



الجامعة
UNIVERSITI
TEKNOLOGI
MARA

Cawangan Terengganu
Kampus Bukit Besi

**TITLE: INTEGRATION OF BOW TIE ANALYSIS
AND ALOHA SOFTWARE FOR RISK AND
CONSEQUENCES EVALUATION FOR HEAT
EXCHANGER IN PRODUCTION OF ACETIC
ACID DURING CHEMICAL PROCESS
DEVELOPMENT AND DESIGN**

**SUPERVISOR:
SIR MUHAMMAD FIRDAUS BIN HUSIN**

**SCHOOL OF CHEMICAL ENGINEERING
COLLEGE OF ENGINEERING**

2023

ABSTRACT

The top priority of the industry in the current days is the safety and health of the chemical plant. This to ensure the workers could work without any worries and ease the civilian nearby. Despite this effort which has been so much time into there still an accident that related to heat exchanger in the chemical industry plant. Some of them were cause by loss of containment that lead to heat exchanger rupture and cause an explosion. The purpose of this study is to analyse the risk that presence in the heat exchanger for the production of acetic acid in the preliminary stage and do risk analysis using bow tie analysis and ALOHA modelling software and create risk mitigation. Risk analysis using bow tie only provide risk assessment without consequences analysis in detail thus using ALOHA modelling software to show the threat zone of the consequences in diagram. Analysing the result of ALOHA modelling software the most dangerous chemical that could cause the largest area of highest level hazard is the acetic acid with the red threat zone which the highest level of hazard raging around 700 meters. Implementing both bow-tie analysis and ALOHA in the preliminary stage could provide more detail and sophisticated risk analysis and create a prevention method to lowered the chance for the risk to occur.

TABLE OF CONTENTS

	Page
AUTHOR'S DECLARATION	2
ABSTRACT	3
TABLE OF CONTENTS	4
CHAPTER ONE BACKGROUND	5
1.1 Introduction	5
1.2 Literature Review	6
1.2.1 Methanol	6
1.2.2 Carbon monoxide	7
1.2.3 Acetic acid	8
1.2.4 Heat exchanger	8
1.2.5 Bow tie analysis	10
1.2.1 Inherent safer design (ISD)	11
1.2.2 Areal Location Hazardous Atmosphere (ALOHA)	11
1.3 Problem Statement	11
1.4 Objectives	12
1.5 Scope of Study	12
CHAPTER TWO METHODOLOGY	13
2.1 Introduction	13
2.2 Hazard identification	13
2.3 Risk assessment	14
2.3.1 Bow Tie Analysis	14
2.3.2 Areal Location Hazardous Atmosphere (ALOHA)	15
2.4 Risk and hazard acceptance	25
CHAPTER THREE RESULT AND DISCUSSION	26
3.1 Introduction	26
3.2 Bow tie analysis	27

3.3	Aloha result	30
3.4	Direct sources	30
3.5	Puddle (evaporating puddle)	32
3.6	Puddle (pool fire)	34
3.7	Tank (Not-burning)	36
3.8	Tank (Burning)	38
3.9	Tank (Bleve)	40
3.10	Discussion	42
CHAPTER FOUR CONCLUSION AND RECOMMENDATION		43
4.1	Conclusion	43
4.2	Recommendation	43
REFERENCES		44

CHAPTER ONE

BACKGROUND

1.1 Introduction

This rapidly growing world where technology was one of the most important and essential needs in humanity life, the pace of the industrial area also growing at tremendous speed to catch up with the current era. As the industrial era also growing it was a given that the chemical factory or production factory or anything that is related to them also stand side by side with them. But despite the everyday life or welfare of humanity also change rapidly there was also a problem that occur along as well, such as the safety of a plant or safety of working environment. This is an inescapable curse as the industry need to catchup with the immense growing of the market demand. To abate the anxiety of the citizen the safety of the industrial and site also have main priority that have been put up above the rest of the order in the industrial area. The safety engineer effort have been put 100 percent into the improvement of the safety of the site. Safety engineering also has been working tirelessly into researching way to prevent and avoid the tragedy that can incur anytime like a ticking time bomb. The safety engineer also have to consider the safety design of the equipment long before the start of the operation. The safe of design has two things that need to be consider which is hazard detection and risk assessment. This two things that need to be consider due to prevent of such cataclysm disaster that may occur if things went wrong. An accident on such large scale of plant could lead to enormous damage to surrounding environment, people or financial.

To avoid such a catastrophe from happening, safety and risk analysis must be done without any sparring even a little amount of time and effort. To lower the risk of such event occur a risk analysis method known as bow tie should be implemented in the plant. The bow tie analysis is a risk assessment method that contain diagram of threat, mitigative and prevention barrier, and the consequence of the event. The bow tie is a simplified graphic version of the fault tree of the incident that occurred. The bow tie analysis was one of the method that contain the perfect inherent safety design (ISD) inside the preventive barrier. The ISD contain four element, minimize, moderate, Simplify and Substitution. After implementing this method the result can be justified as resolution thus cutting down the risk of the hazard that may occur in the factory. Due to this reason the bow tie analysis should be consider a top method to lowering down the risk of hazard. The preventive barrier of the bow tie may act as an action that could be apply if a hazard that been assessed occurred. The Areal Locations of Hazardous Atmospheres (ALOHA) is a method to analyze the consequence of the hazard such as the chemical release if a certain scenario may occur at the factory. This analysis software depict the dispersion and release of the factory into a graphic. This graphic shown when the software has been key in specific input. Then the software will shown threat zone that display specific range of dispersion and chemical release that occur. Some of the source that can be use to find the threat zone of the chemical release such as direct source, puddle, tank and gas pipeline sources. ALOHA also can be use to determine the threat zone of specific incident such BLEEVE (Boiling Liquid Expanding Vapor Explosion), jet flames, pool fire and vapor cloud explosion. This ability to analyze the scenario and from various source make ALOHA as one of the important software that can be use in safety design for factory.

From the implementation of both bow tie analysis and ALOHA software could create a comprehensive assessment that will be helpful in process safety design of chemical plant industries. This will then improve the safety of the factory may reduce the probability of an incident occur in future. Though the implementation of both method may not always 100 percent accurate and the incident may also happen but this will greatly reduce the anxiety of the workers and civilian and could create a peaceful atmosphere.

1.2 Literature Review

1.2.1 Methanol

Methanol, CH₃OH also known as methyl alcohol is a toxic chemical that have been widely used in the chemical industry nowadays. Methanol is liquid at room temperature and has a boiling point and freezing point respectively at 64.96 degree Celsius and -93.90 degree Celsius. Methanol is one of the most important raw chemical that has been used in many ways. Production od acetic acid also use the methanol as it` s