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Analysing Qualitative Data Systematically using Thematic Analysis for Deodoriser Troubleshooting in Palm Oil Refining

Intan Suhairi Salleh[a], Nur Syuhada' Mohamad Ali[a], Khairiyah Mohd-Yusof*[,b], Hishamuddin Jamaluddin[c]

[a]Department of Chemical Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, UTM Skudai, 81310 Johor Bahru, Malaysia
[b]Centre for Engineering Education, Universiti Teknologi Malaysia, UTM Skudai, 81310 Johor Bahru
[c]Faculty of Engineering and IT, Kolej Universiti Selatan, 81310 Skudai, Johor, Malaysia
khairiyah@cheme.utm.my

Troubleshooting the deodoriser in palm oil refining is challenging because of complex design of vacuum system. Not all the required information to develop a good troubleshooting system can be obtained from documents and the literature. A mistake in corrective action may cause failure in plant operation and final oil quality. Since experienced plant workers have in-depth knowledge on the specific equipment and process that they are in-charge of, systematic knowledge acquisition from them can be used to develop a fuzzy logic-based troubleshooting system. This system can help other less experienced staff in identifying root cause of deodoriser failure before taking any corrective action. The qualitative data obtained from interviewing the plant experts must be analysed systematically to ensure that the information obtained are trustworthy. Therefore, this study implemented thematic analysis to sort knowledge based on a theme of the root cause of deodoriser failure. The thematic analysis consists of 5 steps, which are data familiarisation, code generation, theme searching, reviewing and description. Fifteen plant workers (includes engineer, supervisor, technician and operators) were interviewed to develop themes. The useful information is captured from the interview session through code generation. Two senior managers verified the final themes, and the theme is further described based on the theoretical knowledge and process description. The final themes presented as thematic tree provide fault propagation, while troubleshooting table has information on root cause and its necessary action. The main themes presented the root cause of deodoriser failure based on critical location, i.e. ejector. The documented thematic analysis can assist inexperienced workers to learn the prior knowledge of deodoriser failure sources from troubleshooting table and thematic tree.

1. Introduction

Failing to obtain knowledge from workers in the plant especially from the front liner to troubleshoot failures during the process contributes to wrong decision making, wasting cost and time consuming. The absence of operators' experienced and knowledge of the experts' not only lead to incorrect way to diagnose fault and unable to eliminate and isolate the causes, but it also led to incorrect action to troubleshoot the failures, which all of its led to the negative outcome to overall plant performance. Due to the realisation of the urgency to obtain and integrating the experienced and knowledge of plant workers, it is emphasised to have a systematic guideline for troubleshooting failures at the process by organising, coding and writing the data using systematic approached call thematic analysis.

Thematic analysis is an established method of organising qualitative data and has good potential in capturing knowledge and experienced of workers and experts. Boyatzis (1998) described thematic analysis is a method to identify, analyse and report patterns (themes) within the data. Thematic analysis has given advantageous in educational, early childhood and safety field. In educational field, results from thematic analysis can helps the lecturers to improve their teaching techniques by identifying knowledge obtained by the students in Problem Based Learning (PBL) class (Mohd-Yusof et al., 2014). The students' knowledge has been discovered by

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analysing their reflection journal and assignment reports. Raufelder et al. (2016) has identified method to improve teacher and student relation based on student perception by extracting themes and subthemes that describe the students' perception of "good" and "bad" teacher. The quality of teacher and student relationship, teaching expertise and teacher personal characteristic are the emerging themes revealed from the analysis. Meanwhile in early childhood field, the result from thematic analysis able to discover the children level of gratitude. Children from middle class family have less grateful compared to children from lower class family. This is because children from middle class family easily get things that they wanted (Halberstadt et al., 2016). Rylatt and Cartwright (2015) had identified parental feeding behaviour and motivation at pre-school age children. Based on the study, model, rewards, pressure and encouragement, repeated exposure, creativity, and limiting food intake are the emerging themes from the study. Recently, a study of thematic analysis has been conducted in safety industry. Fyffe et al. (2016) has conducted a thematic analysis to analyse the key issues in order to improve safety and process efficiency at chemical facilities using qualitative and quantitative characteristic. There are five emerging themes discovered from this study which are design and engineering, standards, process hazard analysis, emergency planning and response, and hazard recognition were examine closely to identify particular focus area in which changing in process safety management can be considered. The emerging themes will be evaluated for update the process safety management.

Thematic analysis is the useful methods to merge with fuzzy expert system, where the knowledge of experience plant workers can be organised according to fuzzy system requirement that needs both qualitative and quantitative data. Other troubleshooting methods such as Fault Tree Analysis (FTA), Failure Modes Effect Analysis (FMEA), and root cause analysis require more quantitative data that is found to be challenging in palm oil refining due to missing data and uncertainty.

In this study, thematic analysis is used to integrate the interview data with fuzzy expert system to troubleshoot failure at deodorisation process in palm oil refining since the data is very useful for complex process and required systematic analysis. The themes were presented in the form of a tree and troubleshooting table. Thematic tree was developed after all the themes emerged. Thematic tree with fault propagation will be used to create if-part in the fuzzy rule, while troubleshooting table that consists of necessary action on the possible faults will be used for the then-part.

2. Methodology

Thematic analysis consists of five steps: data familiarisation, code generation, theme search, themes revision, and theme definition (Braun and Clarke, 2006). The method has been modified to fit in technical problem in solving industrial complex operation, where the data familiarisation includes field observation along with interview sessions. The revised themes were involved senior manager that experienced more in troubleshooting, while the final themes were defined based on process description and presented as thematic tree and troubleshooting table. The thematic tree can represent and link all the possible faults (final themes and subthemes) based on fault propagation, while troubleshooting table match the possible fault to its action.

The interview data were analysed using thematic analysis to obtain the pattern of possible faults in the deodoriser failure. The method of thematic analysis is commonly used in qualitative research to capture the complexities of meaning within a textual data set (Guest et al., 2012). The analysis is time consuming due to the continuous coding process throughout the entire analysis that requires repeated reading the entire data to see for the pattern and its interpretation. The analysis provides detailed analysis of the possible deodoriser faults instead of the overall data description. The analysis was driven by the theoretical interest in finding the possible faults of deodoriser failure that requires more involvement and interpretation by the researcher. The possible faults were represented as a theme by organising the pattern of complaints by the experienced plant workers. The phases in the thematic analysis are summarised in Figure 1.

2.1 Data familiarisation

Data familiarisation is a process to be immersed and familiarised with the data that obtained interactively during field observation and interview sessions, where the initial ideas on the possible faults were remarked. The field observation gives prior knowledge that possesses initial analytic interests or thought. During field observation, the process of unit operation and tips on plant troubleshooting were investigated with some ideas of possible problem. The theoretically driven data familiarisation motivates researcher to read the entire data repeatedly to search for meaning and pattern during identifying the possible faults of deodoriser failure. Field observation provides opportunities to learn about deodorisation and plant troubleshooting. Field observation is useful to identify whose experienced plant workers and some ideas on troubleshooting of deodoriser failure. The identification of experienced plant workers is important for interview sessions. During the interview sessions, the experienced plant workers will be asked about the root cause of the deodoriser failure and its necessary actions. The identification of the term used is useful during interview sessions for asking better troubleshooting questionnaires. During the interview sessions, 80 questionnaires were asked randomly to 15 experienced plant workers. Each worker received different number of questionnaire range, 3 to 22 depending on their experiences in troubleshooting the failure at the deodoriser column, fatty acid distillate and vacuum system. The interview and discussion sessions were audio recorded to capture plant workers experience.

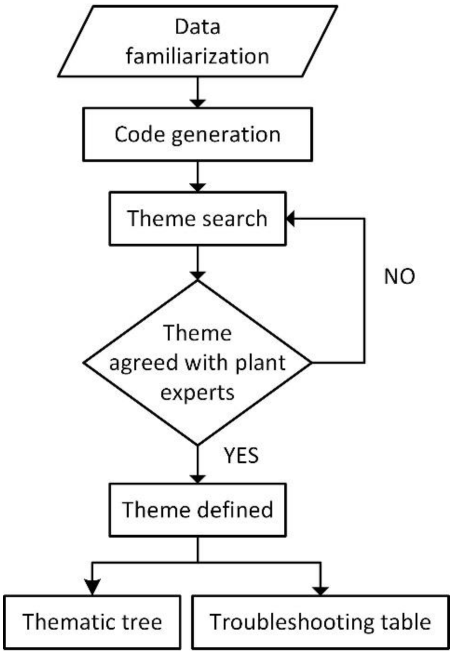

Figure 1: Thematic analysis flowchart

2.2 Code generation

The coded data was generated from the list of ideas on the possible faults that extracted from individual transcripts. The ideas were coded manually based on feature similarities such as location, unit operation, and function, processing parameter, etc. that helps the researcher to distinguish quickly the coded data from each other. The manual technique of coding process gives researcher opportunity to control the ideas obtained and interpret the different terms used by experienced plant workers. During analysing the individual transcript, different terms used by plant experts, but describe the same meaning were bold or remarked. The pattern of ideas on the possible faults was coded.

2.3 Theme searching and revision

In theme searching, the list of coded data was analysed and sorted into potential themes at the broader level of deodoriser failure. The coded data were combined based on the relationship of themes and subthemes that relying on the process flow diagram, unit operations and process parameter condition. The themes were represented as critical locations in the deodoriser failure, while subthemes were specific location or possible faults. The complex deodoriser decomposed into critical locations or themes.

In theme revision, the plant expert revised themes and subthemes that based on the deodoriser process description and how the failure occurred. The revision made through several times meeting to check the correct interpretation of the interview data. The agreed themes and subthemes by plant experts were renamed and defined.

2.4 Theme definition

The defined themes and subthemes were justified as possible faults in the deodoriser failure. The renamed themes have been finalised to represent the possible faults that contributed to the deodoriser failure and produced high acidity of refined palm oil. The detailed analysis of renamed themes includes the essence of each theme and the effect of possible faults to the deodoriser failure as thematic tree and troubleshooting table.

3. Result and discussion

3.1 Ejector and theme formation

The interview data were transcribed and quoted to generate codes and themes afterwards. In this example, the motive steam pressure was coded from the term of “steam” that based on three quotations of experienced plant workers. The terms used are “steam supply,” “steam” and “steam header” that are slightly different among executive, supervisor and operator but have similar meaning. The generated code of motive steam pressure was sorted based on fault location, “vacuum system” to form theme and subtheme. The subtheme is the specific fault location while theme is a general fault location. However, vacuum system is complex area and hardly to be identified during troubleshooting. Therefore, the theme of “vacuum system” was split into specific fault location such as ejector, vacuum condenser and cooling tower. Figure 2 shows the ejector theme formed from the generated code of motive steam pressure.

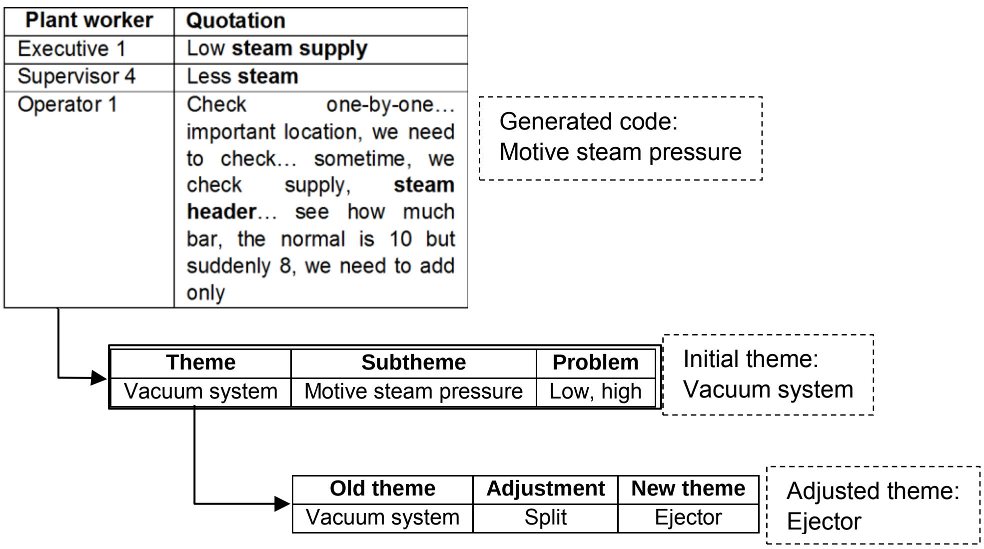

Figure 2: Ejector theme formation

3.2 Thematic tree

The thematic tree provides the deodoriser fault propagation by using a logical gate based on the chemical process in a unit operation. The thematic trees consist of themes and subthemes in different level (Sturt and Crocker, 1998). The logical gate such as "and" and "or" operator is crucial to connect the possible faults. Figure 3 shows the thematic tree for motive steam, which is consists of a theme and three subthemes with or-operator. The theme is ejector, while subthemes are motive steam pressure, motive nozzle and total steam flowrate. The theme is a failure equipment, while subthemes are the sources of equipment failure. In this case, the sources of ejector failure are low motive steam pressure or worn motive nozzle or low total steam flow rate.

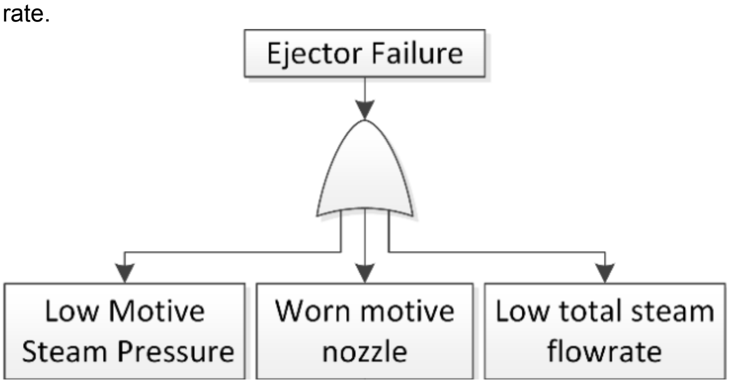

Figure 3: Ejector thematic tree

3.3 Troubleshooting table

The troubleshooting table combined the possible faults and the necessary action to guide field plant workers in plant troubleshooting. The possible fault is identified based on the sequence of necessary actions. The necessary action is listed based on the plant expert suggestion. The first column has information on the possible faults with a new coded label, the second column shows the description of each coded possible faults, the third column is the condition data range, fourth column is the condition of each possible fault, and the fifth column is the necessary action. The necessary action is crucial to prevent recurrence of failures that can be separated into near-term and long-term requirements. The actions can be supplemented with an action plan or a notation of action assignments and action status (Heinz and Fred, 1999).
Table 2 shows the troubleshooting table for motive steam pressure. The troubleshooting table related possible fault of motive steam pressure to its necessary actions suggested by the plant experts. $VS1$ is a code for motive steam pressure. The designed pressure is 9 bar. The pressure with 20 % higher than designing pressure can damage the motive nozzle orifice. Therefore, the action is to decrease setting is recommended. Pressure lower than 9 bar caused less steam to compress the suction fluid. Vacuum pressure will drop without the action of increase setting to reach minimum designed pressure.

Table 1: Troubleshooting table of motive steam pressure

Code	Possible fault			Necessary Action
$VS1$	Motive steam pressure (P, bar)	Low	< 9[d]	Increase setting[d]
		Normal	9[a] – 12[c]	Do nothing[d]
		High	> 12[d]	Decrease setting[d]
$VS2$	Total steam flowrate (F, kg/h)	Low[d]	< 3,000[d]	Increase valve opening[c]
		Normal[d]	3,000 – 4,000[d]	Do nothing[c]
		High[d]	> 4,000[d]	Decrease valve opening[c]
$VS3$	Motive nozzle (ΔA, %)	Normal[d]	< 7[c]	Do nothing[c]
		Worn[d]	≥ 7[c]	Replace[b, c]

[a] Operation checklist: Körting-Hannover (1998);
[b, c] Technical literature: [b] vacuum systems (Heat Exchange Institute, 2014); [c] ejector system (Lines and Smith, 1997);
[d] Knowledge of experienced plant workers and expert

Similarly, $VS2$ is code for total steam flowrate. The normal range is 3,000 to 4,000 kg/h. Flowrate less than 3,000 kg/h steam provide less energy to compress suction fluid in the ejector. The action to increase valve opening to reach minimum 3,000 m^3/h is recommended. However, flowrate more than 4,000 kg/h can waste steam and damage motive nozzle. Therefore, gradually decrease valve opening is suggested. $VS3$ is motive nozzle condition. Increasing area to more than 7 % can waste steam. Replace steam nozzles with a smaller throat diameter is a workable solution (Lines and Smith, 1997) but requires plant shut down for maintenance.

4. Conclusions

It can be concluded that, the thematic analysis able to capture the potential failure at deodorisation process in palm oil refining. The analysis data obtained able to generate the root cause for deodoriser failure. Fault propagation at the deodoriser system was illustrates in the thematic tree, while troubleshooting table is describing necessary action to be taken. Therefore, the thematic analysis can be used as a systematic guideline for troubleshooting deodoriser failure.

Acknowledgments

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