INTEGRATED PROCESS KNOWLEDGE MANAGEMENT SYSTEM BASED ON RISK BASED PROCESS SAFETY IN PETROCHEMICAL INDUSTRIES

NUR IZZATI BINTI PAKHOR ANUAR

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I/We* have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

____

(Supervisor's Signature)

Full Name : T.S DR. HANIDA BINTI ABDUL AZIZ

Position : SENIOR LECTURER

Date : 17th August 2022

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : NUR IZZATI BINTI PAKHOR ANUAR

ID Number : MTS19001

Date : 17th August 2022

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NUR IZZATI BINTI PAKHOR ANUAR

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ABSTRAK

Garis panduan *Risk Based Process Safety (RBPS*) adalah untuk membantu industri petrokimia untuk mematuhi undang-undang *Process Safety Management (PSM).* Maklumat loji proses yang tidak dikemaskini, berselerak dan sukar diakses telah dikenal pasti diantara faktor penyebab utama kemalangan berimpak besar ini masih berlaku. Penukaran data elemen *Process Knowledge Management (PKM)* turut menjejaskan integriti dan ketepatan maklumat elemen-elemen *RBPS* yang lain dan sebaliknya. Kekurangan kajian berhubung perkaitan antara elemen PKM dan 19 elemen RBPS yang lain telah membantutkan keberkesanan pelaksanaan program ini. Kekurangan sistem yang merangkumi integrasi antara elemen PKM dan elemen-elemen RBPS yang lain turut tidak menyumbang peningkatan tahap keselamatan proses di tempat kerja secara sistematik. Objektif kajian ialah menentukan perkaitan antara elemen *PKM* dengan 19 elemen-element *RBPS* yang lain, menbangunkan carta alir PKM dan carta alir bersepadu berdasarkan garis panduan *RBPS*, membangunkan sistem *PKM* bersepadu yang dinamakan *Process Safety Knowledge Expert (PSKE)* dan untuk mengesahkan *PSKE* yang dibangunkan melalui kajian kes, perbincangan kumpulan fokus dan *System Usability Study (SUS)* dalam industri petrokimia. Metodologi kajian menggunakan penyelidikan secara kualititif, penerokaan. Perkaitan elemen PKM dan 19 elemen RBPS secara berheirarki *(waterfall approach)* yang merangkumi aktiviti kerja telah diterokai. Hasil dapatan perkaitan ini dibentangkan dalam rajah pemetaan dan jadual matriks. Rangka kerja PKM, yang terdiri daripada maklumat utama dan strategi pelaksanaan untuk memenuhi keperluan garis panduan RBPS telah dibangunkan. Rangka kerja bersepadu yang menonjolkan kesalinghubungan PKM dan elemen RBPS lain turut dibangunkan berdasarkan tinjauan literatur yang komprehensif. Seterusnya *Process PSKE* dibangunkan menggunakan konsep *System Development Life Cycle (SDLC*). Teknologi bahagian hadapan PSKE menggunakan pembangunan aplikasi rangka kerja Ionik; sementara itu, teknologi belakang menggunakan produk Firebase oleh Google. Pengesahan sistem melibatkan tiga peringkat termasuk kajian kes di loji Petrokimia X, perbincangan kumpulan fokus dan kajian *SUS* di kalangan 9 kakitangan loji dari HSSE dan Jabatan Operasi. Jadual matriks saling hubungan PKM yang dibangunkan telah secara sistematik menunjukkan PKM mempunyai perkaitan dengan elemen RBPS yang lain. Manakala, Daripada kajian kes, PSKE membenarkan pengguna akhir menyimpan, menyemak, mengubah suai dan mengemas kini data berkenaan bahan kimia berbahaya, teknologi dan maklumat peralatan dalam masa nyata. Antara muka PSKE membolehkan pihak pengurusan melakukan audit semakan sendiri dan membantu pihak pengurusan menjejaki maklumat. Sebagai penunjuk utama, PSKE membolehkan pengguna menyemak status keseluruhan pematuhan syarikat kepada standard keselamatan. Selain itu, PSKE membenarkan pengurusan atau pekerja mengurus dan menyemak program PKM, *Process Hazard Analysis (PHA)* dan program *Asset Integrity and Reliability (AIAR*) secara serentak. Untuk kajian *SUS*, terdapat empat pernyataan mendapat markah 89% dan kesemua 10 pernyataan SUS mendapat peratusan sifar untuk skala ‘Tidak Setuju’ dan ‘Sangat Tidak Setuju’. Kesimpulannya, PSKE mendapat maklum balas positif dari segi kebolehgunaan dalam industri petrokimia. Diharapkan sistem ini dapat membantu meningkatkan tahap keselamatan di industri petrokimia dan mencegah kemalangan besar secara serentak.

ABSTRACT

Risk Based Process Safety (RBPS) guideline objective is to help the petrochemical industries to comply with Process Safety Management (PSM) standard. Outdated, scatted, and inaccessible process knowledge have been identified as significant causal factors of major accidents. Changing Process Knowledge Management (PKM) data can affect other elements, and changes in other elements also affect the reliability and accuracy of PKM elements. The shortcoming of study regarding PKM element interrelationship with other 19 Risk Based Process Safety (RBPS) has hindered the effectiveness of RBPS program. Besides that, lacking systematic system to implement the PKM program that integrates with others RBPS elements also delayed the improvement of process safety levels at the workplace. The research objectives of the study are to determine interrelationship of PKM element with other 19 RBPS elements, to develop a PKM flowchart and integrated flowchart based on RBPS guidelines, to develop integrated PKM system named Process Safety Knowledge Expert (PSKE) and to validate the developed PSKE via case studies, focus group discussion and System Usability Scale (SUS) study in Petrochemical industries. The research methodology used a qualitative, exploratory research design. The interrelationship of the PKM element with other 19 RBPS elements based on possible work activities used hierarchical structure (waterfall approach) and the interrelationship is presented into the mapping diagram and matrix table. A PKM flowchart, which consists of vital information and an implementation strategy to fulfil RBPS guideline requirements, was developed and integrated flowchart that highlights the interrelationship of PKM with other RBPS elements was developed after comprehensive literature review. Then, PSKE was developed using System Development Life Cycle (SDLC) approach. The front-end technology of PSKE used the Ionic framework apps development, meanwhile back-end technology used Firebase product by Google. Validation of the system involved three stages including case study at petrochemical Plant X, focus group discussion and System Usability Scale (SUS) study involving nine plant personnel (expert and key person) from HSSE and Operation department. PKM interrelationship matrix table has systematically confirmed that PKM has significant interrelationship with all of 19 RBPS elements. From the case study, PSKE allow the end-user to store, review, modify and update the data regarding hazardous chemicals, technology, and equipment information in real time. PSKE interfaces allow management to do a self-check audit and help the management to track the information. As a leading indicator, PSKE allows the user to review the overall status of the company compliance to the safety standard. In addition, PSKE allows management or employees to manage and review the PKM program, Process Hazard Analysis (PHA) and Asset Integrity and Reliability (AIAR) program simultaneously. For the SUS study, there are four statements scored 89% and all of 10 SUS statements got 0% for the scale ‘Disagree’ and ‘Strongly Disagree’. It can be concluded that PSKE received positive feedback in term of usability in petrochemical industries. Hopefully the system could help to increase the safety level at petrochemical plant and prevent major accidents simultaneously.

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LIST OF SYMBOLS

%	Percentage
kgf/cm2	Kilogram-force per square centimetre
^{o}C	Degree Celsius
CO_2	Carbon dioxide

LIST OF ABBREVIATIONS

PSM	Process Safety Management
AIAR	Asset Integrity and Reliability
AICHE	American Institute of Chemical Engineers
CBS	Chemical Safety Board
CCPS	Center for Chemical Process Safety
CLASS	Classification, Labelling and Safety Data Sheet of Hazardous Chemical
CIMAH	Control of Industrial Major Accident Hazard
CIMS	Chemical Information Management System
DOSH	Department of Occupational Safety and Health
EP	Employee Participation
FFAR	Fixed Film Anaerobic Reactor
HIRA	Hazard Identification and Risk Analysis
HTHA	High Temperature Hydrogen Attack
HAZOP	Hazard and Operability study
II	Incident Investigation
LPG	Liquified Petroleum Gas
MI	Mechanical Integrity
MIDA	Malaysia Investment Development Authority
MOC	Management of Change
MHI	Major Hazard Installation
OSHA	Occupational Safety Health Administration
PDCA	Plan Do Check Act
PSI4ms	Process Safety Information System
PKM	Process Knowledge Management
PSKE	Process Safety Knowledge Expert
PHA	Process Hazard Analysis
PHM-LabPP	Process Hazards Management for Lab Scale Pilot Plant
PPM	Part Per Millions
PSC	Process Safety Culture
PSPC	Process Safety Competency

P&ID	Piping and Instrumentation Diagram
RBPS	Risk Based Process Safety
ROG	Reactor off Gases
SDLC	System Development Life Cycle
SUS	System Usability Scale
SQL	Structured Query Language
STEL	Short-Term Exposure Limit
TWA	Time Weighted Average
WWT	Wastewater Treatment
WI	Worker Involvement

LIST OF APPENDICES

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