UNIVERSITI TEKNIKAL MALAYSIA MELAKA

COMPARATIVE STUDY OF EFFECTIVENESS BETWEEN GLYCOL AND WATER AS A REFRIGERANT MEDIUM

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Refrigeration & Air-Conditioning System) with Honours

by

MUHAMAD AFIQRI BIN ROHMAT
B071210026
870825-23-5103

FACULTY OF ENGINEERING TECHNOLOGY
2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **COMPARATIVE STUDY OF EFFECTIVENESS BETWEEN GLYCOL AND WATER AS A REFRIGERANT MEDIUM**

SESI PENGAJIAN: **2015/16 Semester 1**

Saya **MUHAMAD AFIQRI BIN ROHMAT**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TERHAD	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☑	TIDAK TERHAD	

Disahkan oleh:

Alamat Tetap:

No.9 Jalan Mutiara, Kampung Kangkar 1

85400 Cha'ah, Segamat,

Johor Darul Tak'zim.

Cop Rasmi:

Tarikh:

25 January 2016

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled "Comparative Study of Effectiveness between Glycol and Water as a Refrigerant Medium" is the results of my own research except as cited in references.

Signature **:………………………**

Name **:** Muhamad Afiqri Bin Rohmat

Date **:** 25 January 2016

`

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Refrigeration & Air-Conditioning Systems) (Hons.). The member of the supervisory is as follow:

……………………………….

(Mr. Azwan Bin Aziz)

ABSTRACT

Ethylene glycol and water was used as a coolant in either cold or hot condition. The effectiveness in heat transfer was depend on percentage of mixture between ethylene glycol and water. How the percentage of mixture between ethylene glycol and water influencing the cooling effect was the question. Thus, the comparative study of effectiveness between glycol and water as a refrigerant medium were conducted in this paper by experimental method. This experiment was carried out by using an evaporative coil model at reduced scales. The medium used were ethylene glycol, water and the mixture of ethylene glycol and water. To identify the relationship between the medium, several parameter were required in these experiment which is the changes of temperature of air that flow through the evaporative coil, temperature of medium and temperature of cooler medium (cold water) base on the percentage of medium mixture and time taken of the processes. Cooling efficiency of each medium solutions is also been discussed in this study in order to compare the effectiveness of the medium solution. Meanwhile, the new set of data was provided in this paper to analyse the percentage of medium solution mixture that influence in the cooling efficiency. From the result, the increasing of water percentage in a medium has increased the temperature different and reduced time taken for the cooling effect.

ABSTRAK

Etilena glikol dan air digunakan sebagai bahan penyejuk sama ada dalam keadaan sejuk atau panas. Keberkesanan dalam pemindahan haba adalah bergantung kepada peratusan campuran antara etilena glikol dan air. Bagaimana peratusan campuran antara etilena glikol dan air mempengaruhi kesan penyejukan adalah menjadi persoalan. Oleh itu, kajian perbandingan keberkesanan antara glikol dan air sebagai medium penyejuk telah dijalankan dalam kertas kerja ini dengan kaedah eksperimen. Eksperimen ini dijalankan dengan menggunakan model gegelung penyejatan pada skala yang dikurangkan. Medium yang digunakan adalah etilena glikol, air dan campuran antara etilena glikol dan air. Untuk mengenal pasti hubungan antara setiap medium, beberapa parameter dikehendaki dalam eksperimen ini iaitu perubahan suhu udara yang mengalir melalui gegelung penyejatan, suhu medium dan suhu penyejuk medium (air sejuk) berdasarkan kepada peratusan campuran medium dan masa yang diambil untuk proses tersebut. Kecekapan penyejukan setiap medium juga telah dibincangkan dalam kajian ini untuk membandingkan keberkesanan setiap medium. Sementara itu, set data yang baru telah disediakan dalam kertas ini untuk menganalisis peratusan campuran penyelesaian sederhana pengaruh yang dalam kecekapan penyejukan. Daripada hasil dapatan, peningkatan peratusan air dalam medium telah meningkatkan kadar perbezaan suhu dan mengurangkan masa yang diambil untuk kesan penyejukan.

DEDICATIONS

I would like to dedicate my disquisition work to my family and friends. A feeling of humble and gratitude to my loving parents, Rohmat Bin Samarto and Jumenah Bt Hussin whose words of encouragement and push for tenacity ring in my ears. My brother Muhamad Afiq Bin Rohmat has never left my side and always be there for me. I also dedicate this disquisition to my friends and classmates who have always giving me encouragements throughout the process. I will always appreciate all they have done, especially Muhammad Akmal Bin Azlan for helping me develop my English skills and for many hours of proof reading, Mukminin Bin Mahamad for being all ears on the long nights of complaining, and my class mates for helping me complete this research with ease. I dedicate this work and give special thanks to my best friends Ahmad Lutfi Rabani Bin Abdul Rahman, Abdul Hakim Bin Abdul Aziz, Ahmad Syamin Bin Kamarudzaman, and Muhammad Fida'iy Bin Mohd Zulkifli for being there for me throughout the entire bachelor degree project. All of you have been my best cheerleaders.

ACKNOWLEDGMENTS

I would like to thank to my faculty members who were more than generous with their expertise and precious time. A special thanks to Mr. Azwan Bin Aziz, my supervisor for his countless hours of reflecting, reading, encouraging, teaching, and most of all patience throughout the entire process. Thank you to my bachelor degree project group mates, Choo Hong Liang, Sarni Nur Atikah Bt.Abdul Rahman, Muhammad Ikram Bin Sarani, Mohd Amir Safwan Bin Mohd Yusof, Muhamad Fadhil Bin Jamaludin, Karthigeyen A/L Ramakrishnan and Thanintharen A/L Panir Selvam for completing the researches together. Special thanks goes to our Assistant Engineer in JTKM, Mr. Khairul Fitri Bin Zainal the person that hold the responsibility in handling any activities in the HVAC Laboratory for allowing me doing my research in the laboratory under his surveillance; putting full trust on me for using all the related equipment's and device in the lab and providing any assistance requested. Finally, I would like to thank my academic advisor, Mr Muhammad Fairuz Bin Abu Bakar, the beginning teachers, mentor-teachers and administrators in our university faculty and library that assisted me with this research. Their excitement and willingness to provide feedback made the completion of this research an enjoyable experience.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

ACR	– Air Conditioning and Refrigeration Field Service
ASTM	– American Society for Testing and Material
ASME	– American Society of Mechanical Engineering
ASME B280	– Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASME	– Pressure piping
EG	– Ethylene glycol
PG	– Propylene glycol
OD	– Outside Diameter
RH	– Relative Humidity
P	– Allowable pressure of the pipe internal, (psi)
S	– Maximum allowable stress in tension, (psi)
T_{min}	– Minimum wall thickness of pipe
D_{max}	– Maximum outside diameter
C	– corrosion resistance (constant)
%	– Percentage

CHAPTER 1

INTRODUCTION

1.1 Background of study

Nowadays water and ethylene glycol has been used widely in the industries and daily basis. Glycol, water or the mixture between glycol and water commonly used as a cooling medium for the purpose of heat transfer. Glycol and water have different characteristic and different ability in creating a temperature different as in order to reduce an initial temperature. In general application, water is the most preferred because of several factors for example it is readily available, low cost and more efficient compared to ethylene glycol. The application of this medium commonly used in automobile radiators, heat exchanger in heating, ventilation and air conditioning (HVAC system), injection molding and other industries that required a cooling process. In injection molding processes, there are six major steps involve and one of the steps is cooling which is an important step. The cooling step is important because it is constitutes almost 60% of cycle time before mold opening and ejection step (Rahul Vashisht, 2014). For automobile application, coolant is important to remove heat produced by the engine and increase a performance of the engine (Juger. J., 1999). In HVAC application, glycol and water mixture is used as a catalyst medium during the heat transfer process. It will absorb heat energy from the water in the storage and transfer the heat to the other side of system (condenser) for another heat rejection process. The heat transfer process is in a close loop of cycle without mixing between the glycol-water mixture, and the medium to be cool in the storage (Marc A. Rosen, 2009).

1.2 Problem statements

The effectiveness between glycol and water medium in producing a cooling effect is very important. Glycol and water have a different characteristics for example ability in heat absorption, and efficiency in heat transfer to create a temperature differences. How the percentage of mixture between ethylene glycol and water influencing the cooling effect was the question. In order to identify the effectiveness of the medium, several factors need to include in an account for example temperature differences, and dilution percentage of the mixture. Thus cooling efficiencies of a medium is required before the efficiency of a medium can be identified.

1.3 Objectives

1.3.1 Main objective

To compare the effectiveness between water and glycol medium solutions in producing cooling effect.

1.3.2 Specific objectives

1. To measure the temperature differences of air that flow through the cooling coil.
2. To measure the temperature differences of medium that flow in the evaporative coil.
3. To identify the relationship between the temperature differences and dilution percentage of medium that influence in producing a cooling effect.

1.4 Scopes

This study focusing on;

1. Collecting data of inlet and outlet air temperature that flow through the evaporative coil.

2. Comparing the collected data and evaluate the best medium solution which is depending on dilution percentage of the medium in order to produce a cooling effect.

1.5 Results and expectations

The expected results of this experiment are the effectiveness between water and ethylene glycol solution in producing a cooling effect through a cooling efficiency can be determined. Several parameters should be able to analyze in form of new sets of data after all the measurement process is done. The most important parameter is a temperature different of air in order to calculate the cooling efficiency of the medium solutions. Since the cooling efficiency of medium solution is depending on the percentage of the mixture between water and ethylene glycol, relationship between the percentage of the medium mixture, temperature different, time taken, and cooling efficiency of the medium solution should be identify. The flow chart and project planning as per attach in Appendix A.

CHAPTER 2

LITERATURE REVIEW

Water is probably the most efficient heat transfer fluid known. If it did not freeze, water would be the ideal heat transfer fluid for cooling applications (Corning, 1985). The disadvantage of using water is its freezing point of 0°C (32°F). According to Elkins, (1964) the freezing point can be reducing by a simple method which is by adding a sodium chloride (common salt) in the water. The solution that contained with 23.6% by weight of the sodium chloride has a eutectic freezing point of -22°C (7.6°F). Even though the solution has a low freezing point, there is another problem has to solve. The solution is corrosive to the common metals and consequently requires the use of specially protected system. There is another method can be used to overcome the problem which is by adding a solution of ethylene glycol in water.

When the solution contained with 45% of ethylene glycol, it able to reduce a freezing point and able to reduce the temperature of solution to -30°C without freezing (Marc A. Rosen, 2009). Even though the addition of glycol slightly reduced the heat transfer of water, but most climates and applications, freeze protection are critical. In addition, there are a small amount of other ingredients like corrosion inhibitors, antifoams, dyes and others. (Corning, 1985). Such solutions have been employed for many years as low temperature coolants for automobile engines because glycol and water mixture are highly corrosive at the operating temperature of internal combustion engines. It is important to protect the cooling system against a wide variety type of corrosion for example pitting, crevice corrosion, erosion or cavitation (Basf, 2000).

2.1 Freezing point and boiling point

Ethylene glycol is completely miscible with water in all proportions. Mixtures of ethylene glycol and water will change water properties for example reduction on freezing point and increments of boiling point (Elkins, 1964). The effect of reduction of freezing point and increments of boiling point is depending on a percentage of ethylene glycol in water as shown in Table 2.1.

Table 2.1 : Freezing point and boiling point against percentage (Elkins, 1964)

Ethylene Glycol Percentage, %	**Freezing Point, °C**	**Boiling Point, °C**
10	-4.0	100.0
20	-9.0	102.2
30	-16.0	105.0
40	-25.0	106.1
50	-36.5	111.1
60	-49.0	114.4
70	-44.0	118.3
80	-43.0	120.0
90	-27.0	142.2

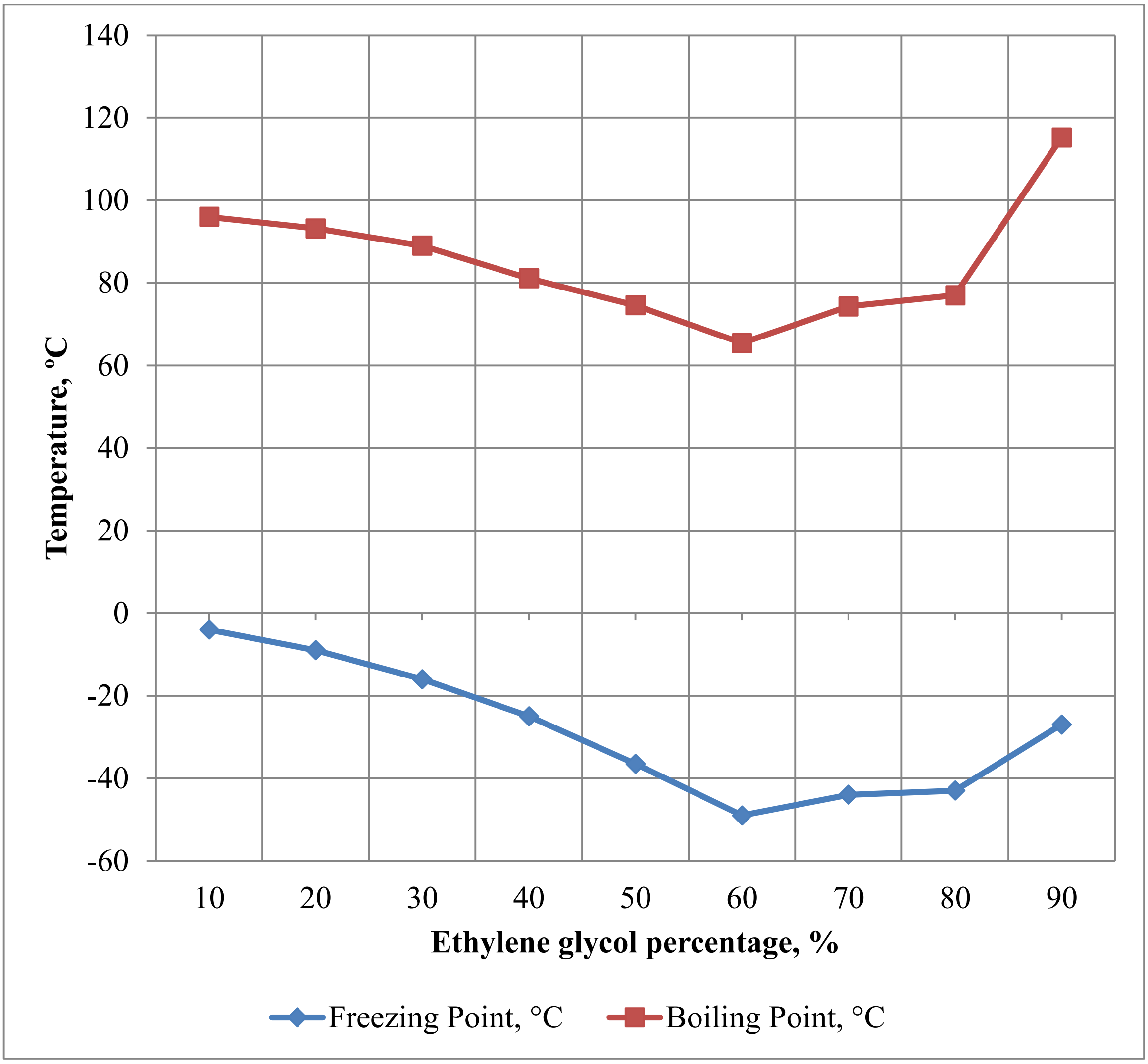

Figure 2.1 : Draft of reduction of freezing point and increment of boiling point.

For the freezing point, it is decreasing when the percentage of ethylene glycol is increasing until the freezing point reach -49°C which is when the percentage of ethylene glycol reach 60%. When the percentage of ethylene glycol is greater than 60%, the freezing point is increase with respect to the percentage of ethylene glycol until reach -12°C which is at 100% of ethylene glycol. However, the boiling point of water is directly proportional which is increasing with respect to the percentage of ethylene glycol. The draft of reduction of freezing point and increment of boiling point is shown in Figure 2.1.

2.2 Cooling time

In injection molding, the cooling time takes by the mold usually up to 70% to 80% of the entire cycle time. As long as the mold cooling effect is concerned, few parameters need to take in account which is cooling channel type, length of cooling channel, flow rate of cooling medium, and cooling medium used. The cooling channel type used is serpentine coil with 6mm in diameter and extends up to 25mm length. On the other hands, the coolant parameter for cooling simulation specified are 20L/min and -25°C (-13°F) of coolant inlet temperature. (Rahul Vashisht, 2014)

Generally water is used widely for mold cooling purpose, but the major effect of the use is that it causes metal to rust. With all the salt contained like magnesium, calcium and chlorine in water, the boiling and freezing point can be reduce. For example, clean water (H_2O) have a boiling point of 100°C (212°F) compared to water (in tap water) that can have it boiling point less than 58°C. Instead of low in boiling point, after long use of this water, the salt deposits can be seen as a whitish stuff for example at the bottom of kettles. The deposits cause clog in the cooling channel and stresses the cooling channel line and pump. Thus, it leads to the failure of the cooling channel line and effect the cooling efficiency. Table 2.2 showed the relationship between mold cooling time, and mold temperature produced by several cooling medium which is water, pure ethylene glycol and oil. (Rahul Vashisht, 2014)

Table 2.2 : Relationship between cooling time and mold temperature

Name	Cool Time (s)	Mold Temperature (°C)
Water	26.8	45.8
Ethylene Glycol (pure)	26.9	46.6
Oil	27.7	48.4

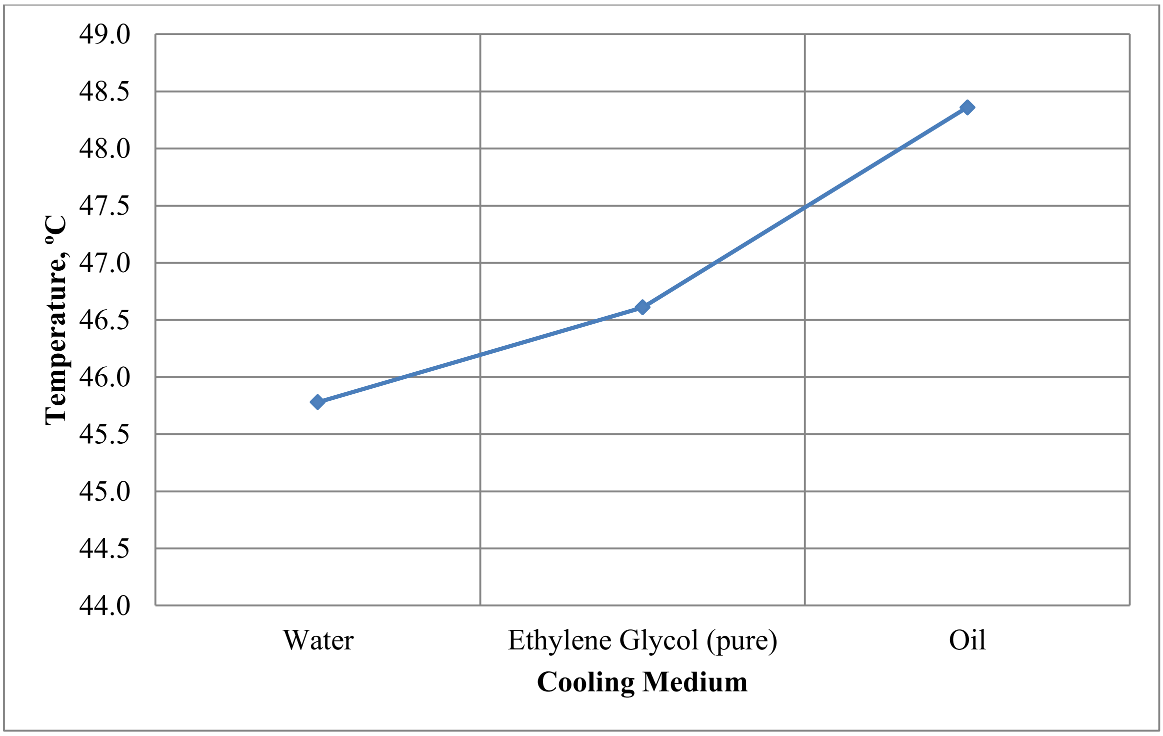

Figure 2.2 : Comparison temperatures of mold come out for each medium.

From Figure 2.2 and Figure 2.3, the plotted graph shown that the water has a lowest cooling time and mold temperature come out followed by ethylene glycol and finally oil. It is showed that water is more effective in terms of heat removal among the coolant medium compared to oil which is least effective among the coolant medium.

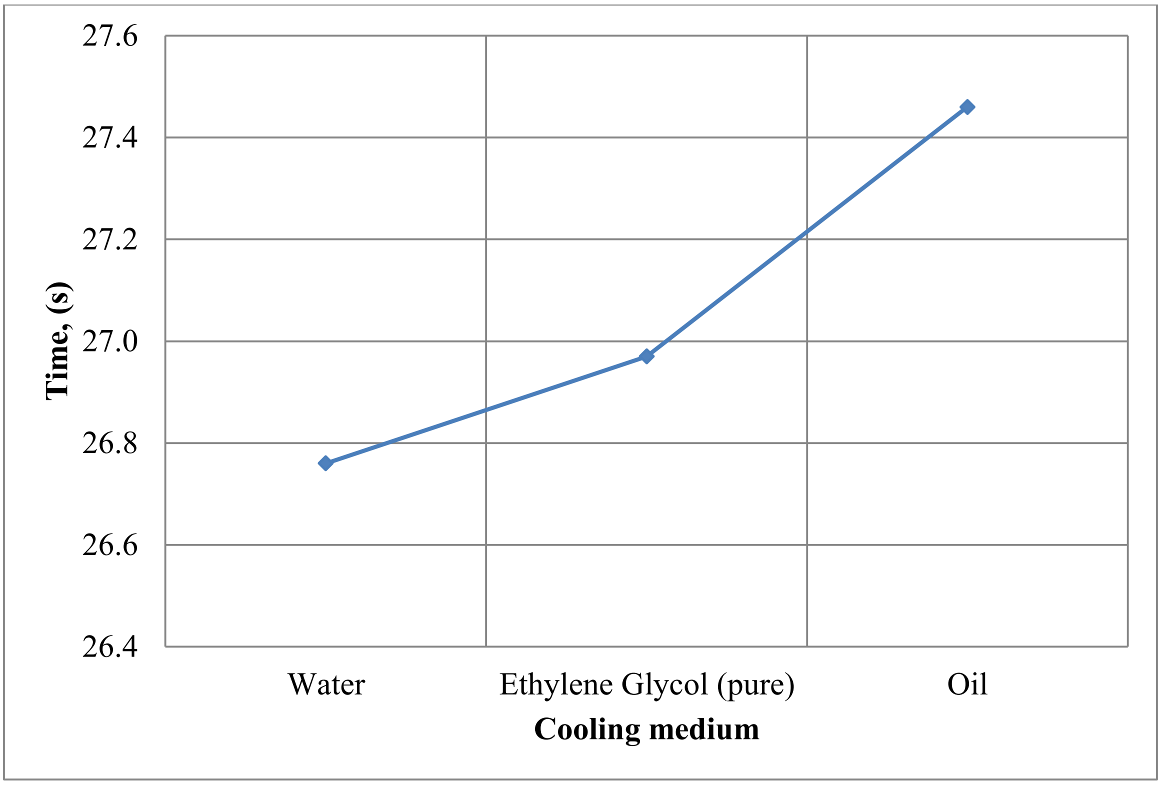

Figure 2.3 : Comparison of time for cooling.

Table 2.3 showed the different refrigerant which is used for the simulation process with properties that affects the cooling process. The properties that affect the cooling process are density, specific heat and thermal conductivity. The different of the coolant are compared in this table.

Table 2.3 : Properties of cooling medium.

Name	Density (g/cm^3)	Specific Heat (J/kg.C)	Thermal Conductivity (W/m.C)
Water	0.988	4180	0.643
Ethylene Glycol (pure)	0.836	2250	0.136
Oil	0.836	2250	0.136