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Hazardous area classification for wheat flour processing plant

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Abstract

Dust explosion possibly occurs in common unit operations such as mills, grinders, dryers, and other modes of transport. The basic element for the setting of hazardous zone types consist of identifies release sources, determination of classification region of hazardous area, overviewing the basic operation in wheat flour processing plant with their specification requirement and use of a suitable code or calculations to determine area scope. Therefore, this analysis can be more elaborate by classifying the hazardous area into several areas using the International Electro Technical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres standard. Thus, wheat flour processing plant area classification can be categorized according to three zones based on the quantity of an explosion into atmosphere and its release frequencies which are zones 20, zones 21, and zones 22. From the results, it can be summarized that zone 20 is almost inside or closer one with the main equipment located near the ignition source which could lead to dust explosion, whereas zone 21 and zone 22 comes after zone 20 which is a less hazardous area as compared to zone 20 areas.

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1.0 Introduction

Dust explosions are very common in the industry to lead to huge explosions (Abbasi & Abbasi, 2007). This is caused by flour dust suspended in the air and not by moulded or fungal gasses eating the flour (Cloney & Snoeys, 2019). Grain and flour powders can form explosive nukes due to several factors such as significant amounts of agricultural dust during food grain handling, wheat, (Copelli et al., 2019), bulk transport and storage (Mittal, 2013). A dust explosion is analysed as the rapid evolution of flame-propagating energy and large-scale heat and reaction of dust will lead to these major accidents in the workplace (Sulaiman & Kasmani, 2011). There were dust explosion events experienced by several main items of powder processing equipment including mills, which has 51 events, grinders with 47 events, filters (43 events), driers (19 events) and silos/hoppers (15 events); and other equipment (95 events) (Council, 2014).

Several researchers focus on variety of dust explosion experiments, such as research on modelling for aluminium dust explosion venting (Song et al., 2019), experiment of thermal and dust explosion characteristic on nano-polystyrene (Sun et al., 2019), study the effect of sodium bicarbonate suppression on polyethylene dust explosion (Wang et al., 2020) development of risk matrix model for polyethylene dust using different particles size (Pang et al., 2020), application of flammable powder dust before and after drying testing into process safety management (Wei, et al. 2020), kinetic model on suppression mechanism of inert gas for aluminium dust explosion (Zhang et al., 2021), predictive dust explosion model integrated with pyrolysis model of organic powders (Pietraccini et al., 2021).

It is recommended to have standard practice for the design, installation, and use of appliances related to potential explosion incident for powder processing plant. One of the standard method to analyse and classify environment which could have gas atmosphere explosion is Hazard Area Classification (Eckhoff, 2003; Skjold & Rolf, 2016). This method classifies hazardous areas into their zones and identify the potential risk level of explosion based on the International Electro Technical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx) standard (Cashdollar, 2000; Commission, 2009). This research will be focusing on the dust explosion that could occur in the wheat flour processing plant. This study would be highlighting the application of IECEx standard for hazardous classification according to zone 20, zone 21 and zone 22 using wheat flour processing plant as case study in every section or equipment. Therefore, every section of wheat flour processing plant will have specific drawings according to the type and extent of zones, tables with locations, and identification of sources of release/plans (Vijayaraghavan, 2011). Thus, with these hazardous classification results, preventive and risk reduction strategies will be addressed for every equipment according to zone 20, 21 and 22.

The extent of an area for explosive dust atmospheres is defined as the distance from the edge of a source of dust release in any direction to the point where the hazard associated with that zone is no longer considered to exist (Eckhoff, 2003). Explosive dust atmospheres from a dust cloud will generally be considered zero if the dust concentration is an acceptable safety margin less than the minimum dust concentration needed for an explosive dust atmosphere (Eckhoff, 2003). Consideration should be given to the fact that fine dust inside a building can be carried by air movement from a source of release. Where the classification occurs in limited, unclassified areas between classified areas, the classification should be applied to the entire region (Wang et al., 2020).

The area classification layer symbols were illustrated in Figure 1 as the preferred ones in the drawing. This classify can distinguish each part of zones being analysed for this hazard identification areas. Figure 2 presents process flowchart for hazardous area classification process, which need identification of potential release source, estimation of the leakage or release duration, ventilation effectiveness evaluation before can be classified according to zone 20, 21 and 22.

2.0 Methodology

2.1 Wheat flour processing flow

The wheat flour process started from the transport vehicle park at pits, which the wheat flour is transferred via conveyors and bucket elevators into large bins or bulk storage. To prevent condition which wheat could ferment, mildew or sprout, right air, heat and moisture must be ensured. During storage, a fumigation process to remove insect pests would

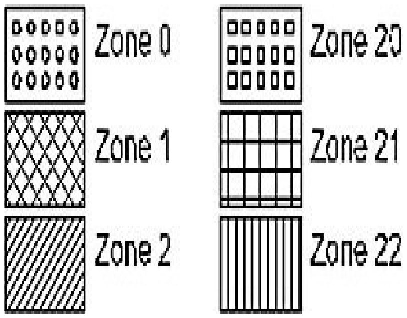

Fig. 1: Identification of zones on drawing

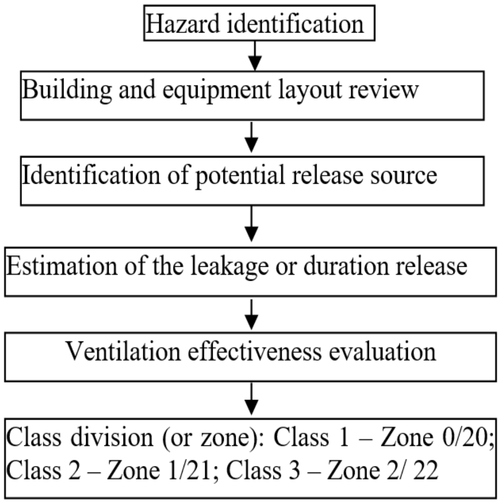

Fig. 2: Process flow chart for hazardous area classification process

happen. Storage of wheat is based on protein level and several quality criteria. According (Sisman & Ergin, 2011), the raw material is stored at 27°C while at 70 percent relative humidity and equilibrium moisture content (EMC) of wheat is 13.5. Silos can be unloaded into rail cars, trucks or use inclined conveyor methods to fill them. Most silos use gravitational force to flow the grain from the top of the silo out through an opening at the bottom near the centre. The temperatures inside a silo can exceed 30°C and pressure around 3 – 4 bar only.

A process of wheat flour continues to the vibrator separator where the unwanted component or substances have been removed or eliminated with large output from grains. Based on (Wang et al., 2020), the sieve in the vibrator separator can give a maximum particle 180x200 size reduction. Next, through horizontal movement of the sieve box, the Wheat Rotary Sieve Classifier will separate small and large impurities such as sand, small seeds, rocks, straws and others from the grain. For this process, targeted particle size of wheat flour is less than 90 µm (Hashmi, 2016). The next step is scourer, where it contains a central revolving shaft with tilted beaters, surrounded by a wire mesh jacket. Wheat is fed at one end and repeatedly beaten by the beaters which creates the friction between beater and grain, grain to grain and grain to jacket as it travels to the opposite end. By reducing the microbial count (bacteria, fungi, and others) as well as decreasing the presence of insects or their fragments, can greatly improve product hygiene. The amount of particulate material that passes through the sieve, counted as a percentage, is the Particle Size Index (PSI); the PSI is increases as wheat hardness decreases (Hashmi, 2016). The next process is Tempering, where the bran needs to be toughened while the inner endosperm needs to be mellow through specific amounts of moisture. This means the kernel sections to be quickly and cleanly separated. Tempered wheat is stored in 8–24-hour bins, depending on the wheat form soft, medium, or hard. Tempering humidity was set at 11%, 13%, 15%, and 17%, while rotational stone speeds were set at 173, 260, and 346 rpm (Williams & Rosentrater, 2007). According to the AFIA (2015), the desired volume of water has applied to the wheat cover and shake for 10 seconds per minute for 5 minutes before the water is distributed, without adding more than 5% a day. A temperature of 77°F for 2 to 3 days. Add a day where the temperature is even lower than 77°F.

Next step in wheat flour processing plant is milling process. In this milling process, there are reduction of the kernels of wheat gradually to become endosperm particles, then these particles are graded by sieves and separated from the bran by purifiers. Each size returns to the rollers and until the desired flour is obtained, the same process is repeated. The rolls are coupled and rotate with each other inward, rotating at various speeds. The wheat flour particles of different sizes varied from 42.42 to 13.63 μm, for mean granule diameter (D50) while the ranged from 148.70 to 31.98 μm is for D90 (Lin et al., 2019).

The second last of this process is flour sifting which aeration method moistened and jammed the flour. Sifting process also removes foreign substance and eliminate moisture in the flour. Particle size wheat flour produced size from 358 to 17 μm during the sifting process, then it will be examined using scanning electron microscopy (SEM) (Demontis & Cremante, 2012). The last process is storing the bulk material in storage silo where wheat flour is prepared for respiration phase. Oxygen is swallowed with respiration, and the inherent sugars are de-composed (Ahmad et al., 2017). Carbon dioxide, water, and heat are created as a result. A lack of weight induces this decomposition (Kuracina et al., 2017). Wang et al., (2020) recommends to keep the grain at 4.4ºC as at higher temperature of 21ºC to 32ºC, there are mold growth and insect infestation.

2.2 Procedure of hazard classification

To analyse the hazard on several part of equipment in the production plant, there is a standard based on analytical assessments that involved particular criteria such as the real ventilation of the area, the concentrations of potentially explosive mixtures, the residence times to possible dust explosion occurred concerning the LEL (Lower Explosive Limit) and the ventilation of the place. Thus, this dangerous area classification can be classified in one of the following three zones based on the frequency of the formation and retention of an explosive atmosphere which zones 20, zones 21, zones 22 and non-combustible hazardous area (safe area) (Demontis & Cremante, 2012).

The guide considers several parameters to determine if, indeed, there is a danger of explosion due to the presence of dust particles hence its fire composition also. First of all, it's necessary to define the number of hazardous substances in sufficient amount and the existence of a source of emission. Subsequently, it's necessary to follow the procedure proposed by the guide 31-35 for the classification of hazardous areas (Rogala, 2015).

2.3 Hazard identification

Identification of hazards is necessary to identify which substances are to be classified and their characteristics in the environment (Stobnicka & Górny, 2015). Therefore, it is important to establish whether the material is combustible and to evaluate the material characteristics, such as particle size, moisture content, cloud and layer minimum ignition temperature and electrical resistivity, and the correct dust level, to determine ignition sources.

Recognizing dangerous combustible dust situations in manufacturing plants and processing facilities helps you to quickly observe and recognize an unsafe situation in everyday work environments, evaluate whether you and your co-workers are in harm's way, and decide what steps are necessary to make the area safe (Stobnicka & Górny, 2015).

2.4 Building and equipment layout review

Th Equipment layout is one of the most important deliverables of a piping department. It shows location and placement of all equipment in a particular process or utility area along with various types of access and maintenance areas. For this new equipment or procedure or system upgrade this technological method anticipates hazards and possible hazards to prevent getting them into the workplace (Stobnicka & Górny, 2015). The details about the design of the processing equipment must be registered. Codes and standards were need to revised on to establish best engineering practise toward the hazard control and assessment (Ogle, 2016).

2.5 Evaluation on potential release sources and leakage duration

This section is necessary to conduct as it gives a review to the identification of potential release sources in the certain equipment or layout of the plant. Hence, verification of the possibility to remove or reduce them as much as possible is simple. The release sources are the principal key (hole) or areas (opening) from which the flammable substance is introduced into the environment in the form of dust or gas (Castellanos, 2008). Generally, emission sources are plant parts such as tanks, pipes, tubes, valves, joints, inspection hatches from which flammable gasses or vapours may escape during normal operation or due to predictable defects, wear, or malfunction (Castellanos, 2008).

Not every cause of release would automatically create an atmosphere of explosive material, depending on the circumstances. On the other hand, a dilute or small continuous release source in time will create a potentially dangerous layer of dust. The inside and outside of a powder containment need to be considered separately. For powders and dust, this might include explosibility (dust deflagration constant (Kst)) and ignitability (minimum ignition energy of a dust cloud (MIE), minimum ignition temperature of both a dust cloud and layer (MITc and MITl), minimum explosible concentration (MEC)) tests, and conductivity properties (Eckhoff, 2006). When it comes to gases or liquids, major checks include flammability thresholds, flashpoints (liquids), gas or vapor density, auto-ignition temperature (AIT), minimum ignition current (MIC), and maximum experimental safe distance (MESG) (Eckhoff, 2006). The release sources in normal and abnormal conditions need to verify, estimating the duration of leaks or releases while determines if there is an ignitable mixture likely to occur during any release or leakage as a result of repairs or maintenance

2.6 Ventilation effectiveness evaluation

nce identified, the sources of emissions should be evaluated and evacuate the possible safety measures need to consider as to reduce or eliminates the hazard in the plant. The standard EN 60079-10-2 is followed for area classification and thus, for considerations regarding the required ventilation in the specified zone of a plant, the classification of hazardous areas for the presence of fuel dust is concerned (Eckhoff, 2006). This standard indicates the principles for the scientific evaluation of ventilation n degree (Liu et al., 2019). This Guide is a precious reference for all specialists who have to classify a dangerous area and need to be guaranteed about the precision of their evaluations (Eckhoff, 2006).

When the type of material that can be present in normal plant conditions is identified and the potential sources of emissions are known, the reference values of ambient temperature and the characteristics of the ventilation must be specified to determine the degree of risk (Liu et al., 2019). Once the process potential for release is known, each source of release shall be identified, and its grade or grades of release determined. Grades of release are as follows:

(a) Continuous grade of release
    A condition where a dust cloud exists continuously release for long periods, or for short periods that occur frequently;
(b) Primary grade of release
    A condition where release can be expected to occur periodically or occasionally during a normal operation;
(c) Secondary grade of release
    A condition where the release is not expected to occur in a normal operation and, if this occurs, it is likely to do so only occasionally and for a brief period.

Based on the possibility of explosive dust atmospheres being produced, the areas may be classified based on Table 1.

3.0 Results and discussion

3.1 Classify hazardous area for wheat flour plant

Fig. 3 illustrates the hazardous classification area for the whole process of wheat flour processing plant started from the grain storage where it facilitated in open space contains a lot of bulk raw material before it is processed to the final product. Combustible dust explosions could pose a major risk for the majority area of a mill, where equipment that produces dust particles becomes airborne and dispersed throughout the plant.

The serious hazards associated with handling fine dust and powdered materials may be ignored by plant workers as the potential risk from dust explosion are not fully understood (Wan Sulaiman et al., 2020). Inspection of dust present in a factory is now the priority item during an audit, and factory management must implement a strategic plan for managing combustible dust and provide mitigating measures (Wan Sulaiman et al., 2020).

Table 1: Designation of zones depending on presence of dust (IEC, 2009)

Presence of dust	Zone classification of area of dust clouds
Continuous grade of release	20
Primary grade of release	21
Secondary grade of release	22

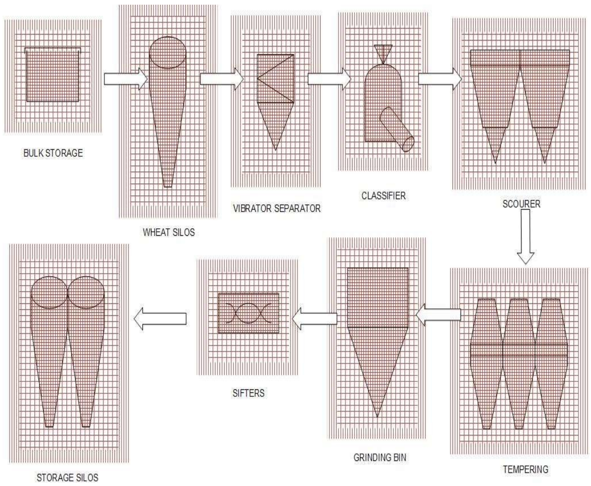

Fig. 3: Process flow for wheat flour processing plant

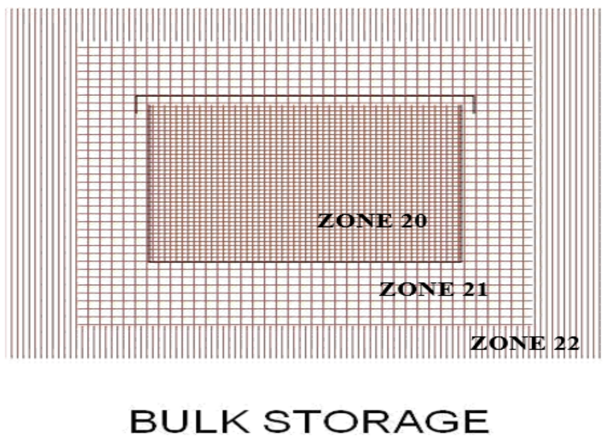

Fig. 4: Hazardous area classification at bulk storage

3.1.1 *Bulk storage*

At the initial of this process, the raw materials being transfer to the bulk storage from the trucks or lorries where these places store the raw material in good condition. Unlike bin storage, goods stored in bulk storage often use original containers. From the evaluation for safety measures, this bulk storage is more often exposed to the dust hazard because this place was handling the raw material which is in dust particles. Based on Fig. 4, zone 20 is characterised where there is dust accumulation that takes place at the volume inside the bulker. Meanwhile, zone 21 was located near the bulk storage as explosive dust could occur during normal operation. The next area of the zone in which an explosive dust atmosphere is not likely to occur in normal operation is zone 22 (Rogala, 2015).

3.1.2 *Wheat silos*

Typically, wheat silos are in cylindrical structures with a height (10 to 90 m) (Eckhoff, 2016). Silos storing grain, cement, and woodchips are typically unloaded with air slides. Silos can be unloaded into rail cars, trucks or use inclined conveyor methods to fill them. Fig. 5 illustrates the hazardous area classification for each zone at wheat silos where most silos use gravitational force to flow the grain from the top of the silo out through an opening at the bottom near the centre. The temperatures inside a silo can exceed 30 °C and pressure around 3 to 4 bar only. The source of igniting from these wheat silos is the internal volume of the silo has been classified as zone 20. The selection of suitable equipment (or safety measures) for a hazardous zone is based on the premise that an event generating an explosive atmosphere and an event producing an ignition source are independent of each other (Williams & Rosentrater, 2007).

Therefore, some safety precautions should be enhancing toward this major equipment where the source of ignition and grade of release would be determined to overcome the dust control for this equipment. Zone 21 has been classified as outside the volume of silos and adjacent areas, whereas a place where dust can be deposited in layers with an extension of a few meters from zone 21 area is zone 22 (Rogala, 2015). Zone 20 can be a less hazardous area if there is frequent cleaning to remove dust in the work areas, especially on elevated surfaces, before it accumulates to hazardous levels.

3.1.3 Vibrator separator and classifier

The process of wheat flour continues to the vibrator separator where the unwanted component or substances have been removed or eliminated with large output from grains. Zone 20 is located in the part of the vibrator separator itself where the heat source can be found since these cleaning processes would increase the temperature (Rogala, 2015). Zone 21 is located outside of the equipment, and hazard zone 22 is located outside the part of the equipment area with an extension of a few meters from zone 21. This zoning area can be reduced by maintaining the normal operating condition of the equipment such as continuously check the bearing temperature. For example, as the temperature is too high, plant workers must check the rolling distance, whether it is too tight, or any problems regarding lubrication and transmission parts (IEC, 2009). Furthermore, management must ensure maintenance programs such as overhaul and maintain the bearing every six months and always preventing the handle faults during the operation or adjusting the grinding steps (IEC, 2009).

Meanwhile, hazardous area classification for each separator where zone 20 is located nearest to the equipment whereas zone 21 and zone 22 are located outside of the equipment and outside area with an extension of a few meters from the zone 21 respectively. Removing a large amount of dust accumulation on walls, sills and beams will reduce potential explosions. Hence, zone 20 can be reduced to zone 21, which is a less hazardous area (Hashmi, 2016).

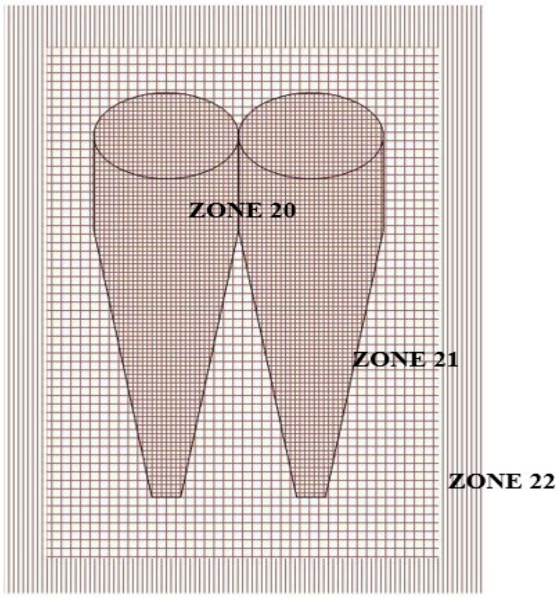

Fig. 5: Hazardous area classification at storage silos.

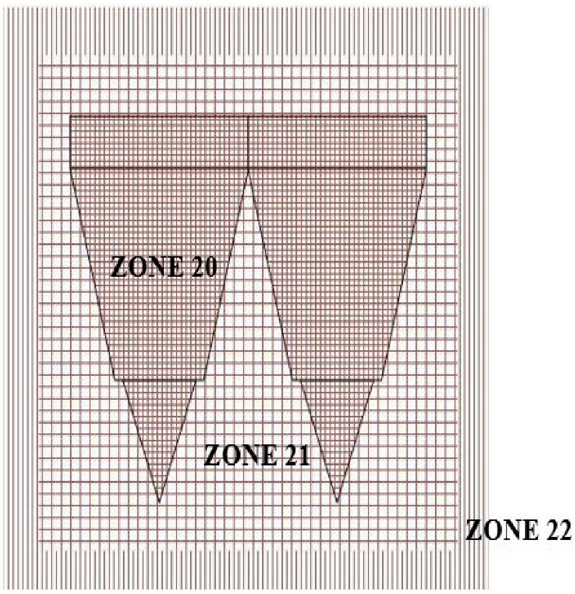

Fig. 6: Hazardous area classification at scourer.

3.1.4 Scourer

Scourer is used to extract impurities that stick to the wheat skin and other dirty stuff such as dust, mud, coal, etc. By reducing the microbial count (bacteria, fungi, etc.) as well as decreasing the presence of insects or their fragments, can greatly improve product hygiene (Leroux, 2016). Based on Fig. 6, zone 20 is located inside the scourer where the grade of release combustible dust would occur if there were an abnormal condition. In this elevated zone, 20 areas were infrequently cleaned, so wheat flour dust accumulated to dangerous levels. Meanwhile, an area where it is located outside this equipment is labelled as zone 21 for the hazardous area in the wheat flour processing plant. The area near the equipment where there is opened occasionally can be categorised as zone 22. For the safety precautions, this equipment should be handled appropriately and ensure a clean environment near this equipment. The housekeeping should be arranged frequently to avoid equipment contaminating with this dust (Ahmad et al., 2017).

3.1.5 Tempering

Wheat is conditioned for milling. Moisture is added in certain amounts to toughen the bran and mellow the inner endosperm. This means the kernel sections to be quickly and cleanly separated. Tempered wheat is stored in 8–24-hour bins, depending on the wheat forms; soft, medium, or hard.

Zone 20 is classified inside the equipment since the wheat dust takes place in the tempering process. If there is an abnormal condition in this process, the high pressure could lead to an increase the particle collision inside the tempering motor. Hence, it could create dust clouds in this equipment. Proper maintenance for this tempering motor could reduce the probability for the ignition source would create. Therefore, a region where the area outside of the equipment would be labelled as zone 21 and zone 22 is located outside of the equipment and outside area with an extension of a few meters from zone 21 (Rogala, 2015).

3.1.6 Grinding bin

The milling method is a gradual reduction of the kernels of wheat to produce endosperm particles which are then graded and separated from the bran by sieves and purifiers. Each size returns to the corresponding rollers and until the desired flour is obtained, the same process is repeated. Zone 20 is a position where an explosive atmosphere is present constantly, or for long periods or regularly for short periods, in the form of a cloud of combustible dust in the air where dust accumulations are known to occur on equipment like inside the grinding bin. Therefore, zone 21 can be classified where an explosive environment, in the form of a cloud of fuel dust in the air, is likely to occur periodically during regular activity and zone 22 where this area is outside from the likelihood of the explosive areas that are unlikely to occur during normal activity but will only exist for a short period if it does (Rogala, 2015).

A written housekeeping program with instructions to manage and remove dust accumulations on ledges, floors, equipment, and other exposed surfaces must be practised to avoid the possibility of a dust explosion could be happened (Hashmi, 2016).

3.1.7 Sifters

Hazardous area classification at sifters can be classified into three zones, which the first one is zone 20 where is located inside of the equipment (Rogala, 2015). The failure of rotating brushes and spiral conveyors affected by the dust accumulated in this part of equipment would lead to the dust explosion (Leroux, 2016). Secondly, zone 21 has been classified at the outside of the volume of sifters and adjacent areas whereas a place where dust can be deposited in layers with an extension of a few meters from zone 21 area is zone 22. Therefore, to improve the safety level in this process, plant owner must ensure the equipment is not exposed to extreme humidity, heat, or water condition which might adversely affect it and provide adequate power to maintain spindle speed as for maintaining the equipment in a safe operating condition (IEC, 2009).

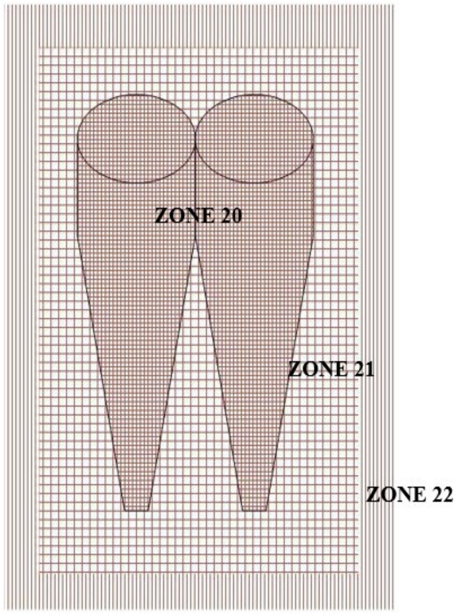

Fig. 7: Hazardous area classification at storage silos

3.1.8 Storage silos

Hazardous area classification in storage silos can be illustrated in Fig. 7. As the grain is contained in the silo, the dust produced is continuous and the whole silo volume is classified as zone 20. During the phases of loading and unloading near the silo, the doors commonly emitted some amount of dust through the outside. These doors of loading and unloading become the source of dust explosion zone 21 or boundary of zone 22 if there is frequent or continuous operation (Rogala, 2015). To mitigate dust releases and wheat flour spillage, routine maintenance was carried out on wheat flour conveying and packaging equipment, and accumulated dust and spilt flour was removed promptly (IEC, 2009). There is a scenario in sugar dust release, which could become an explosion as sugar dust is contained and remain suspended in an enclosed steel belt. This is because this enclosed space is unventilated, could rapidly accumulate to a concentration above MEC; although normal operation in silo tunnel before this steel belt, the dust concentration is below MEC (AFIA, 2015).

3.1.9 Summary table of zone classification and safety preventive for all equipment

This study outlined the hazard area classification evaluation for the wheat flour processing plant as presented in Table 2. The result of this research had been made based on the IECEx Standard for a dust explosion. In certain plants and factories manufacturing dust, the interior of the dusting equipment would be zone 20 or zone 21. If they are to be zoned, the less restrictive zone 22 hazardous area identification should only be rooms inside the building (Rogala, 2015). Zone 21 would need to be a few very small places which explosive dust escapes in quantities in regular activity. The estimated distance range for zone 20 is 1 m radius inside the equipment, 2 m radius for zone 21 from outside zone 20, and 3 m radius for zone 22 from zone 21 (Rogala, 2015).

3.2 Safety measures for dust control for wheat flour plant

A fire hazard could occur in wheat flour plant for the accumulation of combustible dust on the horizontal surfaces as this dust could be ignited and burned (Leroux, 2016). When flour dust and flours released from equipment in the buildings, there are a need to have scheduled housekeeping activities which could eliminate accumulation of dust in horizontal surfaces and on the floor before the layer of the dust increase

Table 2: Summary table of zone classification and safety preventive for all equipment

Type of Equipment	Zone Classification			Safety Preventive
	Zone 20	Zone 21	Zone 22	
Bulk storage	Volume inside the bulker. A 1-meter radius from the bulker.	Near the bulk storage in which an explosive dust atmosphere is likely to occur in normal operation. A 2-meter radius from zone 20.	Which an explosive dust atmosphere is not likely to occur in normal operation is zone 22. A 3-meter radius from zone 21.	The configuration of the equipment, even in the case of unusual accidents relevant to the equipment, must ensure safety. Except in the event of two faults arising independently of each other, protection must be assured.
Wheat silos	The source of ignite from these wheat silos is the internal volume of the silo has been classified as zone 20. A 1-meter radius from the bulker.	Zone 21 been classified where outside the volume of silos and adjacent areas. A 2-meter radius from zone 20.	Zone 22 is a location where dust can be collected in layers that reach a few meters from zone 21. A 3-meter radius from zone 21.	Zone 20 can be less hazard area if there is frequently cleaning to remove dust in the work areas, especially on elevated surfaces, before it accumulated to hazardous levels.
Vibrator separator	Zone 20 is located in the part of vibrator separator itself where the heat source can be found since these cleaning process would increase the temperature. A 1 meter radius from the bulker.	It is located outside of the equipment. A 2-meter radius from zone 20.	Zone 22 is located outside the part of equipment area with an extension of a few meters from zone 21. A 3-meter radius from zone 21.	Thoroughly overhaul and maintain the bearing every six months and always preventing the handle faults during the operation or adjusting the grinding steps.
Classifier	Zone 20 is located nearest to the equipment. A 1-meter radius from the bulker.	It is located outside of the equipment. A 2-meter radius from zone 20.	Outside area with an extension of a few meters from the zone 21. A 3-meter radius from zone 21.	By removing large amount accumulations of dust on beams, sills, and walls, continuous explosion will be eliminated and hence zone 20 can be reduced to zone 21 which is less hazardous area
Scourer	Zone 20 is located inside the scourer where the grade of release combustible dust would occur if there is abnormal condition. A 1-meter radius from the bulker.	An area where it located outside for this equipment labelled as zone 21. A 2-meter radius from zone 20.	Area near the equipment where there is opened occasionally can be categorised as zone 22. A 3-meter radius from zone 21.	Proper handle and ensuring a clean environment near with this equipment as the housekeeping should be arranges frequently to avoid equipment contaminate with this dust.
Tempering	Zone 20 is classified inside the equipment since the wheat dust takes places in tempering process. A1 meter radius from the bulker.	A region where the area outside of the equipment would label as zone 21. A 2-meter radius from zone 20.	Zone 22 are located outside of the equipment and outside area with an extension of a few meters from the zone 21. A 3-meter radius from zone 21.	Proper maintenance for this tempering motor could reduce the probability for the ignition source would create.
Grinding bin	Zone 20 is a position where an explosive atmosphere is present constantly, or for long periods or regularly for short periods, in the form of a cloud of combustible dust in air where a dust accumulation is known to occur on equipment likes inside the grinding bin. A 1-meter radius from the bulker.	Zone 21 can be classified where an explosive environment, in the form of a cloud of fuel dust in the air, is likely to occur periodically during regular activity. A 2-meter radius from zone 20.	Zone 22 where this area is outside from the likelihood of the explosive areas that is unlikely to occur during normal activity but will only exist for a short period if it does. A 3-meter radius from zone 21.	Implementing a written housekeeping program with instructions to reduce dust accumulations on ledges, floors, equipment and other exposed surfaces.
Sifters	It is located inside of the equipment. A 1-meter radius from the bulker.	Zone 21 can be classified where at the outside the volume of sifters and adjacent areas. A 2-meter radius from zone 20.	A place where dust can be deposited in layers with an extension of a few meters from zone 21 area. A 3-meter radius from zone 21.	Ensuring the equipment not exposed an area too high humidity, heat or water which might adversely affect it and providing adequate power to maintain spindle speed as for maintaining the equipment in safe operating condition
Storage silos	Inside the volume of the silo. A 1-meter radius from the bulker.	The outside the volume of sifters and adjacent areas. A 2-meter radius from zone 20.	Located outside of the equipment and outside area with an extension of a few meters from the zone 21. A 3-meter radius from zone 21.	

to hazardous level. Therefore, it is important to consider the efficiency of the dust collection system through overall risk assessment and activity (IEC, 2009). Effective dust collecting systems that comply with the risk assessment activity can improve dust dispersion (Hashmi, 2016). All electrical and mechanical equipment must follow standard design, manufacturing and maintenance for explosion protection to avoid becoming a source of ignition for suspended dust in the wheat flour plant (Hashmi, 2016).

3.2.1 Reducing the risk of dust explosions

Dust explosion could occur when there are dust accumulation and dispersed in the air with the presence of an ignition source. These accumulations can be inside of equipment, and/or release from equipment, then settle into the surface of the working area. To prevent a dust explosion, based on Eckhoff (2009), there are 3'R could be the best engineering practices for dust explosion control:

i) Replace
If there is a process using combustible dust, the best option is to replace the combustible dust with other dust that is combustible if it can be complied.

ii) Reduce
Reducing the inventory of the material that is hazardous with material that is less hazardous or replaces it.

iii) Refine
If the initial cannot be mitigated, refine the process to make it less hazardous such as eliminating a dust dispersal process if could possible

3.2.2 Proper handling and maintenance for dust control

Wheat flour dust accumulations on elevated surfaces and spilt flour on the floors surrounding equipment could lead to energy explosion (Stobnicka & Górny, 2015). The fireballs continued to be fuelled by wheat flour dust. In that the dust collection systems were ineffective, the only solution for minimising wheat flour dust accumulation to prevent a dust explosion would be timely and effective housekeeping practices to remove the wheat flour dust from the work areas but first, it must be contained before the dust can be controlled (Eckhoff, 2006).

Factory management must ensure all equipment is gasketed and tight as proper as possible (Williams & Rosentrater, 2007). Equipment that emits dust should have attached suction hood and/or connection for suction vent. Sanitation and health problems can be reduced as recovered flour returned to product stream. Flour explosions are becoming less common, as mills continuously provide improvement for worker health and sanitation, thus reduce the potential for major accidents (Leroux, 2016). Based on the hazardous area classification in sifters, zone 20 can reduce its hazard and be classified as zone 21 if all potential ignition sources have been eliminated or controlled like ensure the electrical equipment not been introduced without any evaluation first and it is located away from the hazardous area (Rogala, 2015).

Meanwhile, the dust explosion can be avoided if there is best practice to minimise the creation of dust clouds in bulk storage such as introduce proper and scheduled maintenance program (IEC, 2009). Major equipment usually has a maintenance program as a problem at this equipment could stop the whole process operation. However, a dust control system is often overlooked as this system does not affect the whole operation. A dust controls system must be maintained to ensure it is effectively working. For example, there is a situation where a dust control duct is plugged with material, but this problem is unnoticed (Hashmi, 2016). Therefore, it is recommended to include the dust control system in a planned maintenance program. Regularly inspect the major equipment to avoid any failure or abnormal operation conditions during the process (Ahmad et al., 2017). Certain overlooked things could be checked, such as a plugged-up hood or duct, elbow's worn-out, a plugged cyclone and obvious parts such as bearings and drive belts (Kuracina et al., 2017).

Whenever any change in a system is contemplated, the design calculations must be rechecked to see if such a change could be properly incorporated into the existing system and, if so, what modifications would have to be made to permit it (AFIA, 2015).. Many good dust control systems (as well as, air systems of all types) have been rendered totally ineffective by modifications made without design considerations.

3.2.3 Level of ventilation

The use of local extract ventilation reduces the quantity of dust in the extracted space so could conceivably downgrade the classification from zone 20 to zone 21 (Rogala, 2015). On the other hand, the

Table 3: Recommended frequency of housekeeping (NFPA, 2021)

Depth of Dust Accumulation on Equipment (1)	Area Classification (2)	Release Frequency (3)	Housekeeping Activity (4)
Negligible, up to < 1 mm (1/32 in.)	Unclassified	Infrequent	Clean as appropriate
Up to 3 mm (1/8 in.)	Class II, Division 2	Infrequent	Clean as necessary to maintain less than 3 mm (1/8 in.)
Up to 3 mm (1/8 in.) or occasional cloud formation	Class II, Division 1, or Division 2	Occasional	Clean at frequency appropriate to minimise additional dust accumulation or formation of a cloud
>3 mm (1/8 in.) to layer test value, or presence of dust cloud	Class II, Division 1	Continuous/ frequently	Clean at frequency appropriate to minimise additional dust accumulations
Exceeds layer test value, or presence of extensive dust cloud	Class II, Division 1	Infrequent	Immediately shut down and clean equipment

extracted dust will now be concentrated in the dust collection unit where the risk of an explosion can be high (Cortem Group, 2012). Secondly, general ventilation can also reduce the quantity of dust in the extracted space and small quantities of dust may prevent an explosive dust cloud from forming at all. General ventilation may also be helpful with housekeeping. Thirdly, fluctuating ventilation such as natural ventilation created by the wind may be helpful in reducing the quantity of dust in an area, but it may also create explosive dust clouds where housekeeping is poor, and layers of powder can be raised up into a dust cloud.

3.2.4 Housekeeping

Housekeeping is the most important tool we can use to minimise the risk of dust explosions as it minimises the volume of combustible dust and the consequences of an explosion (Branion, 1976). If there is no proper monitoring to this housekeeping the dust accumulative creates a layer of dust that will act as a source of easily dispersed combustible material. If dispersed by a small primary explosion this can quickly lead to a much larger secondary dust explosion. Also, dust layers that form on the top of equipment can be heated and act as a source of ignition. Table 3 shows the recommended frequency of housekeeping based on the area classification and depth of dust accumulation on equipment.

4.0 Conclusions

This research focuses on how to identify and classify the hazardous zone area in the wheat flour plant based on IECEx Standard. Thus, to analyse the hazard on several parts of equipment in the production plant, analytical assessments that consider several parameters such as the real ventilation of the area, the concentrations of potentially explosive mixtures, the residence times to possible dust explosion occurred in relation to the LEL and the ventilation of the place was identified and calculated. Thus, wheat flour processing plant area classification can be classified in one of the following three zones based on the frequency of the formation and retention of an explosive atmosphere, which are zones 20, zones 21, and zones 22. From these results, it can be summarised that zone 20 is almost inside or closer one with the main equipment, which is a source of ignition, whereas zone 21 and zone 22 comes after zone 20, which is a less hazardous area as compared to zone 20 areas.

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