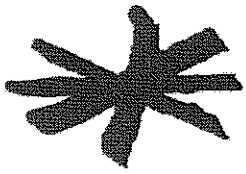

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FACULTY OF SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS

BACHELOR OF ENGINEERING (HONS) IN MECHANICAL ENGINEERING

MEE4999 ENGINEERING DESIGN PROJECT

GROUP PROJECT REPORT

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Declaration of Honesty in Academic Work

We declare that every tasks handed in is original except for source material explicitly acknowledged, and that the same or related material has not been previously submitted for another course. The whole project has been carried out for 2 semesters since August 2014 – May 2015. We also acknowledge that we are aware of University policy and regulations on honesty in academic work, and of the disciplinary guidelines and procedures applicable to breaches of such policy and regulations.

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My group has a total of 4 members including myself. I, Loh U-Jo the group leader of team 2 and 3 other group members, Woon Soon Kwen, Prashan Perera and Wong Siong Weng will be co-operating with each other for 2 semesters in order to make this engineering design project a success. Our supervisor, Dr Chuah Keng Hoo will be guiding us throughout 2 semesters and provide constructive suggestions and comments to improve our design. Regular meetings with supervisor are held once a week. There are many chapters in this project for it to run smoothly. Firstly, a Gantt chart is suggested by Dr How as a schedule table to check our work according to the date and time given. After that, literature review is carried out to have a better understanding on the project given. All the members are given specific tasks to do researches on insulation materials. Then, simulation with the program FloEFD is done to provide a better picture as well as supporting evidence. The results and calculations are carried out to justify the theory. Also, discussions are made after brainstorming with all the group members and supervisor. Last but never the least, conclusion is made. Relevant references, appendixes and diagrams are attached to the project.

Table of contents

Content	Page(s)
Introduction	4
Background	4
Problem Statement	4
Aims	5
Objectives	5
Scope of project	5
Outline of Research and Report	5
Literature Review -Mould - History of Insulation - Types of Insulation - Introduction of Insulation Materials -Aerogel & Polyurethane	6 6-7 8 8 9-14 15-24
Theories	25
Calculations	26-30
Methodology	31
Computational Fluid Dynamics (CFD)	32-35
Results and Discussions	36-49
Conclusion	50
Recommendations for further work	50
Reference	51-54
Appendices	55-61

List of Figures

Figure Number	Title of the Figure	Page Number
1	Differences of open cell and closed cell	9
2	Cellulose	10
3	Cotton	11
4	Fiberglass	11
5	Mineral Wool	12
6	Foam	
7	Concrete Block	13
8	Aerogel	14
9	Translucent Aerogel Glazed Windows	16
10	Translucent aerogel roof in a pharmacy of Switzerland	16
11	Flexible aerogel blankets and solid aerogel boards	17
12	Removal by adsorption of VOCs from air with Pristina™	17
13	Rose and finger placed above the Bunsen burner	18
14	Sound velocity measurements	18
15	Basic Heat Transfer	26
16	The isometric view of the hospital	32
17	The front view of the hospital	34
18	The right view of the hospital	34
19	Top view of the hospital	35
20	The ceiling of the hospital made of fiberglass	35
21	Initial Process of simulation	36
22	In progress of simulation	36
23	The top view of the hospital when simulation has ended	37
24	The view of the door of the operation theatre	37
25	The top view of the hospital	38
26	The isometric view of the operation theatre with insulation panel	38
27	The view of outer wall surfaces	39
28	The view of the door outside the operation theatre	39
29	The zoom in view of the edges	40

List of Tables

Table Number	Title of the Table	Page Number
1	Aerogel Features	15
2	Types of insulation method	23
3	Parameters for the simulation, FloEFD	33
4	Comparison between Fiberglass and Cellulose	41
5	Comparison between polyurethane and aerogel	43
6	Differences in each insulation materials	45
7	Rating for all the insulation materials	47
8	Final Comparison between polyurethane and aerogel	48

List of Abbreviations and Symbols

Abbreviations/Symbols	Descriptions
ρ	Density of air
v	Velocity of air
l	Characteristic length
μ	Dynamic viscosity
Nu	Nusselt number
h	Heat transfer coefficient
K	Thermal conductivity
Pr	Prandtl number
Re	Reynold's number
Q.	Heat lost
T_1	Inside surface wall temperature
T_2	Outside surface wall temperature
Δx	Thickness of wall

Abstract

This project tackles the problem of wall surfaces condensation and mould growth issue in a 24 hour air-conditioned room. Firstly, the project consists of the types of insulation materials that are common in the market. In order to design a wall with insulation to prevent water condensation on wall that leads to mould growth requires knowledge of heat transfer and thermodynamics. The scope of the project is to determine insulation materials that provide the best insulating effect considering parameters such as installation method, cost and maintenance cost, lifespan, sustainability and health and safety issues. Literature reviews from Oxford University reviews the art of aerogel applications in buildings supports the idea of having aerogel as the insulation material that can prevent mould growth on wall surfaces. Computational Fluid Dynamics helps to simulate the actual problem by using a program known as FloEFD with a given set of parameters. The comparison of insulation materials proves that aerogel is the best choice among the others. The project challenge is to discover the relationship between Reynold's Number and the Nusselt Number in order to determine heat transfer coefficient for both internal and external wall surfaces thereby finding the surface temperature of both inner and outer wall surfaces. The calculated Nusselt Number shows that the convection plays a more important role than conduction. Last but not least, the conclusion states that aerogel insulation seems to have the most potential and will definitely replace other insulation materials in the near future.

INTRODUCTION

1.1 Background

Insulation is very important as it is able to save energy by reducing the usage of heater and air conditioner, to increase comfort and reduce noise pollution and also to create a healthy environment for a better living. The primary use of insulation is to prevent heat loss to the environment, allowing air conditioned systems to operate more efficiently. Insafoam Insulation Sdn.Bhd is a leading company that specializes in insulation of piping and ducts especially in polyurethane products such as Insaduct, Insapanel, and Insugard. They collaborated with INTI International University students to design an insulation to prevent mould growth in a 24-hours air-conditioned room. The rate of heat transfer is thoroughly studied to calculate the surface temperature of internal and external wall and the dew point temperature that causes water to condensate. This situation will lead to mould growth and therefore must be considered seriously as mould causes many diseases and illnesses. In a hospital, operation theatre operates for 24 hours a day. The conditions are maintained at 18°C all the time as it would be the best temperature during operation for the patients. The operation theatre is very important and should be free from mouldas most of the patients are susceptible to fungi based bacterial infections.The seriousness of mould and fungal growth lead us to find ways to prevent them. This is a report of an engineering design project to tackle the given problem.

1.2 Problem statement

Mould can be hazardous to human health, especially in places such as hospital when the immunity of the patients is very low. The operation theatre is 24 hours air conditioned as it would be the optimum temperature for the patients to go through surgery and operation. However, the cold temperature from the operation theatre will be transferred to the wall connected to it due to conduction. The heat transferred to the wall connected will cause theexternal wall temperature to drop below the dew point temperature. This leads to condensation and mould growth. The current solution would be by installing insulation to reduce the rate of heat transfer. In this project, factors such as materials, thickness, lifespan, installation methods, sustainability, health and safety and cost must be considered. Therefore, a design that optimizes all the above factors will be cost effective and energy efficient in preventing mould growth.

1.3 Aims

To build a hospital that is free from mould by preventing the condensation that takes place on the surface of the wall to ensure the health and safety of the people especially weak patients.

1.4 Objectives

To design insulation with optimum thickness that is cost effective and is able to prevent water condensation on wall that leads to mould growth by reducing the rate of heat transfer between the concrete walls.

1.5 Scope of the project

There are many ways to reduce the growth rate of mould in air conditioned places and one of the ways is to reduce the water condensation on wall surfaces. Water condensation on wall surfaces can be reduced by installing insulationto the walls so that the rate of heat transfer is low. The scope of the project emphasizes on the insulation material that provides the best insulating effect by determining several criteria such as installation method, lifespan, health and safety, cost, and sustainability. The conditions or parameters of the operation theatre have been set and fixed as the boundary conditions. Numerical simulations using FloEFD are applied to optimize the design.

1.6 Outline of the report

Firstly, many of the insulation materials such as cellulose, fiberglass, polyurethane, aerogel blankets are compared based on physical properties such as density, thermal conductivity and aspects such as thickness, lifespan, installation methods, sustainability, health and safety and cost. Many literature reviews have been read through and compiled under chapter 2.0. All the information is very important as it is allow us to distinguish between a good material and the best material. Besides, calculations based on theories are done by using Microsoft Excel to determine the dew point temperature, surface temperature of the internal and external wall, optimum thickness of the insulation and also total costs to insulate the operation theatre. Calculations are attached in the appendix. In chapter 3, under Computational Fluid Dynamics (CFD), a simulation through a software known as FloEFD is done to verify the calculation and also to produce a clearer and better visual of the result. In chapter 4, comparisons between insulation materials are made and discussed in a detailed manner to obtain the best insulation material. Lastly, conclusion is made and further work is recommended.

2.0 Literature Review

Mould

These spores present in both indoor and outdoor air as well as construction materials where the nutrients to support mould growth are provided. Moulds can be introduces as an organism that is neither plant nor animal. They belong to what is referred to as the fungi kingdom. Moulds do not get the energy from the process photosynthesis, a process that involves sunlight, unlike plants. In fact, ultraviolet light from the sun is deadly to mould growth. In order for mould to grow there should be enough nutrients such as oxygen and organic materials containing carbon. (fsec.ucf,2014)

Moisture

The main requirement however for the mould to grow is moisture. Mould cannot exist without moisture. Moisture accumulation is mainly because of humidity, condensation or water intrusion. The best way to avoid mould growth in indoors is to reduce the moisture.

Temperature

Another factor that affect mould growth is the right temperature. Mould is said to grow best in warm temperatures. However, there are some species of mould that could survive in as low temperatures as 2 degree Celsius. In some cases where the temperature becomes unfavourable, a mould colony could lay dormant till the temperature becomes ideal again and will continue to grow.

If the conditions are ideal for the mould growth, as in the temperature, oxygen, light and proper nutrients are available in right conditions, mould uses spores to reproduce just like a plant uses seeds. Once the spores are formed they will be released in to the air to create new mould colonies. Just as how the mould prefers moisture, the spores also grow in to mould once a surface is damped for 24-48 hours. These mould spores constantly float through the air both indoors and outdoors making it impossible to completely eliminate. Spores can be very resilient, that they could stay dormant for years without germinating, till suitable conditions are presented. (fsec.ucf,2014)

Mould as we know it is a very serious issue that we encounter in our day to day life. Mould can be both hazardous to both building structures as well as human health. In recent years it was discovered that the mould in home, schools office environment could cause various ailments and disabilities. It is for this reason why "toxic mould" has attracted attention from renowned organizations such as American College of Occupational and Environmental Medicine (ACOEM). This organization mainly directs their attention to the scientific knowledge of fungal-related illnesses emphasizing their possible relation to the indoor environments. Mould and other fungi could affect human health in three basic processes.

1)Allergy

2)Infection

3)Toxicity

It is found that about 10% of the population has antibodies to fungal antigens. Of that only 5% shows clinical illnesses. The allergic reactions are most commonly presented as allergic asthma or allergic rhinitis. Exposure to very high fungal concentrations could cause hypersensitivity pneumonitis which could ultimately be life threatening.

(fsec,ucf,2014)

History of insulation

Ever since civilization begins, humans realize the need for insulation but in other forms such as clothing with wool and skins from animals especially in extreme climates. From clothing, it slowly evolves to shelters made of wood, stones, earth and other materials to withstand, to simply live comfortably or to protect one from the freezing cold winter and the scorching heat of summer. This definitely explains the importance of insulation. (Insulators24,2007)

For example, ancient Greeks and Romans found asbestos and use it due to its resistance to heat and fire. The Romans use cork for insulation like the one use in shoes , primarily to keep their feet warm. As they became more industrialized, cork was used as an insulation for ice houses. After that, mechanical refrigeration was born and cork was used to insulate pipes and equipment. For simple understanding, Insulation is meant to keep heat out in the summer and to keep heat in during winter. (Insulators24,2007)

Types of insulation

As mentioned earlier in the introduction, there are many types of insulation materials. For now, we will look at it in a more detailed manner. The reason why do we add insulation into buildings is to improve energy performance of the building as well as to lessen its environmental impact. For example, a space heating and cooling consume 44% of all energy used at home according to the Department of Energy. By spending a few hundred dollars' worth of insulation can reduce annual heating and cooling bill from 10 to 30%. Thus, investment in an insulation can be paid off very quickly. There are many common materials used for insulation and each of them has its benefits and drawbacks. For example, cellulose, cotton, fiberglass, mineral wool and foam. All the materials are researched and compared. However, our group decided to use aerogel for insulation as it has the highest insulation value with the lowest thermal conductivity value of any solid (0.013 W/mK). (greenhomeguide,2009)

Introduction of insulation materials

Insulation is measured in "R-value" (where the higher the value, the more resistant to heat transfer) . In medieval times, northern group of people tried to use straw and mud plaster to keep their house warm. After that, insulation slowly evolves until 1932 where fiberglass was discovered by an accident. However, due to its drawbacks such as releasing of fine glass particles into the air that damages the lungs, might cut the hands of the installer, must be properly ventilated to prevent mould from growing and difficulties to be packed into odd shaped spaces, a new alternative is then widely used which is known as the "Cellulose". (a4arch,2013). Although spray in polyurethane foams was developed in the 1940's, it only became popular in the late 1970's. The insulation applied to wall with two separate components interacting at the nozzle head to create a self-expanding chemical foam. In this digital era, it is very important for us to understand completely about insulation as it is very beneficial. By this way, not only we can fully utilized the characteristics and properties of insulation material to enhance the performance of insulation but also to save cost in long term due to the decrease in usage of heating and cooling as well as to decrease the amount of carbon dioxide release into the atmosphere thus preventing global warming. (a4arch,2013)

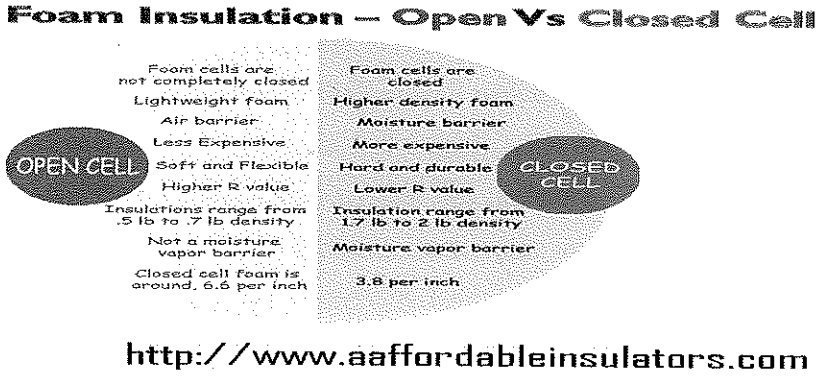

Figure 1 : Differences of open cell and closed cell (Aaffordableinsulators,2014)

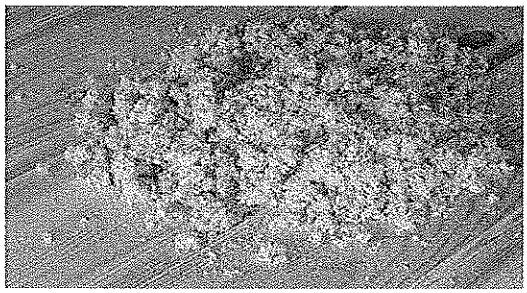

Figure 2: Cellulose (Wikipedia,2014)

Cellulose

Cellulose insulation is basically made from recycled paper as 75% of the material are from post-consumer waste paper. It has the highest average recycled content of all insulation types. Moreover, the manufacture of cellulose insulation as compared to the manufacture of mineral wool and fiberglass insulation requires only a small fraction of energy use and pollution. Scrap of cellulose produced during installation can be reused which reduces on waste. In addition, cellulose insulation has no significant effect on indoor air quality as the off gassing of the volatile organic compound (VOCs) contained in ink on newspaper waste in cellulose insulation is not a health issue since the ink is mostly vegetable based. The amount of boron used in cellulose is only harmful to human being when ingested. The usage of it is to act as a flame retardant. Cellulose insulation is normally blown into wall and ceiling cavities, it can be installed through a series of small holes drilled in wall which cause minimal disturbances during remodelling. Although so, it is not suitable for application below grade that is below the perimeter of the foundation or any locations that has moisture. The reason is because cellulose absorbs moisture causing it to decrease its R-value over time and continuous exposure to moisture for long duration will eventually lead to rotting and growing of mould. However, vapour barrier can be installed if the insulation has dried completely to prevent moisture from reaching the insulation. Last but not least, loose fill cellulose typically costs 25% less than fiberglass but installation might be slightly more costly. Wet spray or dense pack installation are more expensive than fiberglass installation but these methods are extremely airtight and thus the R-values are more commonly achieved compared to fiberglass batts. (greenhomeguide,2009)