ANALYZE THE SPRINKLER SYSTEM IN UMP LECTURE ROOM USING CFD (COMPUTATIONAL FLUID DYNAMICS) ANALYSIS

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ABSTRACT

An automatic sprinkler system is one of the most effective methods of controlling or suppressing the fire. Sprinklers are generally located at the ceiling level of the level of a building. They are equipped with a fusible link that melts when the heat given off by a fire heats the sprinkler. Currently there is no sprinklers system that installed in UMP (Universiti Malaysia Pahang) lecture room. In this project by using CFD (Computational Fluid Dynamics) a simulation of fire occurred is created to prove the effect of sprinkler in one of the lecture room (Block Y-BK8). For this simulation, assume that the fire happen due to shock circuit at personal computer. Now from CFD, simulation required finding out boundary condition in that room like power output of lamp and PC. Also air flow rate by air conditioner and sprinkler. From the result of simulation, the sprinkler system is effective if the fire occurred in the lecture room. As a conclusion, a sprinkler system can be installed as a precaution at the lecture room.
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CHAPTER 1

INTRODUCTION

1.1 Project background

Sprinkler system is used to contain fire and in many cases put it out, even before the fire department arrives. Currently, in Universiti Malaysia Pahang (UMP) there is no sprinkler system installed in lecture rooms. There is possibility that the room may have a fire due to short circuit at electronic appliances such as computer in the room. So, to prevent hazard to the room, sprinkler system is essentially needed. Usually the sprinkler system is installed following the rule set by fire department.

1.2 Objective

Using CFD to analyze the effect of sprinkler system in the lecture room at UMP (Block Y-DK8)
1.3 Scope of Study

The scopes of this project are divided into 3 mains part:

a) Predict fire propagation inside the room
b) Understand sprinkler system
c) Using CFD to analyze fire in the room
1.4 Flow Chart

1. Literature review/study on sprinkler system and CFD analysis in room
2. Measure actual size of the room and find out the boundary condition
3. Designing the model of room
4. Simulation/analyze the room using CFD
5. Analysis results
6. Results discussion and conclusion
7. Working on the project proposal
8. Presentation

Figure 1.1: Flow chart
CHAPTER 2

LITERATURE STUDY

2.1 Fire

Fire is essentially a chemical reaction known as combustion. It can spread in minutes and kill in second. Knowing the characteristics of fire and understanding how can help Architects, Engineers and other professional to formulate strategies on life safety and property protection in building designs.

Three factors are needed to start a fire are FUEL, OXYGEN AND HEAT. This is known as the “Fire Triangle”. If this chemical reaction is allowed spread unchecked, a very small fire will quickly develop into an inferno and involve the entire building.
2.1.1 Fire Growth Stages

2.1.1.1 IGNITION

Combustion can be very fast, as in a gas explosion or it can be slow smouldering process.

2.1.1.2 GROWTH

A fire can once started can grow rapidly as it creates the conditions for its own growth. In an enclosed compartment, a critical stage may be reached where all the combustion materials are heated to flammable concentrations of gases and the fire suddenly flashes throughout the whole compartment. This is known as a “Flashover”.

Figure 2.1: Fire Triangle (Prof Datuk Dr Soh Chai Hock, 1998).
2.1.1.2 DEVELOPMENT

The fire passes through a development stage after the initial rapid growth. During this stage the fire temperature increases more slowly. However the fire continues to spread into other areas, which then in turn continues the process of rapid initial growth.

2.1.1.3 DECAY

In the final stage, the fire will burn itself out due to lack of fuel or oxygen. In an enclosed compartment, a fire may smolder for a long period. A sudden rush of oxygen, example breaking a window, can reignite the fire with explosive violence.

2.1.1.4 FIRE LOAD

The total amount of combustible materials available to fire. Certain combustible materials released more heat than others when they burn and so contribute more to the fire load. For example 1 kg of kerosene will release 46050 kJ of heat where as the same weight of paper releases about 16900 kJ.
2.1.2 How Fire Spread

Through natural laws, heat and smoke will travel from hotter to cooler areas by any of the tree methods.

2.1.2.1 Convection

More than 75 percent of the combustion products of a fire example smoke, burning brands, toxic gases are dissipated in rising convection currents of hot gases at temperatures of 800-1000 degree centigrade which heat anything in their path. It will create a "mushroom effect", when the convection current is blocked example by underside of floor or ceiling. It can also smoke log escape routes and prevent means of escape (Prof Datuk Dr Soh Chai Hock, 1998).

2.1.2.2 Radiation

Radiant heat is transmitted to buildings or material not shielded from fire –it is the transfer of heat energy as electromagnetic waves. Radiation passes through normal glass window easily, and building with many or large windows are more likely to spread fire to other building.
2.1.2.3 Conduction

The movement of heat through materials example metals is better conductors of heat than stones. Conducted heat can travel through partitions, floor, ceilings, and walls, to adjacent rooms, especially through metal piping, metal frames and joists. Combustible materials or internal linings of adjacent rooms can be heated to their ignition temperature by conducted heat.

2.2 Sprinkler System

An automatic sprinkler system is intended to detect, control and extinguish a fire, and warn the occupants of the occurrence of fire. The installation comprises fire pumps, water storage tanks, control valve sets, sprinkler heads, flow switches, pressure switches, pipe work and valves. The system operates automatically without human intervention.

Sprinkler is equipped with high water pressure to put out fire instantly like fireman hose. It is made with specific pipe called Chlorinated Polyvinyl Chloride or CPVC and discharged about 25 gallons water per minute (around 113.65 liters per minute). The sprinkler is equipped with a fusible link that melts when the heat given off by a fire and then the water is spray out. For example:
2.2.1 Automatic Sprinklers Model HC Bulb Spray Series

CROSS SECTION

Figure 2.2: Sprinkler

Figure 2.3: Cross Section of Sprinkler

2.2.1.1 Description and Operation

The Globe Model HC Adjustable Concealed Sprinkler is an independent sprinkler designed for use with concealed piping systems for those areas where an attractive appearance is of primary importance. The Model HC is an assembly provided with a cover plate which completely hides the sprinkler head. After installation all that is visible is the small flat cover which can be factory painted any color you wish. Incorporated in its design is an adjustable feature which is infinitely variable for a full 1.27 cm. This will compensate for uneven ceiling heights and allow adjustment of the sprinkler cover at any time. The feature will also allow the removal of the cover plate to facilitate the changing of soiled or damaged ceiling tiles without the removal of the sprinkler head. This provides significant savings for building maintenance.
The cover plate is designed to fall away during a fire and expose the concealed sprinkler to the rising temperatures of the fire. The deflector drops down to a point below the ceiling line. The heat of the fire then operates the glass bulb sprinkler and water is discharged onto the fire.

2.2.1.2 Technical Description

a) Temperature ratings
   155°F (68°C) Sprinkler, 135°F (57°C) Cover Plate
   200°F (93°C) Sprinkler, 165°F (74°C) Cover Plate
b) Water Working Pressure Rating - 175 psi (12 Bars)
c) Factory tested hydrostatically to 500 psi (34 Bars)
d) Maximum low temperature glass bulb rating is -67°F (-55°C)
e) Frame – brass     Deflector – bronze       Screw – brass
f) Bulb seat – copper Spring - nickel alloy Seal – Teflon
g) Bulb - glass with glycerin solution, 5mm

2.2.1.3 Specification of Sprinkler

a) Orifice size: 1/2" (15mm)
b) K Factors: 5.6 (80 metric)
c) Thread Size: 1/2" NPT
d) Finishes: Bright Chrome White Printed
2.2.2 Sprinkler System Design Requirement

2.2.2.1 Design Standard

Under the Uniform Building By-laws 1984, By-laws 226 and 228 refer to the requirement for sprinkler systems. The accepted standards for automatic sprinkler installations are:

a) LPC Rules for Automatic Sprinklers, UK
b) B.S. 5306: Part 2- Specification for Sprinkler systems

In the addition to the above, the other standards may be accepted by the Fire and Rescue Department Malaysia but prior approval must be obtained. Some of the standards which have been accepted are:

a) NFPA 13
b) Australian STD A.S. 2118
c) Factory Mutual

Sprinkler systems are designed based on the hazard classification described in B.S. 5306: Part 2 as follows:

a) Light Hazard for non-industrial occupancies with low quantity and combustible contents. For example: apartments, schools and home.
b) Ordinary Hazard for commercial and industrial occupancies handling and storing ordinary combustible materials. For example: Offices, restaurant and hotels.

c) High Hazard for commercial and industrial occupancies having abnormal fire loads covering process hazards, high piled storage hazards and oil and flammable liquid hazards. For example: Furniture and textiles factories.

For this project case, the sprinkler system should be designed according to Light Hazard.

2.3 Computational Fluid Dynamics (CFD)

CFD is the systematic application of computing systems and computational solution techniques to mathematical models formulated to describe and simulate fluid dynamic phenomena.

CFD is part of computational mechanics, which in turn is part of simulation techniques. Simulation is used by engineers and physicists to forecast or reconstruct the behavior of an engineering product or physical situation under assumed or measured boundary conditions (geometry, initial states, loads, etc.).

CFD also is a computational technology that enables us to study the dynamics of things that flow. Using CFD, we can build a computational model that represents a system or device that we want to study. Then we apply the fluid flow physics and chemistry to this virtual prototype, and the software will output a prediction of the fluid dynamics and related physical phenomena. Therefore, CFD is a sophisticated computationally-based design and analysis technique. CFD software gives us the power to simulate flows of gases and liquids, heat and mass transfer, moving bodies, multiphase physics, chemical reaction, fluid-structure interaction and acoustics through
computer modeling. Using CFD software, we can build a 'virtual prototype' of the system or device that we wish to analyze and then apply real-world physics and chemistry to the model, and the software will provide us with images and data, which predict the performance of that design.

To run a simulation using CFD, the lecture room's boundary condition must be figured out first.

### 2.3.1 Lecture Room's Boundary Conditions

A general room has heat and flow boundary that is as follows:

#### 2.3.1.1 Air Conditioner

![Air Conditioner](image)

**Figure 2.4:** Air Conditioner (YORK Prestige Ceiling Exposed)

The function of this conditioner is to cool the room. When this air conditioner operate, it produce air flow rate. This air flow rate is one of the boundary condition that