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Information-sharing system supporting onsite work for chemical plants

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ABSTRACT

According to a recent report by the Japanese government, about 40% of accidents in the chemical industrial complex are caused by human factors, including misjudgment, misoperation, recognitions and confirmation error. Many kinds of hazardous materials are present at chemical facilities, and improving the safety and reliability of work procedures is extremely important for employees and local residents. However, industrial technology has changed, becoming highly diversified and complicated; especially in an emergency, plant operators are having more trouble grasping the overall situation. This study created a system for sharing information between field operators and control room operators via a web browser and a dynamic plant simulator. Operators are required to make quick decisions to prevent the expansion of an accident, and this system can support them to monitor the situation in real time from the control room and in the field. Sharing plant information is important for making quick decisions, and the paper outlines how the system prevents miscommunication. The system described here displays plant information that is linked to a dynamic simulator, enabling text message communication, among other things. Instructions to field operators are usually conveyed verbally, such as by paging. Here, a visual element in addition to the output of information by sound helps to accurately convey information. In this system, dynamic simulator information (a kind of virtual plant) is used instead of actual plant information. Thus, this system can be used for safety training using a real work environment.

1. Introduction

Preventing accidents in chemical plants is crucial to protecting the safety of employees and local residents. However, the number of accidents that occurred from 1989 to 2014 has been increasing, and several accidents at large industrial facilities have occurred continuously. Detailed information on the accident trend in chemical plants was published in the report "Liaison Committee for Municipalities and Agencies Reviewing Measures for the Prevention of Industrial Accidents at Petrochemical Complexes, etc." The report was compiled via a Joint Press Release with the Fire and Disaster Management Agency and the Ministry of Health, Labor, and Welfare of Japan (2015). In FY2014, there were 253 accidents reported by 697 establishments in special disaster prevention areas such as petrochemical industrial complexes, totaling 24 cases more than the previous year. Of the total number of cases, 98 (39.0%) were due to human factors, 140 (55.3%) were due to physical factors (e.g., corrosion, equipment failure), and 15 (6.0%) were due to disasters such as earthquakes, arson, and others. As causes of industrial accidents, there are many types of human errors, such as cognition/confirmation mistakes, misoperation, and misjudgment by employees. In terms of the number of accidents in 2014, 58 of the cases (23.0%) caused by human factors were due to misoperation and insufficient operation confirmation. In a cognitive/confirmed mistake, employees receive misinformation; thus, when they communicate with their peers, the information is not accurately conveyed, and the necessary confirmation is not performed. Misoperation refers to an erroneous operation that is executed habitually, that is performed due to fatigue or strain, or when a similar device (valve) is operated by mistake. Misjudgment refers to an erroneous judgment that is made based on a similar successful experience from the past, a judgment that is made based on the wrong information, a judgment that is made without understanding the meaning of the work, etc. (Dekker, S. 2006).

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There are numerous contexts surrounding accidents caused by human factors (Jürgen, 2013). In order to clarify the scope of the application of the system proposed in this paper, a specific onsite operation was used: equipment operations such as valves and pumps are cooperatively performed by onsite operators (hereinafter: field operators) and control room operators (hereinafter: board operators) who are in charge of monitoring/remote control from the control room (Nakai et al., 2014). The device operation is performed according to the operating procedure manual. Voice communication through paging is mainly used for communication between the control room operator and field operator. In voice communication, erroneous judgment due to mistakes, misunderstanding, and cognition/confirmation errors is likely to occur by hearing incorrectly. In particular, petrochemical plants are prone to misoperations due to similarly shaped equipment such as various valves and piping that have different contents but can be mistaken for one another. Achieving a smooth operation requires cooperative work in both areas (Pasman and Rogers, 2014). At the present, operation procedures in case of non-steady situation have not been fully developed. When accidents do occur, accurate judgments and their corresponding operational steps are very important to preventing accidents from escalating (Suzuki et al., 2013). Control problems in both software and hardware have been increasing as the social situation changes, and we need better ways to detect potential risks and use a safe process design to prevent human error (Dekker, 2006). Fig. 1.

Shows the concept for the proposed system. Here, information about the cooperative work between field operators and board operators is more accurately conveyed because it contains a visual element in addition to the output information given through voice paging. In addition, the system proposes a method for sharing plant information to communicate. The proposed system aims to help chemical plant operators share correct operational information without human error.

2. Purpose and approach

One of the main causes of accidents in chemical plants is when the workload per employee increases due to labor-saving cost schemes. This has increased the possibility of erroneous operation and erroneous judgment by field operators due to operators' fatigue and lack of safety education (Suzuki et al., 2013). Hara and Kuwabara (2015) and Fumoto et al. (2016) developed an operation support system using augmented reality technology; it was developed as a measure to prevent accidents caused by human factors. Using augmented reality technology, it confirms the operation target from among a large number of devices; however, it often required to use auxiliary equipment such as AR (Augmented Reality) markers and IC (Integrated Circuits) tags. Setting AR markers/IC tags for all valves and piping of a chemical plant requires enormous labor, time and cost, and is not a realistic measure. Yating et al., (2015) developed the system for practical skill training using image recognition technology. The present system considers sharing the operational information that is required to prevent misoperation and misjudgment onsite. In this study, we used a dynamic plant simulator instead of a real chemical plant to reproduce the behavior of the plant. Plant operators can use tablet PCs in the field or desktop PCs in the control room. The proposed system can display information on the tablet PCs that have been standardized to include various operational procedures under regular conditions as well as during emergencies. The plant information is stored in a database that can be accessed and used as needed. The field operators can communicate with the control room about ongoing situations using the camera included in the tablet PC. In many chemical plants, onsite workers cannot quantitatively know the degree of a valve opening, and in order to know whether the work they did was appropriate, they must contact the control room. To solve this inefficiency, in this system, the process value of the plant simulator is routed to the tablet PC (Fukano et al., 2013).

There are three important aspects of using this system: safety responsibilities concerning individuals, sharing information to gain mutual understanding and willingness between the board operators and the field operators, and promoting the inheritance of technology and safety knowledge. These things should be stimulated by supervisors and higher management. In addition by using this system, it is possible to construct a cooperative work environment featuring virtual connection.

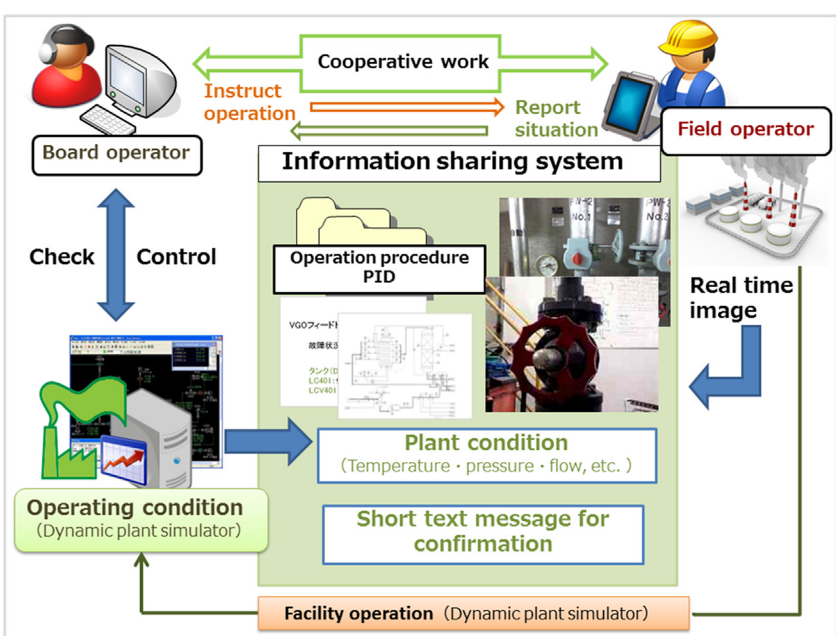

Fig. 1. Concept of the proposed system.