Unnes Journal of Public Health 8 (1) (2019)

Unnes Journal of Public Health

http://journal.unnes.ac.id/sju/index.php/ujph

Failure Mode and Effect Analysis (FMEA) Application for Safety Risk Assessment Design of "X" Bakery

Rizky Fajri Ramadhan✉, Evi Widowati, Mardiana

Public Health Science Department, Universitas Negeri Semarang

Article Info

Article History:
Submitted March 2018
Accepted December 2018
Published January 2019

Keywords:
Failure Mode and Effect Analysis (FMEA), Potential Hazard, Risk Assessment.

Abstract

Companies in the food sector have 8 production process lines including: receiving raw materials, storing, making dough, baking, frying, cooling, packaging, and distributing. Potential hazards can include: slipping, stuck in a mixer machine, crushed in a dough press machine, crushed in a packing machine, head hit by an elevator, short circuit, fire, explosion, leak, hot oil splash, the potential danger of ergonomics, heat stress, and respiratory disorders. This study aimed to design a risk assessment to minimize the incidence of workplace accidents. This type of research is research and development with a semi-quantitative approach. The informants were determined as many as 2 people with a purposive sampling technique. The research instrument used observation sheets, interview sheets, and FMEA worksheets. Product design is validated by an expert team. The results show 23 potential hazards in 8 production processes. The highest hazard potential is slip (RPN = 140) and the lowest is explosion (RPN = 10). So that it requires administrative control, engineering, inspection, repairs to electrical installations and gas pipes, and using personal protective equipment.

Abstrak

Perusahaan di bidang makanan terdapat 8 alur proses produksi antara lain: Penerimaan bahan baku, penyimpanan, pembuatan adonan, pemanggangan, penggorengan, pendinginan, pengemasan, dan pendistribusian. Potensi bahaya dapat berupa: terpeleset, terjepit mesin mixer, terjepit mesin penggiling, terjepit mesin packing, kepala terbentur lift, arus pendek listrik, kebakaran, ledakan, kebocoran, percikan minyak panas,bahaya ergonomi, heat stress, dan gangguan saluran pernapasan. Penelitian ini bertujuan untuk membuat perancangan penilaian risiko untuk meminimalisir kejadian kecelakaan kerja. Jenis penelitian ini adalah research and developent dengan pendekatan semi kuantitatif. Informan yang ditetapkan sebanyak 2 orang dengan teknik purposive sampling. Instrumen penelitian menggunakan lembar observasi, lembar wawancara, dan FMEA worksheet. Desain produk dilakukan validasi oleh tim pakar. Hasil menunjukkan 23 potensi bahaya tersebar di 8 proses produksi. Potensi bahaya tertinggi adalah terpeleset (RPN=140) dan terendah adalah ledakan (RPN=10). Sehingga diperlukan pengendalian administratif, rekayasa teknik, inspeksi secara ruitn, perbaikan terhadap instalasi listrik dan pipa gas, serta menggunakan alat pelindung diri.

✉ Corespondence Address:
F5 Building 2nd floor, Universitas Negeri Semarang, Sekaran, Gunungpati Semarang Jawa Tengah 50229
E-mail: rizky.fajri.rf@gmail.com

pISSN 2252-6781
eISSN 2584-7604

INTRODUCTION

The food processing industry is one of the fastest growing industries and absorbs quite a large workforce. But on the other hand, there are potential hazards found in the food processing industry. The main determinant of a company is the existence of workers. Company worker is one of the factors of production and plays an important role. The work can allow a danger that threatens safety and health. A work accident is one of the unwanted events. Risk of causing losses to companies and workers. Accidents occur because of damage to heavy equipment used to lift the engine, so that the engine falls and hits the worker. So there needs to be an effort to protect the safety of workers in completing work (Destari et al, 2017; Apriyan et al., 2017; Statistic On Workers In Australia, 2014).

Industries that are engaged in the manufacture of bread and cakes, generally have 8 production process lines including: receipt of raw materials, storage, making of dough, baking, frying, cooling, packaging, and distribution. There are 4 Quality Control Circle in one production unit that are responsible for producing each type of food. The variety of foods are sweet bread, sponge cake, milk pie, pastry, and dried food. Potential hazards that can occur in food processing production units include: slipping, stuck in a mixer machine, crushed in a dough press machine, crushed in a packing machine, head hit by an elevator, short circuit, fire, explosion, leak, hot oil splash, the potential danger of ergonomics, heat stress, and respiratory disorders (Food and Drink Federation and Dairy U.K., 2011; Health and Safety Authority, 2014).

Work accidents in the processing industry, mostly in the form of cases resulting in minor injuries. In handling minor injuries, companies can carry out referral and treatment actions, make Standard Operating Procedures (SOPs), and provide Personal Protective Equipment (PPE) as an intervention step. But not all companies have carried out data collection on safety cases and analytical actions. Steps that can be taken to assess how high the risk is in food processing production units (Susilo et al., 2011; Syauqi & Susanty, 2016).

Work safety can be improved by carrying out a good analytical approach to determine potential hazards and occupational safety risks that might occur in a design or process of making a product. Failure Mode and Effect Analysis (FMEA) can be chosen as the right method to minimize the incidence of accidents in the workplace. FMEA can be used to analyze system failures, by describing the effects that arise from these failures. The FMEA method has been used by commercial industries with the aim of reducing the potential for system failure, reducing adverse effects on environmental and economic aspects, and improving safety (Andiyanto et al., 2015; Ramli, 2010).

This study aimed to design a risk assessment to minimize the incidence of workplace accidents by conducting a risk assessment of the hazards found. It is expected that the results of this study can be a control recommendation for various risks in the industry.

METHOD

This research is Research and Development (R & D) research with a semi-quantitative approach that aimed to analyze the safety risks of workers in the production section of PT. X in the city of Semarang. Failure Mode and Effect Analysis (FMEA) was used as a method of risk analysis. The FMEA implementation began with observing the work process in the production system, identifying work safety risks, carrying out an analysis of the work safety risks that have been found, and making recommendations to take control measures. This research began by taking data on accident rates and work incidents in the last 3 years (2015, 2016, 2017). Then after looking at the work accident rate data obtained from the company, work safety risk analysis was carried out and conducted interview with informants. Interview was conducted to find the limits of the scope and work processes that exist.

The type and design of the research in this study is Research and Development (R & D). This study identified potential hazards and occupational safety risks then carried out a design by formulating control measures in the form of FMEA documents. This study aimed to obtain information about the safety risks of workers in the production department, then compared with the results of observations of researchers and international standards that are used as a reference to determine the level of occupational safety risks, namely Standard for Performing a Mode and Effects Analysis (FMEA) and Establishing a Critical Items List (CIL) of NASA's Flight Assurance Procedure (FAP), 2010. The risk assessment method used was Failure Mode and Effect Analysis (FMEA) which started from identifying risks, evaluating risks, and determining recommendations for controlling risk.

Research limitations by conducting studies from work process observations to final product designs, and not conducting trials to apply the design results at the Company. This is constrained by the lack of human resources in the company and does not obtain permission from the Company to conduct trials.

Before observations performed, informing the research subject as a research data source. So

that the research subjects studied knew from the beginning to the end about the activities of researchers. The type of interview used in this study was semi-structured interview (in-depth interview). This method aims to obtain certain information from all informants, but the wording and sequence are adjusted to the characteristics of each informant and needs at the interview.

The instruments used in this study include 1) interview guidelines; 2) Observation sheet; 3) Cameras to take pictures as documentation with the aim of increasing the validity of the data; 4) Field notes and stationery to record interview results; 5) A recording device was used to record all interactions and communications that were not recorded in the study.

In this study there were 5 stages in conducting research, namely; 1) Stage of discovering potential and problems that begin. Conducted by coordinating with company leaders, head of production, and head of Research and Development (R & D). Then followed by a preliminary study by conducting observations and interviews and through secondary data that can be used; 2) Stage of gathering information and study of literature by conducting data processing as a basis for making product design. The literature study is guided by the Standard for Performing a Fashion Mode and Effects Analysis (FMEA) and Establishing a Critical Items List (CIL) of NASA's Flight Assurance Procedure (FAP), 2010, identifying and analyzing potential hazards; 3) The stage of making product design by making a matrix of potential hazard and risk that is objectified and refers to existing standards; 4) Design validation stage by evaluating the product design that has been made. Design validation is carried out by a team of expert experts. The expert team is the HSE Office of the Manpower and Transmigration Office of Central Java Province and the Head of Corporate's R & D; 5) The stage of testing design is the final stage of product design. Products made have gone through a process of validation and revision.

RESULTS AND DISCUSSION

Identification of Potential Hazards

"X" Bakery is a company engaged in the production of goods, by producing products in the form of sweet bread, sponge, pastry, donuts, pie, tart, fried foods and wet cakes. The results of the identification show that there are 100% potential accident hazards and 50% potential for ergonomic hazards in the process of receiving raw materials. Workers manually lift raw materials by hand from an expedition truck to a trolley, with an average load of over 20 kilograms. The top of the freight elevator in the factory, only 150 cm high and the elevator area with a size of 1.5m × 1.5m. There are walls made of plywood that surround the elevator, the walls are 40 cm long.

The storage process is divided into two stages. There are 66% of potential accident hazards and 33% of potential fire hazards. The results of the identification show that workers carry large quantities of raw materials in one trolley. The dough making process consists of 3 stages. There are 100% potential for accident hazards, 33% potential for ergonomic hazards, and 33% potential hazard for physical factors due to dust. When the researchers made observations on shift 1 which was attended by 80 workers, only 28 workers (35%) were wearing shoes, the rest were wearing sandals.

The baking process is divided into 2 stages. There is a 50% potential for fire hazard, 50% potential for explosion hazards, 50% potential danger of an accident. Grill oven with a size of 2m × 2m, and around it there are electrical installations and diesel fuel pipe distribution. In the frying process, 100% explosive hazard potential, 100% potential for leakage hazard, 100% potential for accident hazard, and 100% potential danger of physical factors due to heat. The frying area does not have a window that functions as an air vent. The frying area only has a chimney channel to release smoke from the combustion. This causes the frying area hot and stuffy. In addition, there are 15 gas stoves and 35 gas cylinders. Gas cylinders in the frying area are 42 kg and 12 kg weight. Based on the results of the observation, the densest cooling process is 100% the potential danger of an accident. In the packaging process, there is a 100% potential danger of an accident.

The last process is the distribution process. Workers bring finished products from the factory area to the store to display the product. In this process, there is a 100% potential hazard of an accident. Workers carry products using trolleys. Workers drive the trolley from the factory to the store with a distance of 100 m. Products with more quantities will be carried by car. The road is a residential road. The condition of the housing road is flat and quiet so it is safe to pass. However, there is potential hazard in the process of transporting goods from the finished goods warehouse to the trolley area. Based on the results of observations, the items that are lifted can fall on workers. In addition, wheel trolleys can also run over workers' feet if workers are not careful.

Risk Assessment

The potential of workers who slip can be found in the process of making dough, frying, and cooling. The potential of workers who slip is the highest potential hazard. The risk of slipping workers is very high, because the floor in the production

Table 1. High Risk

Potential Hazard	***Risk Priority Number*** **(RPN)**
Slip	140
Head hit by an elevator	108
Fire	100
Leakage	100

area is rarely cleaned, even though there are already parts that are responsible for cleaning the floor. In addition, the production area involves raw materials that are slippery if they fall to the floor such as: water, oil and flour.

The researcher assessed that a safety sign in the form of a wet floor caution sign was needed to notify other workers. That the production area is slippery or is being cleaned, so it can reduce the possibility of work accidents due to slipping. The application of safety sign in the workplace has proven to be effective in communicating security at work. The use of globally communicative symbols, to overcome language barriers, attract the attention of workers in their work (Ramli, 2010; Anugrah et al., 2015).

The potential for the head to be hit by an elevator is in the storage process, the worker inserts the raw material from the trolley into the elevator. However, the iron bar on the top of the elevator is very low, so it is very possible for workers to hit when they are out of focus. The 2004 Indonesian National Standard (SNI) concerning the general conditions of elevator construction, stated that the minimum height of the elevator is 2 meters. Meanwhile, the height of the elevator in the production section of "X" Bakery is only 1.5 meters. This is a finding that there is a potential danger that workers can hit an elevator in the production section. Control can be done with engineering. Making the upper part of the elevator higher, so that it can reduce the risk of the worker head hit by the elevator (Ambekar et al., 2013; Iswanto, 2013; Khakzad et al., 2015).

The potential for fire hazards is in the storage area. 90% of the raw material in the storage room is covered with cardboard so it is easy to burn. The installation is not neat, can make electrical short circuit resulting in fire. Controls carried out by the company include: periodic checking of electrical installations or equipment in the production area that uses fuel, and the supply of fire. However, what is provided by the company is only water-based. The location of the placement is also not strategic because it is blocked by work equipment.

Minister of Manpower Regulation No. 4 of 1980 concerning Installation and Maintenance of Fire Extinguishers stated that the placement of Fire Extinguishers must be in a strategic location and not disturbed by other objects. Fire Extinguishers used to control fires due to electrical short circuit is dry tipe fire extinguishers including powder, CO_2, and clean agent. Efforts to prevent fires can be made through a good understanding of the causes, processes and effects of fires. Made as a basic principle in carrying out fire control (Ozilgen, 2012; Anugrah et al, 2015; Firdaus, 2011).

The potential danger of leakage is found in the frying process, there is a parallel gas pipe located above a 40 cm high wall. The pipe drains gas from 4 gas cylinders measuring 42 kg. The results of identification of potential hazards and risk assessments indicate that the gas pipe is located above the wall and is open without protection. Resulting in the potential for gas pipeline leakage caused by workplace accidents or work environment factors. Control carried out by the company in preventing leakage is to carry out routine checks carried out every 3 months. A check to find out if there is a problem with the gas flow system used in the frying process. The recommended control can be done by closing the gas pipe. Insert the gas pipe into the wall, so that the gas pipe is protected from collisions which can cause leakage. In addition, inspection of HSE also needs to be done. Because it affects the increase of awareness about the importance of HSE and plays a role in reducing the trend of workplace accidents (Simorangkir, 2015; Ramli, 2010; Anugrah et al., 2015).

Medium-level fire potential can be found in the baking process. This potential does not involve other flammable tools and materials. In the grill area there is an oven that is turned on using electricity. However, electrical installations near the grill area

Table 2. Medium Risk

Potential Hazard	***Risk Priority Number*** **(RPN)**
Fire	80
Stuck in a mixer machine	60
Feet crushed by raw materials	54

are not well organized. This can lead to a short circuit that can cause a fire. Control that has been done by the company is by conducting routine checks to anticipate problems in electrical installations. The right step to reduce fire risk, namely by renovating electrical installations so that they are neatly arranged. It is important to carry out inspections of the work environment and increase awareness about HSE. Because it is proven in reducing the number of accidents and work incidents (Destari et al., 2017; Pratama et al., 2016; Susilo et al., 2011).

The potential for hands to be stuck in a mixer machine can be found in the process of making the dough. The mixer machine in the QCG area has a cover on the top of the engine. The cover is opened manually by hand, does not have a spring so the cover does not fall. Because of this condition, workers must hold the engine lid when entering raw materials. When the worker is out of focus, the engine cover can fall and crush the worker's hand. The control carried out by the company to minimize the risk of workplace accidents in the process of making the dough, by conducting training. The recommended improvement step is to carry out administrative controls, namely by installing a Standard Operating Procedure (SOP) for the mixer machine operation. In engineering method by attaching springs so that the engine cover does not fall and clamping the workers' hands. Engineering methods are proven to reduce the level of risk and work accident rates (Ozilgen, 2012; Ramli, 2010; Syauqi et al., 2016).

The potential for workers' feet to be crushed by raw materials, can be found at the first stage of the process of receiving raw materials. In the first stage, workers carried out loading and unloading from the expedition truck into a trolley that had been prepared in the factory area. The results of the observation showed that workers who carried out loading and unloading only manually lifted it using their hands. When the hand is not strong enough to hold the load, the raw material will immediately fall. In addition, workers do not wear shoes so that when the raw material is dropped it will directly hit the workers' feet. Control that has been done by the company is to provide training and rest periods to workers. Recommendations that can be made to maximize control, is to increase the number of workers when loading and unloading. The addition of the number of workers results in a more even distribution of workload. Then, it requires workers to use Personal Protective Equipment (PPE) in the form of safety shoes. Safety shoes have a protector to reduce the impact on the front of the foot. The use of PPE has an influence on decreasing the number of work accidents (Andiyanto et al., 2015; Susilo, 2011; Ambekar et al., 2013).

The potential for ergonomic hazards can be found in the process of receiving raw materials, with a Risk Priority Number (RPN) = 36. In the process of making dough with RPN = 20. The factors that differentiate RPN numbers are attitude and workload.

In the process of receiving raw materials, loading and unloading are performed manually by hand. Workers unload raw materials in a bent position and focus the load on the back and done repeatedly. Poor body attitude (not physiological) during work and lasts a long time, causing a burden on the musculoskeletal system and a negative effect on health. Besides that workers are not able to mobilize the ability to work optimally (Sundari, 2011). Existing controls take the form of training on transportation procedures and work attitudes, as well as regulations regarding rest periods. The recommendations are in the form of adding transport workers. Transport workers can be taken from production workers, who are not on duty during the unloading process.

In the process of making dough, workers do not have heavy workload. However, working attitu-

Table 3. Low Risk

Potential Hazard	***Risk Priority Number* (RPN)**
Heat Stress	50
Finger Pressed in Dough Press Machine	48
Feet Crushed by Raw Materials	45
Ergonomic Hazard Potential (Process for Receiving Raw Materials)	36
Contact with a Hot Oven	30
Pressed in Packing Machine	30
Ergonomic Hazard Potential (Dough Making Process)	26
Respiratory Disorders	15
Explosion	10

des that stand during work can cause musculoskeletal disorders. The recommendation that can be done is by giving a chair. So that workers can take a short break to stretch the muscles. A varied work attitude influences the prevention of musculoskeletal disorders (Syauqi et al., 2016; Ozilgen, 2012).

The potential for foot to be crushed by raw materials, can be found in the second stage of the process of receiving raw materials and the storage process. Based on the results of the risk assessment, the potential for the process of receiving raw materials has a better detection rate. Thus making the RPN number smaller. At work, workers will rely on raw materials to the top of the trolley so that raw materials do not directly fall on workers. Control is carried out by the company is to provide training and rest periods to workers. The recommendations given for improvement are by giving work induction. Work induction to remind workers to stay focused, and with the use of PPE in the form of safety shoes that are useful to minimize the effects of an accident (Ramli, 2010; Anugrah et al., 2015; Iswanto, 2013).

The potential for respiratory disorders can be found in the process of making dough. In this process, workers use flour and pour it into a mixer machine or grinder. The process of making dough allows flour to be inhaled by workers. In addition, the room of Quality Control Circle (QCC) uses Air Conditioner. So that it closes the vents and inhibits air circulation. The company has not exercised control regarding potential respiratory tract disorders. The recommendation that can be given is by giving a mask. Recommended masks to ward off dust particles have a code N95 or N100. The use of masks in the bread making industry can reduce the intensity of exposure to flour dust and reduce the potential for respiratory tract disorders (Khakzad et al., 2015; Simorangkir, 2015; Pratama et al., 2016).

In the process of making the dough, there is potential for fingers to be pressed by the dough press machine. In this process, the worker inserts the mixture into the dough press machine. If the worker is not focused, the finger of the worker can be caught in the apron roll on the machine. The control that has been carried out is by conducting work training and induction provided by the head of the production department. The recommendation that can be done is by engineering method, which is to install a cover on the side of the roll apron so that the finger of the worker does not enter and pinch. Control through engineering has proven to have an influence on decreasing the number of work accidents (Firdaus, 2011; Pratama et al., 2016).

The baking process has the potential for workers to come into contact with a hot oven. This potential hazard is considered not to cause significant losses, because workers can still do work as usual. Controls that have been implemented by the company include fabric gloves and oven operating based on SOPs. The recommendation that can be done is by implementing administrative controls. Namely by applying penalties for workers who violate the rules, and the use of long-sleeved clothing to production workers, especially the baking section.

The potential for explosions is in the baking and frying process. At this stage the production process involves diesel fuel. Explosions can occur when the flow of diesel is blocked and fuel leaks out. Control is carried out by conducting routine checks. Giving long distances, between the grill area and the diesel fuel reservoir. Distance can reduce the potential for an explosion. In the frying process, the company controls by immersing a 42 kg gas cylinder into the container, containing 40 cm of water. Soaking gas cylinders to reduce heat pressure on gas cylinders. The recommendation that can be done is by checking the tube and placing the gas cylinder in an area far from the source of heat or fire.

The potential for heat stress can be found in the frying process. In the frying process, there is one air duct to remove heat out of the production area. However, the number of airways is only one, making heat dissipation ineffective. In addition, in the frying area, there is no ventilation or window for air circulation so the area becomes stuffy. Stuffy conditions can trigger work stress due to heat found in the work area. The temperature of a hot environment can cause fatigue, drowsiness, increase the likelihood of work errors. The heavier the degree of physical work, the greater the metabolic burden of the body. Then more body heat must be removed and stress on the ambient temperature will be even higher (Khazad et al., 2015; Destari et al., 2017; Ramli, 2010). Recommendations that can be made is to do an examination of the air ducts. Then with the installation of ventilation or exhaust to facilitate air circulation.

The potential of crushed in packing machines can be found in the packaging process. In this process, workers use packing machines to speed up the production process. The product is placed on the machine then automatically moves and packaged. There are iron rollers that function to move the product. If workers are negligent, workers' fingers can be caught in an iron roll resulting in minor injuries. Control carried out by the company is only limited to the training of packing parts workers. To optimize risk control, recommendations that can be made are administrative control in the form of giving and understanding the SOP of machine operation. In addition, engineering can be done by closing the rollers that are open so that the workers' fingers will not enter and get stuck in the rollers.

CONCLUSION

It is known that there are 23 potential hazards in 8 production processes, among others: receipt of raw materials, storage, manufacture of dough, baking, frying, cooling, packaging, distribution. The highest risk is slipped workers who can be found in the process of making dough, frying process, cooling process with RPN = 140. The lowest risk is an explosion that can be found in the baking and frying process with RPN = 10.

REFERENCES

Ambekar, B. S., Edlabadkar, A., & Shrouty, V. 2013. A Review: Implementation of Failure Mode and Effect Analysis. *International Journal of Engineering and Innovative Technology (IJEIT)*, 2(8): 37-41.

Andiyanto, S., Sutrisno, A., & Punuhsingon, C. 2015. Penerapan Metode FMEA (Failure Mode and Effect Analysis) untuk Kuantifikasi dan Pencegahan Risiko Akibat Terjadinya Lean Waste. *Jurnal Online Poros Teknik Mesin*, 6(1): 45-57.

Anugrah, N. R., Fitria, L., & Desrianty, A. 2015. Usulan Perbaikan Kualitas Produk Menggunakan Metode Fault Tree Analysis (FTA) dan Failure Mode and Effect Analysis (FMEA) di Pabrik Roti Bariton. *Reka Integra*, 5(1): 146-157.

Apriyan, J., Setiawan, H., & Ervianto, W. I. 2017. Analisis Risiko Kecelakaan Kerja pada Proyek Bangunan Gedung dengan Metode FMEA. Jurnal Muara Sains, Teknologi, Kedokteran, dan Ilmu Kesehatan, 1(1):115-123.

Destari, N., Widjasena, B., & Wahyuni, I. 2017. Analisis Implementasi Promosi K3 dalam Upaya Pencegahan Kecelakaan Kerrja di PT X (Proyek Pembangunan Gedung Y Semarang). *Jurnal Kesehatan Masyarakat (e-Journal)*, 5(1):397-404.

Firdaus, R. 2011. Perbaikan Proses Produksi Muffler dengan Metode FMEA pada Industri Kecil di Sidoarjo. *Teknologia*, 5(1):83-88.

Food and Drink Federation (FDF) and Dairy U.K. 2011. *Sharing Health & Safety Key Performance Indicators Within the Food Industry*. London: Food and Drink Federation (FDF) and Dairy U.K.

Health and Safety Authority. 2014. Summary of Workplace Injury, Illness and Fatality Statistic 2013-2014. Dublin: Health and Safety Authority.

Iswanto, A. 2013. Aplikasi Metode Taguchi Analysis dan Failure Metode and Effect Analysis (FMEA) untuk Perbaikan Kualitas Produk di PT XYZ. *E-Jurnal Teknik Industri, FT USU*, 2(1):13-18.

Khakzad, N., Yuan, Z., Khan, F., & Amyotte, P. 2015. Dust Explosions: A Threat to The Process Industries. *Process Safety and Environmental Protection*, 1(98): 57-71.

Ozilgen, S. 2012. Failure Mode and Effect Analysis (FMEA) for confectionery manufacturing in developing countries: Turkish delight production as a Case Study. *Ciência e Tecnologia de Alimentos*, 32(3): 505-514.

Pratama, A., Asih, E. W., & Wisnubroto, P. 2016. Analisis Penyebab Kecacatan Wreapper pada Mesin Single Flowrap (SFW) Menggunakan Metode Failure Mode Effect and Analysis (FMEA) & Fault Tree Analysis (FTA) pada PT. Nestle Indonesia. *Jurnal Rekavasi*, 4(1):1-9

Ramli, S. 2010. Pedoman Praktis Sistem Manajemen Risiko Dalam Perpektif K3 OHS Risk Management. Jakarta: Dian Rakyat.

Simorangkir, H. 2015. Peningkatan Efektifitas Mesin Blowing berdasarkan Evaluasi Overall Equipment Effectiveness dan FMEA pada Industri Manufaktur Plastik. *Jurnal Departemen Teknik Industri Universitas Sumatera Utara*, 2(1):8-17.

Statistic on Workers In Australia. 2014. Number, Frequency Rate and Incidence Rate Of Serious Claims By Industry (2009-10 to 2013-14), Australia: Safe Work Australia.

Susilo, J.L., & Kaho, R. Victor. 2011. *Manajemen Risiko Berbasis ISO 31000 Untuk Industri Nonperbankan*. PPM Manajemen.

Syauqi, Q. A., & Susanty, A. 2016. Analisis Potensi Kecelakaan Kerja pada CV Automotive Workshop dengan Metode Failure Mode and Effect Analysis. *Industrial Engineering Online Journal*, 5(4) : 1-12