

UNIVERSITI TEKNOLOGI MARA

TECHNICAL REPORT

**HEAT TRANSFER BETWEEN HEATING MEDIUM AND FOOD
PACKAGING USING NEWTON'S LAW OF COOLING**

**NURIN DANIA BINTI SALMAN - 2021102371
NUR AFIQAH ALIAH BINTI ZAPRI - 2021102135
NUR NABILAH BINTI ABDUL RAHIM – 2021119121
(P12S22)**

**Report submitted in partial fulfillment of the requirement
for the degree of
Bachelor of Science (Hons.) (Management Mathematics)
College of Computing, Informatics, and Media**

FEBRUARY 2023

ACKNOWLEDGEMENTS

IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

Firstly, we are grateful to Allah S.W.T for giving us the strength and time to complete this study successfully within a predetermined time.

We would like to express our gratitude to our supervisor, Madam Nor Aishah Md Noh and our MSP660 lecturer, Dr Rossidah Wan Abdul Aziz for helping us in giving ideas and encouragement which it really helps us to write this report. The time spent reading and correcting our mistakes is extremely appreciated.

Other than that, we are also thankful to our classmates and everyone who has been involved in guiding our group to achieve the goal and support whenever we need it to complete our study either directly or indirectly.

We also would like to say big thanks to our family who helped us by providing support and advice when we felt giving up and felling down.

Thank you everyone.

TABLE OF CONTENT

| | |
|--|-----------|
| LIST OF TABLES..... | 4 |
| LIST OF FIGURES..... | 4 |
| ABSTRACT | 5 |
| CHAPTER 1..... | 6 |
| INTRODUCTION | 6 |
| 1.1 Motivation..... | 6 |
| 1.2 Problem Statement..... | 8 |
| 1.4 Significant and Benefit of Study | 9 |
| 1.5 Scope and Limitation of Study..... | 9 |
| 1.6 Definition of Terms | 10 |
| CHAPTER 2..... | 11 |
| BACKGROUND THEORY AND LITERATURE REVIEW..... | 11 |
| 2.1 Background Theory | 11 |
| 2.1.1 The Theory of Heat Transfer | 11 |
| 2.1.2 The Theory of Newton’s Law of Cooling | 13 |
| 2.2 Literature Review | 14 |
| 2.2.1 Determining the Convective Heat Transfer Coefficient (<i>h</i>) in Thermal Process of Foods | 14 |
| 2.2.2 Thermal Processing of Milk..... | 15 |
| CHAPTER 3..... | 17 |
| METHODOLOGY AND IMPLEMENTATION | 17 |
| CHAPTER 4..... | 20 |
| RESULTS AND DISCUSSION..... | 20 |
| 4.1 The Convective Heat Transfer Between The Heating Medium and The Package Surface | 20 |
| 4.2 The conductive heat transfer through the package. | 24 |
| CHAPTER 5..... | 27 |
| CONCLUSION AND RECOMMENDATION..... | 27 |
| REFERENCES | 28 |

LIST OF TABLES

| | |
|---|----|
| Table 1: The definition of terms and abbreviation..... | 11 |
| Table 2: Data used for Phase 1 process..... | 19 |
| Table 3: Data used for Phase 2 process..... | 19 |
| Table 4: The temperature used for Phase 1..... | 20 |
| Table 5 Comparison between T_{∞} and $T_{surface}$ | 21 |
| Table 6: Data used for Phase 2..... | 24 |
| Table 7: Value obtained for the rate of temperature over time and the gradient temperature... | 27 |

LIST OF FIGURES

| | |
|---|----|
| Figure 1: Packaged food product being heated by a heat transfer medium..... | 12 |
| Figure 2: Heat transfer from water to milk in a plate heat exchanger..... | 15 |
| Figure 3: A flow chart of conducting the project..... | 17 |
| Figure 4: The difference between the temperature of heat exchanger medium, the temperature of bottle and the quantity of heat flow..... | 21 |
| Figure 5: Huge difference between T_{∞} and $T_{surface}$ | 22 |

ABSTRACT

In food processing, thermal processes exist where it is a process of reducing or destroying microbial activity. During thermal process, food is heated until it reaches a specific temperature for predetermined time and then cooled (Augusto & Cristianini, 2011). From the process, safety and stable food products will be obtained. In food processing operations such as food packaging, thermal processing is the safest method as there is no contact between the processed food and its surroundings. Newton's Law of Cooling is one of the model used in food processing. Newton's Law of Cooling states that the rate of cooled object is proportional to the difference in temperature between the object and its surroundings. In food processing, Newton's Law of Cooling is used to determine the convection of heat transfer between heating medium and package surface.

In this study, we are going to compare the quantity of heat flow in convective heat transfer between heating medium and package surface, and to determine the difference between the rate of temperature over time and the Laplacian of temperature. From the results we obtained for Phase 1, we observe that the quantity of heat transfer from heating medium to package surface is determined by the difference between temperature of heating medium and package surface. Huge difference in both temperatures will increase the heat flow quantity from heating medium to package surface. For Phase 2, we also observe that the Laplacian of the temperature through the package decrease as the longer the time taken for the heat to transfer through the package. In this process also, we manage to prove that this study indicates indirect system methods of thermal processing as the value of heating rate resulted between 0.01 to $10Ks^{-1}$ (de Jong, 2008).

Thermal processing has been one of the safest method used for food production. Since thermal processing involve a low intensity heat treatment of milk (Pratap-Singh & Mandal, 2019), thermal processing can be resulted to unintended consequences such as nutritional losses, the formation of toxic and hazardous substances (acrylamide, furan or acrolein) or having detrimental effects impacts on flavor perception, texture or color (van Boekel et al., 2010). Different types of packaging and liquid will be resulting different quantity of heat flow and Laplacian of temperature. Therefore, extreme care during the process is needed to ensure that none of the unintended consequences happen.