다중판별 장치 스크리닝 알고리즘을 이용한 화학설비 위험도 분석에 관한 연구

김구회*, 안성준, 박정수, 한경훈, 윤종필, 윤인섭
서울대학교 화학공정신기술연구소*, 서울대학교 응용화학부*

Risk Analysis of Chemical Process Using Multi-distinction Equipment Screening Algorithm

Ku Hwoi Kim*, Sung jun Ahn, Jeong Su Park, Kyounghoon Han, jong pil Yoon, En Sup Yoon
Institute of Chemical Processes, Seoul National University*
School of Chemical Engineering, Seoul National University

Introduction

In this research, we have tried to focus on these purposes. Firstly, by using item to distinguish the degree of risk in Process from facilities point of view such as material, operation condition, flow rate, failure rate taking its age into account, we' ll realize which device is implying the worst danger. Secondly, after combining all conditions and distinguishing degree of danger per device in Process, it'll supply good information to make a decision for users. And finally, after distinguishing the worst dangerous device through the degree of risk according to accident rate, it'll help user to be prepared to cope with any situation. All of this purpose has been interested in real industrial field and operation step. The main purpose of this research is to find out the risk having itself in each device and especially which devices could have a far-reaching influence to another equipments when it spreads. But of course, not mention to preparations for this and another effectible devices. The reason which is used Screening Algorithm in order to distinguish between devices with latent maximum degree of danger is, for instance, in case of Pump having danger in itself, which can be stopped due to over-load in control problems or can be oversupplied an amount of flow to the latter part of a pump by Full Circulation when it is given control box Saturation Signal due to malfunction in Analog Output signal. And also in case of happening Leak by defective Sealing, judging from a large-scale overall operation point of view, it can have a far-reaching influence to another equipments when it spreads rather than danger in itself. In case there is a Distillation Tower the latter part of a pump, we can anticipate it exploding due to overheating in Distillation Tower if Pump-Off happens. Moreover, if there is Feed Tank in the former part of a pump and continue to take place Charging, a Feed Tank also can be to be overcharged and later springs up flooding. Like this, in case of devices having a far-reaching influence to another equipments when it spreads rather than danger in itself, that kind of devices should be accepted to calculate in distinguishing main dangerous devices.

MESA (Multi-distinction Equipment Screening Algorithm)

In overall structure, firstly to select the operating devices as a basic input-list in order to distinguish degree of danger and then to input data about size (volume) of the operating devices, source, product and by-product and finally to input Temperature and Pressure. (Except for inputting the sizes of Pump, Piping, Tubing and Valve) The evaluation of the risk we have been interesting was omitted from Screening Process because danger having in it is much less serious than what we try to consider it in Pump and many other things. Each one in Material Property, Flow Rate, Operating Condition and Failure Rate (Age) was ranked as three levels like (A: dangerous, B: cautious, C: safe) and then each device was gotten the risk from Matrix explaining the risk, namely Expert System DB. After resorting the results according to the standard of the risk in Analysis Algorithm list, we can find out which equipment is the worst dangerous as final results and then input this data as the accident propagation effect of the reasoning model. The Matrix related to the influence of the risk and the association of each devices would be made on the basis of above mentioned MSA and then according to the association of the risk per device, Screening method in the general of the risk was deduced the following conclusion, as an example, from Matrix DATA BASE based on the Expert System.

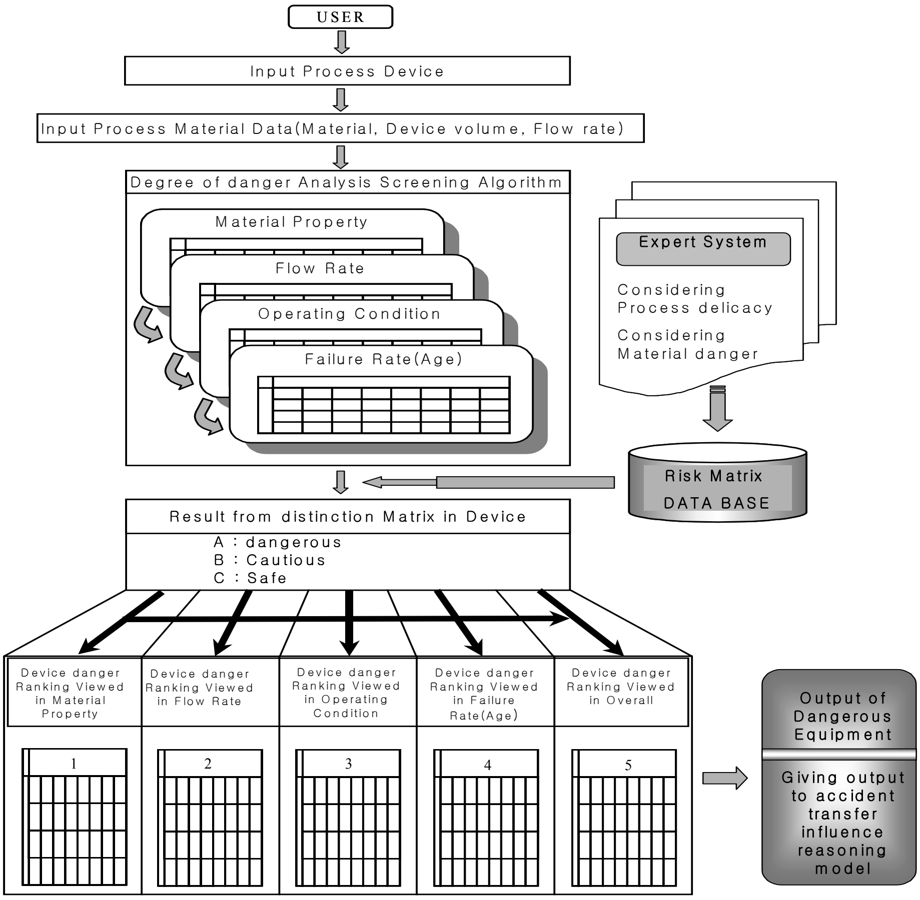

Figure 1. MESA (Multi-distinction Equipment Screening Algorithm) outline

Material Property

The judgment of the risk about material property consider both Nf (Flammable hazard rating) and Nr (Reactivity hazard rating) in NFPA (National Fire Protection Association) code and then make a Matrix about raking it as A, B and C. The content is like this. For example, the standard of Temperature and Pressure in distinguishing list about reactant properties, or Temperature and Pressure on outlet valve, use to distinguish the risk as the same meaning in all Effectors. And In case of Distillation, done having the standard of the Worst Hazard Case.

Flow rate

How to calculate the risk index in flux flow rate:

1. Calculate a conversion radius after converting a device volume into a spherical volume.
2. Calculate hazard propagation explosive area with it.

3. Influx flow rate (kg/sec) multiplied by Hc (Heat of Combustion) of a material and again divided by this area is Heat Propagation Flux in which the standard of Heat Propagation Flux is based on the KOSHA Code.(Korea Occupational Safety Heath Agency). Above deduced virtual spherical explosive Heat Propagation Flux is divided like the following thing, which is on the basis of two dangerous situations prescribed in KOSHA. That is, Anatomical injury standard which exposed to Heat Flux as much as 37.5[kW/m^2] for 10 minutes results in the death and exposed to Heat Flux as much as 4[kW/m2] for 10 minutes results in getting burnt. But we use 1 minute for calculating with SFPE(Society of Fire Protection Engineers) Guidance

Operating Condition

With regard to the range of Temperature and Pressure which is one of operating conditions in some Process, Temperature is divided into three steps on the risk, which is based on FP (Flash Point) and BP (Boiling Point) and Pressure is distinguished from the risk, which is based on 10Kg/cm^2 and 0Kg/cm^2 as a standard. In case of distinguishing Temperature of the risk Matrix, the standard is based on FP (Flash Point) and BP (Boiling Point), which is about to change phase. And In case of distinguishing Pressure, the standard is based on An Method of management Enforcement Ordinance of High pressure Gas Safety heralded in 1984.

Failure Rate (Age)

With regard to the standard distinguishing Failure Rate per device, it totally seems like Pressure durability (inner, outer), causticity and the stress durability of the outside air temperature change. But here the accident expectation results from multiplying Failure Rate by Age. Matrix related to it is like this. (Table 2.6. The risk Matrix on Failure Rate)

Rule base incentive or penalty

There might be the method making the ranking of the risk in order to totally take four mentioned methods into consideration, that is 81 cases. But when trying to expand this kind of Algorithm, we should be able to evaluate hardly each all of cases. That's why it's not good method in expanding to Algorithm.

And another method is putting each weight factor into four lists and adding up all points given according to the weight factor. This method obviously should be able to be controlled by the weight factor, which is based on the results from these cases as many as possible. But some exceptional cases might be resulted in fatal influence to generally the degree of confidence on entire system.

Therefore what we try to suggest in this research is basically this kind of method, which firstly add up all points given according to the weight factor, and then append incentive or penalty to it based on several rules. This method has got some advantage to make the ranking of the risk easily and intuitionally according to some rule base instead of spending waste of time in order to get the weight factors which can explain all several cases.

Case study (LPG underground storage and shipping)

Material hazard rank

Materials used to this case study are Propane (C3H8), Nitrogen (N2), Methanol (CH3OH), Dimethylsulfide ((CH3)2S), and Water (H2O). After examining Nf and Nr of each one, we determine the hazard rank.

Flow rate hazard rank

First of all, fundamentally in case of storing material in equipment to some degree, this amount should be calculated firstly and then flow rate is multiplied by combustible heat. And devices used in Entire Process divided into pump, heater, tank, dryer, valve and so on and then calculation of the cut area of volume or flux per each device, that is, calculation of imaginary sphere radium and surface area and finally each is divided by flow rate multiplied by combustible heat.

Operating condition hazard rank

After examining Temperature and Pressure on the basis of material condition, which is flowing in each device, the hazard rank was made a decision.

Failure rate hazard rank

Because there isn't any information related to Failure Rate about each device in LPG Process, Failure rate hazard rank was determined from assuming that LPG Process DATA is similar to LNG Process DATA. Here let each rank A (25 point), B (15 point) and C (5 point) and then Failure rate hazard rank was determined after giving the weight factor to each one according to Heuristic rule. Viewed in deciding overall ranking with this way, it seems that inner pump in carven, dryer and dryer tank are the most dangerous element and thus quantitative estimation about each device should be done above all.

Conclusion

It appears that the risk in P-2 (pump), dryer and dry tank are high according to applying Multi-Distinction Equipment Screening Algorithm for LPG storage equipment. After analyzing the influence and the cause resulted from derivative operation per some special equipment mentioned in case study, that information will be able to be made use of the accident scenario related to quantitative risk analysis.

Also this kinds of methodology supported in this research ultimately can help not only show more accurate and flexible Emergency Plan in making sure of an reliability of accident influence evaluation on Process Design Steps, but also make the basis of accident scenario.

Therefore, in considering this information on Process Design Steps, saving effect of human and material resources could be achieved, and also Scenario Decision Method based on equipment and material property could be built up on the part of Quantitative Process Safety Evaluation System, and also this Scenario Decision Method will be able to apply influence evaluation in outside of industrial zone. (Table 4.1. The dangerous ranking per equipment)

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