Initiating Events Identification of the IS Process Using the Master Logic Diagram

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1. Introduction

Hydrogen is very attractive as a future secondary energy carrier considering environmental problems. It is important to produce hydrogen from water by use of carbon free primary energy source. The thermochemical water decomposition cycle is one of the methods for the hydrogen production process from water. [1] Japan Atomic Energy Research Institute (JAERI) has been carrying out an R&D on the IS (iodine–sulfur) process that was first proposed by GA (General Atomic Co.) focusing on demonstration the "closed-cycle" continuous hydrogen production on developing a feasible and efficient scheme for the HI processing, and on screening and/or developing materials of construction to be used in the corrosive process environment. [2] The successful continuous operation of the IS-process was demonstrated and this process is one of the thermochemical processes, which is the closest to being industrialized. [3]

Currently, Korea has also started a research about the IS process and the construction of the IS process system is planned. In this study, for risk analysis of the IS process, initiating events of the IS process are identified by using the Master Logic Diagram (MLD) that is method for initiating event identification.

2. Methods and Result

2.1 IS Process

A scheme of the IS process is shown in Fig. 1. The process is composed of the following chemical reactions:

$I_2 + SO_2 + 2H_2O = 2HI + H_2SO_4$ (Bunsen reaction) ... (1)

$2HI = H_2 + I_2$ (200~500℃) ... (2)

$H_2SO_4 = SO_2 + 0.5O_2 + H_2O$ (800℃) ... (3)

The so-called Bunsen reaction (1) is an exothermic sulfur dioxide gas-absorbing reaction in an aqueous phase. The hydriodic acid and the sulfuric acid formed are separated by a liquid–liquid phase separation phenomenon that occurs in the presence of an excess of iodine. The separated hydriodic acid dissolves the iodine and is denoted as the HIx phase. After purification, hydriodic acid is separated from iodine by distillation. The HI is then decomposed to produce hydrogen (2). Similarly, the separated sulfuric acid denoted as the sulfuric acid phase is purified, concentrated, vaporized and decomposed to produce oxygen. Here, the decomposition reaction (3) proceeds endothermically in two stages: firstly, the sulfuric acid decomposes spontaneously into sulfur trioxide and gaseous water at ca. 400℃, and secondly, at higher temperatures, the sulfur trioxide decomposes into sulfur dioxide and oxygen in the presence of a solid catalyst. Thus, these three reactions make a chemical cycle that is an energy converter from heat to hydrogen. [4]

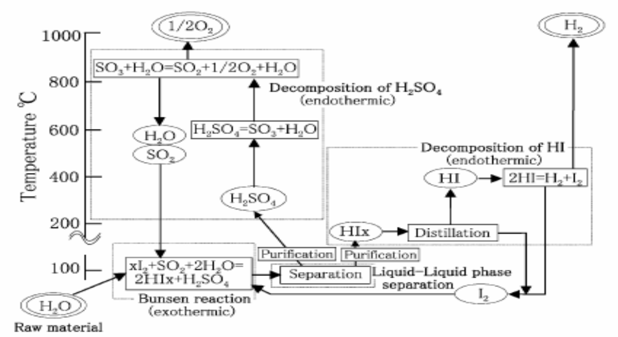

Figure 1. Reaction Scheme of the IS process

2.2 Initiating event identification using the Master Logic Diagram (MLD) in IS process

The starting point of MLD development is begun by defining the top event. In this study, top event is defined to containment failure that can induce the stopping of the system and cause risk. And then, the deductive decomposition is carried out through the following step.

2.2.1 Identification of critical areas

A critical area of the plant is one containing an each other different chemical material.

(1) Bunsen Reaction Step
(2) H_2SO_4 Decomposition Step
(3) HI Decomposition Step
(4) H_2 Step

These four sections have been identified as possible sites of chemical material release. A schematic representation of the division of the IS process plant in the four sections is given in Fig. 2.

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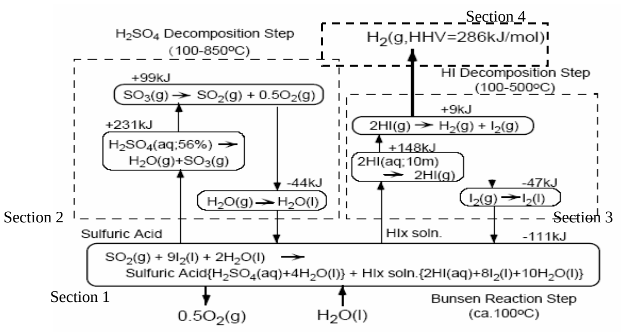

Figure 2. Schematic diagram of the IS process

The first level of decomposition was along the four possible sites of chemical material release as shown Fig.3.

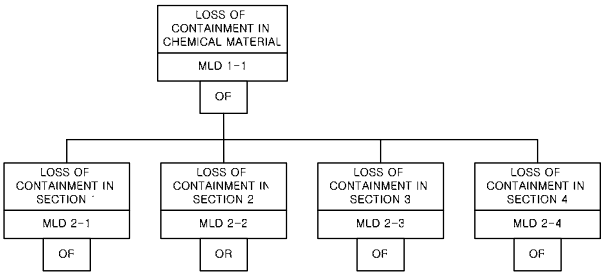

Figure 3. MLD of the IS Process

2.2.2 Specialization of MLD to selected critical areas

In this study, MLD of the H_2SO_4 decomposition section in the four sections is carried out. Fig. 4 gives the MLD of the H_2SO_4 decomposition section.

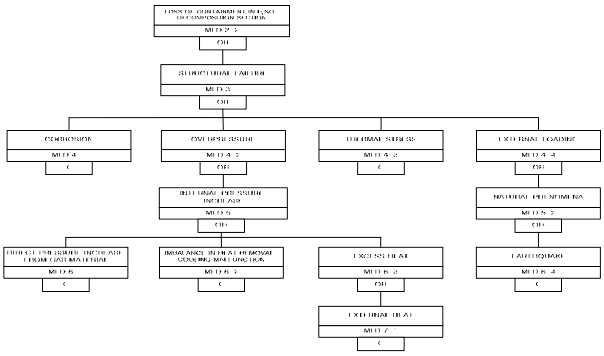

Figure 4. MLD of the H_2SO_4 decomposition section

The various ways the H_2SO_4 decomposition section may fail namely, internal pressure increase have been further decomposed for each process phase. An earthquake is the only natural phenomenon considered which might cause loss of containment. All the others flooding and high winds have been neglected, because this particular system is surrounded to the outside building. Internal pressure increase may occur either if there is imbalance of heat removal when gas phase is converted to liquid phase, or direct pressure increase from evaporated SO_2 gas, or excess heat. Excess heat may occur in external fire.

2.2 Result

The most important initiating events, which were identified with the application of the Master Logic Diagram to the H_2SO_4 decomposition section in IS process, are the following:

(1) Pipebreak owing to corrosion, thermal stress;
(2) Direct pressure increase from evaporated SO_2 gas;
(3) Loss of cooling for that gas phase is converted to liquid phase;
(4) Excess external heat such as fire;
(5) Earthquakes.

3. Conclusion

Initiating event identification use both formed techniques based on systematic and logical method and experienced techniques using former data. [5] The MLD technique is a deductive tool using a top-down approach, which can do a formal and logical identification of initiating events. In this paper, initiating event identification of H_2SO_4 decomposition process in IS process in is carried out by using MLD. Further, it will be used as data to make risk assessment for hydrogen production system using IS process. Moreover, it will be contribute to make plan for preliminary design which will enhance the system safety and safety precaution later on.

ACKNOWLEDGEMENT

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