAPOUR COMPRESION REFRIGERATION SYSTEM USING ELECTROHYDRODYNAMIC (EHD) EFFECT

Jagdish Choudhary, Akash Kamble, Juned Pathan, Nilprabha Yadav, Yuvraj Kadage, Abhishek Patil, Rajmati Patil

Introduction

In Last Five decades, the several heat transfer enhancement techniques have been successfully implemented. In today's world, as the size of heat transfer unit is continuously decreased day by day, many researchers are working on reduction in shape and size of heat exchangers. Condenser and Evaporator of vapour compression refrigeration system have tremendous potential for enhanced heat transfer. Therefore, it is necessary implement some methods to enhance heat transfer from such heat exchanger. These enhancement techniques are classified as: Passive techniques, active techniques and combined active and passive techniques. In passive techniques, special geometrical surface or inserts with augmented surface is used, where as active techniques require use of external fields like electric field, acoustic or vibration etc. The performance of condenser or evaporator is dependent on many factors like mode of heat transfer, single phase or

multiphase etc.

Theory of Electrohydodynamic (EHD)

The electrohydrodynamic (EHD) effect is the effect in which the study of interaction of electric field and flow fields in dielectric fluid is involved. The interaction of electric field with dielectric fluid medium set up electrical body force. The general equation for electrical body force (Landau &Lifshitz) is given by,

$$f_e = \rho_c E - \frac{1}{2}E^2\nabla\epsilon + \frac{1}{2}[E^2\rho(\frac{\partial\epsilon}{\partial\rho})_T$$

Where, ρc =electric field space charge density,

E = applied electric field strength,

ε = dielectric permittivity of the fluid,

ρ = mass density, and T = temperature.

The first term of equation represents Coulomb force which acts on free charges under the action of electric field. This Coulomb force dominates over remaining two forces under the action of direct current in dielectric fluid under high voltage. The second term represents electrophoretic compound force which is due to the spatial change of the permittivity of dielectric fluid medium as a result of temperature gradient. The third term represents electrostrictive component force caused by inhomogeneous electric field strength and the variation of the dielectric constant with density and temperature.

Experimentally, it has been proven that Coulomb force has dominant effect among these forces and rest two can be neglected in EHD effect. Therefore, under high voltage and low current, interaction of electric field with dielectric fluid medium can set up mechanical body force which may be useful in many heat transfer devices including condenser and evaporator of vapour compression refrigeration system. Many different methods have been considered to increase the rate of heat transfer in the forced convection while reducing the size of the heat exchanger and effecting energy savings. Surface methods include any techniques, which directly involves the heat exchanger surface. These can be used on the side of the surface that comes into contact with a fluid of low heat transfer coefficient in order to reduce the thickness of the

boundary layer and to commence better fluid mixing. The primary mechanisms for reduction the boundary layer are increased stream velocity and turbulent mixing. Secondary recirculation flows can further enhance convective transfer such in case of EHD, MHD etc.

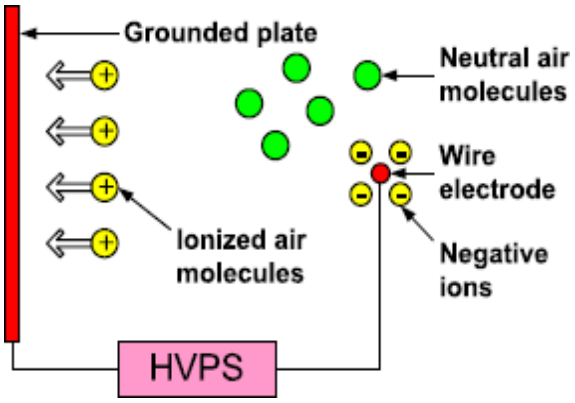

Figure1: Schematic view of the EHD phenomenon of air molecules [21]

When the high voltage at the wire electrode is generated by the high voltage power supply, then the ionic wind is induced by the ionization of a gas near the wire and the drift of positive ionized air molecules to the surface of grounded electrode as shown in Fig.3.6. During movement of the ionized air molecules, they transfer energy from momentum to the neutral air molecules by collisions, thus a movement of the flow field of molecules occurs. In a typical gaseous medium, energy is transferred from the free electrons to the gas molecules, and the latter moves towards a grounded surface to increase the heat transfer coefficient.

A dielectric fluid is an electrical insulator that can be polarized by an applied electric field with high voltage. When a dielectric fluid is placed in an electric field, electric charges do not flow through the material as they do in a conductor, but only slightly shift from their average equilibrium positions causing dielectric polarization. The positive charges are forced to move toward the field and negative charges shift in the opposite direction due to dielectric polarization. This results in an internal electric field that reduces the overall field within the dielectric itself. If a dielectric fluid is composed of weakly bonded molecules, then those molecules too polarized to reorient so that their symmetry axes align to the field.

Experimentation and Instrumentation

An experimental set-up has been designed and fabricated for the investigation of effect of electro hydrodynamic effect on performance of refrigeration system with R-134a. A schematic diagram of the experimental set-up is shown in Figure2**.** Experimental setup consists of the vapour

compression cycle i.e. refrigeration tutor. The cycle consists of main four components compressor, condenser, thermostatic expansion valve, evaporator with pressure measurement gauges, and four temperature measurement thermo couples which gives condenser inlet & outlet condition and evaporator inlet & outlet condition. Also receiver and drier are used.

1. **Compressor:** The refrigerant coming out of the evaporator is compressed in the compressor tothe desired pressure which is required for the phase change of the refrigerant in the cycle.Compressor used for experimentation is the hermetically sealed of Tecompany of 1/3 toncapacity. The compressor is attached to the system by copper tubes.For the cooling of compressor fan is incorporated in the system which an ACsupplied fan with speed of 1280 rpm.Specifications of compressor used for experimentation purpose are as follows:Hermetically sealed compressor using R-134a refrigerant, having capacity 1/3 tons ofrefrigeration. Condensing pressure - max.15 Kg / cm2 (Actual pressures will depend uponworking conditions.)Cooling fan:240 V, 50 Hz, 1 phase Speed- 1280rpm, current- 0.35 amp.

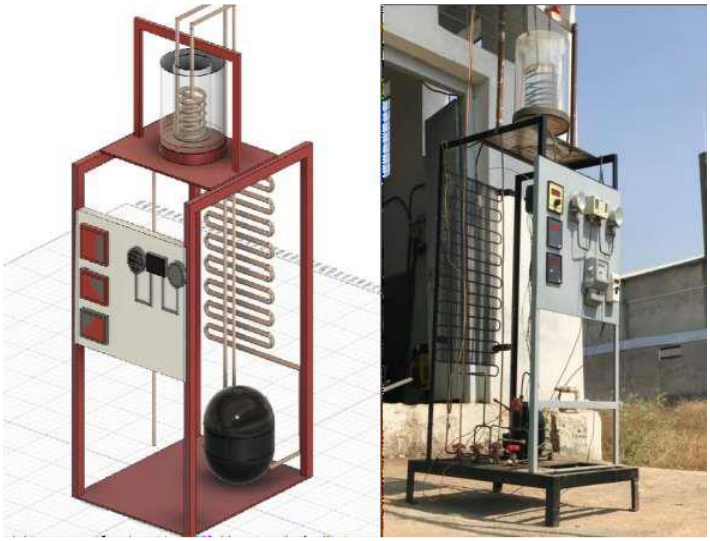

Figure 2: Experimental Test Rig

2. **Energy meter:** This is used for the measurement of compressor work it gives the energy consumption by the compressor during the working. We have to measure the time for ten revolutions of the energy meter in order to calculate the compressor work.

   Temperature Measurement: For the temperature measurement chromel- alumel thermocouple is used which have range of 3 to 1643 ° C. There are such 10 thermocouples are used. For display of these temperature indicator is used. Intron company temperature indicator is used.

Pressure Measurement: For measuring the condensing and evaporating pressure two bourdon pressure gauges are used. For condensing pressure, Pressure gauge range 0 to 20 kg/ cm^2. For evaporating pressure, Pressure gauge range -1 to 14 kg/ cm^2

Conclusion

Experimental study of vapour compression refrigeration system is performed using with and without electro hydrodynamic (EHD) effect. The results showed comparison between with and without electro hydrodynamic (EHD) on the performance of vapour compression refrigeration system. The effects of parameters such as Heat transfer rate, Overall heat transfer coefficient, coefficient of performance on the heat transfer were studied with and without EHD effect. From Table 4.3, it is observed that theoretical C.O.P of vapour compression cycle is increased by 10% with the application of electrohydrodynamic effect. Further, this C.O.P is dependent on the strength of electric field. The conclusions from experimentation work are drawn as follows,

1. The electro hydrodynamic effect causes more temperature drop at outlet of the evaporator which results in decreased compressor work requirement and increases COP of the system.
2. It is found that, with increase in the strength of the electric field, greater turbulence of the dielectric fluid is obtained which ultimately induces secondary flow which is responsible for heat enhancement.
3. By evaluation the result of COP with and without the electrohydrodynamic Effect. It is found that theoretical C.O.P of vapour compression refrigeration system increases by 10% with the application of electrohydrodynamic effect.

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A REVIEW ON APPLICATIONS OF IOT IN HEATING, VENTILATION, AND AIR CONDITIONING AND ITS CONTROL

Shahidhusain R. Narwade, Salman R. Kurane, Md. Anis R. Mulla, Khalid S. Pirjade, Parsad M. Sawant

Abstract

In this review paper it is discussed about how an IOT can be implemented in the refrigeration and air conditioning to save the energy at different climatic problem. We will be discussing about the knowledge of sensor, actuators, and other objects which are connected to Internet and application of IOT. While using IOT in the application it will to sense the different parameter like temperature, voltage etc. and maintain the feasible condition, In order to save the human time. Now-a-days industries are also using IoT to get the better results. The use of IOT is implemented in industry as well as for household purpose. In this paper, the brief description about the application of IOT in different climatic conditions and how it is beneficial for the human comfort and also how it can reduce the wastage of energy.

Key Words: IOT, HVAC, Applications, Control

Introduction

The study of IOT (Internet of Things) focuses on the knowledge of sensors, actuators, and other objects which are connected to Internet, as connecting the people with the virtual world. IOT will also encourage the number of application latest applications such as environmental monitoring, healthcare, and efficient management of energy in smart homes. Heating, Ventilation and Air Conditioning (HVAC) are the most energy required appliances at the time of power-shiftable loads in home buildings. According to the research, they represent 61% of residential energy consumption in UK and Canada, and 43% in USA **[1]**. Devices such as TVs, refrigerators, washing machines we use in day-to-day life and are able to communicate with each other that all credit goes to Machine to Machine (M2M) and Internet of Things (IOT) technologies.

HVAC systems are delivering comfort to the humans in their buildings indoor environment, hence, they are having huge demand and their automated development can ease the work of their users **[2]**. Recently, we have become more and more aware of the concepts of smart city such as smart home, transportation, health, education, energy and smart environment. The concept, "smart home" applications attracts the most demanded applications. IoT is a communication network in which physical objects are linked to each other or rather to larger systems **[4].** Most

of the IoT devices are developed with sensors to detect and monitor the changes in the surrounding by using the data which is generated by these devices. As per the research by the CISCO, the number of things connected to the internet is increasing in remarkable way and it is expected that there will be 50 Billion number of IoT connected devices in total. An IoT designed system can be useful for checking the internal temperature of the refrigerators used in transportation system **[5]**.As per the assumption of World Bank, over 85% of population will be situated in the developing countries by the year 2030. This development can lead to the increase in buildings in city area. In this case, artificial system will be dependent to operate buildings, as the number of people spend their time in the buildings will increase. This has led the engineers and the architects to focus on the development of the buildings by considering its thermal comfortability by means of improving the thermal related tools in the buildings and to ease its operation, as over 80% to 90% will spend their most of time in the buildings.

Applications of IOT in HVAC

IOT is the most promising technology machine-to-machine (M2M) or device-to- device (D2D) communication that can transform a conventional system into a smart one that is low cost as well as energyefficient. One of the biggest Muslim societies in the world is Malaysia, followed by a large number of mosques spread in various areas and these mosques are facing maintenance problems especially in energy consumption. Over 500 worshipers are performing prayers, when weather outside is very cold or hot type, it is very difficult task to manage the comfortability for the worshipers. Moreover, providing a comfortable place to worship requires the AC to be switched on continuously which results in wastage of energy during prayer times. Temperature systems such as Smart thermostats such as are used to deal with the following problem.Mosques experience sudden entry of large numbers of users at five specified times throughout the day, and the consumption of energy by the use of the fans in the mosques is in very inefficient way by wastage of energy, with the five daily Islamic prayers. As per this condition, this project is conducted in order to reduce energy consumption in mosque by developing smart mosque temperature control system. The temperature control focuses on reading the temperature of mosque and then smartly controls fan according to the temperature reading by the application Internet-of-Things (IOT) technology.

The Arduino Uno controller board will read and process the sensors to operate the fan switch. This process of operating the fan according to the ambient temperature of the mosques will help to reduce power consumption. This smart mosque temperature control can be applied in Malaysia in various mosques to make mosques efficient in energyutilization.Thermal comfort is one of the most essential requirements for the satisfaction of mind and ass well as body. The aim of this project application is to design and develop a circuit that will automatically control the speed of a fan according to switch in the temperature of the surrounding areas. Circuit was constructed with a microcontroller, temperature sensor, and supporting components. The temperature and the fan speed are displayed on the LCD screen. The result of the project showed that the speed of the fan is controlled as per the change in temperature remotely controlled via web browser and Apps **[6].**

The A/C-R system or vapor compression is designed of four major components.

1. Compressor
2. Evaporator
3. Expansion valve
4. Condenser, which are arranged as shown in Fig.1.

Scientists have conducted many studies on the developmentwith different angles, which can be shown as,

1. Proper air temperature and humidity of the specific area
2. Improvement of system steady-state performance as well as robustness
3. Reductionofenergyconsumption.

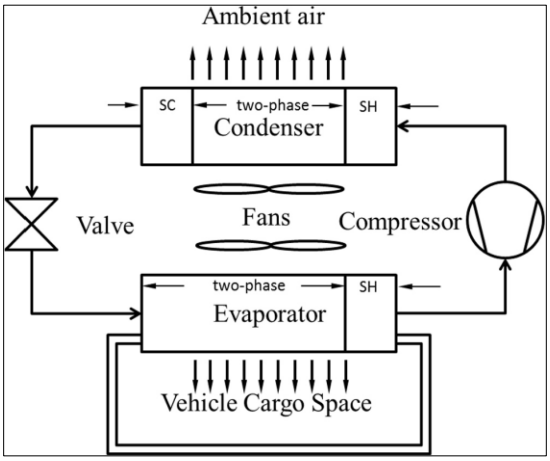

Fig. 1- Schematic Diagram of A/C System.

Initially, turning the switch on/off can result in start or stop the device. But, it is not capable of controlling the temperature according to varying working conditions, such as, the ambient temperature. With the latest application of A/C-R systems in home, vehicles, and industries, a large amount of energy is being utilized. The remarkable growth in the requirement for environment protection and energy conservation is forcing researchers to design green devices with greater energy efficiency. Efficient operation of A/C-R systems can reduce operating cost as well it is not harmful **[7]**.

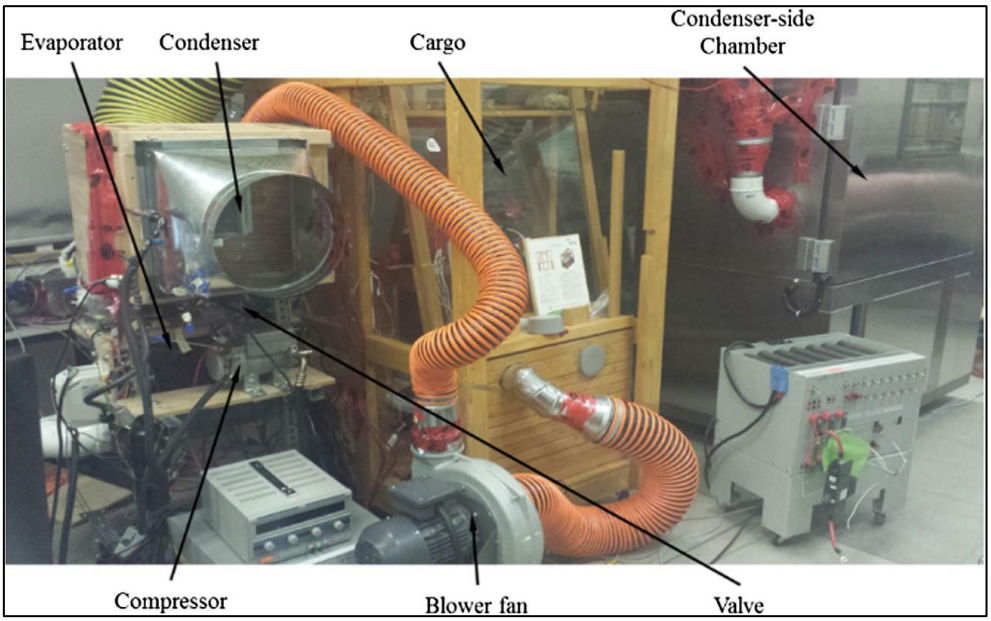

Fig. 2 - Experimental setup of automotive A/C-R **[7].**

Conclusion

From the above description it is concluded as, the use of IoT based appliances makes the work easy and it is also mentioned that how the energy consumption can be reduced by the efficient use of Iot in different appliances. By the use of different sensors, actuators, etc. the work is reduced for the betterment of human comfort. And also the use of IoT products the wastage for energy is minimized. In short, we can say that, by the means of use of IoT the human comfort is also increased and the energy consumption is also reduced.

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