Graduate School of Creative Science and Engineering
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博 士 論 文 概 要
Doctoral Thesis Synopsis

論 文 題 目

A Study of Forecasting Methods for Misuse Accidents at Consumer Products to Promote Product Safety

消費生活用製品の製品安全推進のための
誤使用事故予見方法に関する研究

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In our daily life we are using different types of consumer products at homes, workplaces, etc. However, the accidents while using them keep occurring. According to statistical study has been made by National Institute of Technology and Evaluation (NITE), from 2009 to 2011, 11,037 accidents cases when using consumer products have been reported. The statistical study classified the 11,037 accidents based on their causes, 59% of the accidents were related to the product itself, 22% of the accidents were not related to the product, and the other 19% accidents were classified as unknown. In the 22% that the product was not the cause, 1569 accidents were because of user misuse. From the total number of accidents in the statistical study 122 accidents led to death tragedy and 38 of them were because user misuse [NITE, 2013]. To face the problem of accident occurrence when using consumer products risk assessment processes and methods were often adopted from industrial field. ISO/IEC (guide51: 2014 Safety aspect-Guidelines for their inclusion in standards) is an example of adopted industrial risk assessment processes, and example of methods are Be-safe (Behavioural Safety) and FMEA.

Consumer products defined according to Ministry of Economic, Trade and Industry in Japan [METI, 2017] as the products that consumers use for their daily life needs and buy them from ordinary markets. It is possible to look at consumer products as there are two categories, software products like personal computer application software, and tangible products with physical form, those are the scope of this study. The potential source behind accidents is the hazard. Finding the hazard and the accidents then taking the necessary countermeasures is the general idea of risk assessment.

Around 80 accidents cases while using consumer products that were reported from both National Institute of Technology and Evaluation (NITE) and Consumer Product Safety Association (CPSA) from the period of 2005 to 2010 were reviewed in this study to see what kind of problems stand behind accidents occurrence. It was found that accidents come from two types of hazards, obvious hazards and hidden hazards. Obvious hazards characterized as hazard that are essentially contained in the product and the misuse from the user triggers these obvious hazards leading at the end to accidents occurrence. On the other hand in the case of hidden hazards, products seem almost safe that do not have any noticeable obvious hazard but a deviation from the appropriate usage of the product could lead to accidents occurrence.

For the accidents from obvious hazards, they could be forecasted with using hazard list to check every hazard by the traditional risk assessment method. However, sometimes it could be difficult for the manufacturers to forecast many different possible (feasible) accidents because of the workload of such task to imagine and forecast as many as possible of such possible (feasible) accidents. For the accidents from hidden hazards, the hazard is hidden in those accidents that makes it difficult for the manufacturers to discover them by traditional risk assessment way, therefore it seems different tools or methods are needed.

According to a survey were conducted by (CPSA) about the way to forecast misuse accidents, the majority of consumer products manufacturers relay on their experience for doing that. The reasons for that seem to be the following three points. The workload on risk assessment processes and methods, for example at the risk assessment steps from ISO / IEC 51 guide the process requires after forecasting all possible misuse cases at the targeted product to check each one of them to identify the risk level caused by the hazards contained in the targeted product. Characteristics of consumer products, the traditional risk assessment process and methods are mainly used for industrial machines, where the varieties of use cases are rather limited. Characteristics of consumer products manufactures, as most manufactures of consumer products are rather small and professions or experts of product safety are not always employed.

Based on what was mentioned, the study purpose is designing and developing two risk assessment methods that help in discovering as many as possible of the different obvious and hidden hazards that stand behind accidents, help in forecasting as many as possible accidents when using consumer products in a comprehensive way that covers most of the circumstances around the product targeted, help in reducing the workload when being used, and does not required long training sessions or acquiring certain skills. The targeted people in this research are manufacturers of consumer products. For them two methods were designed and developed, AMWAR (Analysis Method of the Worst Accidents Reasons) that targets obvious hazards and AMDHH (Analysis Method to Discover Hidden Hazards) that targets hidden hazards.

The basic concept of AMWAR is to shift the focus toward high-risk accidents, the worst accidents, to reduce the workload. Sabotage analysis and designed guidewords sets were used to find as many as possible direct reasons and scenarios behind the worst accidents. Sabotage analysis is a type of analysis has been developed at the Soviet Union for security purpose to face the terrorist attacks [Sawaguchi, 2007]. Its concept is to think how to cause the accident and based on that countermeasures would be checked against those accidents. The point here is thinking how to cause worst accidents to occur, this way of thinking will keep stimulating the person mind to identify more reasons besides

help in identifying rare cases that could be difficult to get identified. Every product is surrounded by some items or factors play main roles in affecting the use of that product, such items are mentioned in the current processes and methods in a way or other but without providing a systematic way to cover their relationship with the possible accidents comprehensively. For example, in ISO/IEC guide51 the talk is mainly about the user without referring to other items that also formulate the situations and circumstances around the product. If those items were not covered in a comprehensive way, it might lead to conduct ineffective or insufficient risk assessment. A model that was developed based on the human errors model and analyzing different reported accidents cases shows 8 items surround the product [Komatsubara, 2009]. The main items from that model in the context of usage are five items. User who has connection with the product, which has three types: the primary, the secondary [JoAnn.T and Janice. C, 1998], and the seatmate. Environment, the place that the targeted product is used at. Time of use which shows the longtime of being in contact with the product and the frequency of usage. Method of use which is about the way of using the targeted product. Relation with surrounding other products which is about the products that surround the targeted product and could give undesirable effects on it. The five mentioned items formulate the AMWAR model. Finding how those items could lead at the end to accident occurrence when interacting with the targeted product is the key to have a comprehensive risk assessment so as many as possible of interaction scenarios are desirable. To achieve that a set of guidewords were designed and developed. The guidewords were designed for each item by referring to HAZOP guidewords and ISO 9241-210 (Ergonomics of human-system interaction – Part 210: Human-centered design for interactive systems) [ISO 9241-210(E), 2010].

AMWAR consists of five steps, the first step is to identify obvious hazards contained in the targeted product. OSHA hazard list was utilized to identify the obvious hazards [OSHA, 2002]. The second step is to identify the worst accidents that could result from the obvious hazards, this step will be done by trying to imagine and generate freely as many as possible worst accidents. The third step is to identify the direct reasons of the worst accidents, sabotage analysis will be used to identify the direct reasons of the worst accidents by answering the question (how to cause the worst accident to occur?) and it will be done by trying to imagine and generate freely as many as possible direct reasons. The fourth step is to find out the scenarios that cause the direct reasons, the term scenario means a set of events occur and lead at the end to a certain result, in this case the result is the direct reasons. At this step the designed and developed guidewords sets will be used to imagine as many as possible of direct reasons scenarios. The fifth step is to check the countermeasures of the targeted product against the found scenarios in the fourth step. In order to verify that AMWAR could help achieving the purpose of this study a case study and companies evaluation from experts in the field of risk assessment were planned and conducted.

Case study was conducted by 15 university students with little experience of risk assessment as the case with the manufacturers of consumer products. The chosen consumer product was the electric drill with which the participants are familiar and therefore they expected to be able to imagine the usage cases. The found obvious hazards were 16, the worst accidents were 20, the direct reasons obtained were 129, and the direct reasons scenarios were 390. Around 40% of the scenarios came from the user item, 19% from the environment, 17% from the method, 14% from the time, and 11% from other surrounding products. For companies evaluation, an evaluation sheet and AMWAR manual were distributed to experts in the field of risk assessment. They were asked to read the manual and the case study written in the manual, and based on that, they were asked to imagine or actually conduct AMWAR on their products. 26 evaluation sheets were received. Almost 88% agreed on the concept of AMWAR. Around 62% of the evaluators think that AMWAR could help the people with little experiences in risk assessment. Also around 63% think that AMWAR could reduce workload because AMWAR is focusing the attention only on the worst accidents.

From the results of the case study and the companies evaluation, it was found that AMWAR could help the people with little experiences about risk assessment by reducing the workload, which is the advantage that the traditional risk assessment methods do not have. It was found also that it could be used as risk assessment educational tool. Because of the focus on the worst accidents, it could be also used as a supporting tool with PL (product liability) business to reduce the amount of insurance.

For AMDHH the basic concept is that the deviation from the appropriate way of using the product targeted that leads to accidents is a potential hidden hazard. PDPC method and designed guidewords sets were used to find as many as possible of deviations that lead to accidents. The concept of PDPC method is taken in AMDHH, in PDPC method the deviation from the original plan is looked for, in AMDHH the deviation from the appropriate usage is looked for.

The strategy for building AMDHH is the same as AMWAR, it consists from five steps. The first step is about writing the appropriate usage, to do that the task flow that shows how to use the product safely should be written first. If the task flow is conducted by the appropriate user, at the appropriate environment and so on, the product will be used safely, those items are the same items in the context of usage that was in AMWAR and they will be found in term of appropriateness. The second step is about forecasting deviations from appropriate usage, the deviations from the appropriate usage that cause accidents are potential hidden hazards so as many as possible number of deviations is desired, imagining and generating freely with guidewords approach was used, the process for designing and developing AMDHH guidewords is the same as AMWAR guidewords. The third step is about finding accidents in the forecasted deviations by investigating each one of them, deviations that lead to an accident is a potential hidden hazard. The fourth step is about accidents risk evaluation. The fifth step is about checking the countermeasures, based on the results of risk evaluation for each accident, countermeasures should be checked. In order to verify that AMDHH could help achieving the purpose of this study a case study and companies evaluation from experts in the field of risk assessment were planned and conducted.

Case study was conducted by 16 university students with little experience of risk assessment as the case with the manufacturers of consumer products. The chosen consumer product was the ladder that the participants are familiar with and therefore they are expected to be able to discover hidden hazards without specific knowledge of this product. 54 different types of hidden hazards have been discovered, 24 from method item, 11 from environment, 11 from user (8 from the primary user and 3 from the secondary user), 7 from the other surrounding products, and 1 from the time. For companies evaluation, it was conducted by the same way that was used in AMWAR. 26 evaluation sheets have been received, 23 companies mentioned that they had records of having accidents from hidden hazards and 21 companies from them did not have a specified method to discover hidden hazards. 15 companies agreed completely on the concept of AMDHH and the main reason was that AMDHH is close to user point of view not the designer. They also mentioned that AMDHH have the basic capability to help in the case of having little risk assessment experience.

The results of AMDHH for both case study and the companies evaluation gave a good indicator that AMDHH could be a good solution to handle the problem of hidden hazards accidents beside fulfilling other purposes like risk assessment education, product planning and concept design, and design review and designing the product manual. Since AMDHH targets the hidden hazards, it could be used with AMWAR or with any other risk assessment process or method since the issue of hidden hazards is not addressed by a specific and systematic method like AMDHH.

Based on the results from the case study and companies evaluation for both methods AMWAR and AMDHH, they could be used by themselves or as supplementary methods with risk assessment processes and methods to reduce the workload when handling obvious hazards and to discover hidden hazards beside making the risk assessment more comprehensive with the help of the five items and their guidewords sets. Also from the outputs of the case study and companies evaluation, it seems that there is a need for educational tool that could help in learning and building skills of the appropriate way to conduct risk assessment. Also some product manufacturers seem to look for a way to walk-through the entire process of manufacturing the product and at the same time conducting risk assessment.

This study was divided into 7 chapters. Chapter 1 is an introduction, Chapter 2 is about the study method. Chapter 3 is dedicated to AMWAR, the method is explained in detail. Chapter 4 is about the case study that was conducted with AMWAR and companies evaluation. Chapter 5 is dedicated to AMDHH. Chapter 6 is about the case study that was conducted with AMDHH and companies evaluation. Finally Chapter 7, an overall general discussion about the study, the next actions based on the outcomes from the study, and a final conclusion.

早稲田大学　博士（工学）　学位申請　研究業績書

(List of research achievements for application of doctorate (Dr. of Engineering), Waseda University)

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