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DETERMINING STATISTICAL SURVEY OF OCCUPATIONAL INJURIES IN MINES; RISK ANALYSIS MODELLING, SOFTWARE DEVELOPED ON THE BASIS OF FUZZY LOGIC TO PREVENT JOB ACCIDENTS

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Abstract- In all countries in the world, accidents at work and occupational diseases in mines still remain an important problem to be solved. There are many specific and indefinite hazards associated with worker health and safety at mines. It is very difficult to model risk in a workplace environment with many specific and ambiguous hazards. It is also very difficult to model a system to simulate these hazards. In this study, Adana and Mersin provinces were examined in mines. Employees in these quarries were questioned about worker health and work safety. The data were collected on potential hazards in mines. Software was developed by creating a fuzzy logic based risk assessment analysis model in consideration of many hazards in occupational health and safety in mines. An alternative approach to risk assessment has been proposed using fuzzy decision making approach and matrix method. By this approach, occupational health and safety specialists are provided with blurred linguistic assessments before calculations made. The model will greatly reduce the risks in mines. By this modelling and software, the risk assessment and analysis can be done easily in mines. By this risk assessment and analysis, occupational accidents and occupational diseases in mines will be greatly reduced. Hopefully in the future mine vacations and occupational diseases will not come on the agenda.

Keywords: Occupational Health, Health in Mines, Risk Analysis.

I. INTRODUCTION

Mining is the major source of income for many developing countries today. High technology used today is a big way to prevent such accidents, but it is one of the sectors with the highest risk of mining, accident and death [1]. From search to production and transportation, mining is a very risky industry due to the nature of the work it is involved. It has high job-loss figures as a result of these risks being avoided and becoming undesirable [2]. Mining differs in basic structure from other works, because it is essential to work in the constantly changing environment conditions in mining, to produce at the limits that nature constantly changes.

It shows how important the perception and assessment of the risks in mining are [3]. Specific risk assessment of the workplace environment and the uncertain dangers and make a system modelling to simulate these hazards is very difficult. The dangers brought by the industrialists have increased job accidents in developing countries [4]. Rapid migration from rural to urban areas, inability of low-educated employees to adapt to jobs, adverse conditions of work and inadequate job inspections have led to increased job accidents.

Increased work accidents and prevention of occupational diseases are possible in the first stage with a good risk assessment analysis at the top of the truth level [5]. It is a system that includes the identification of hazards related to occupational health and safety in an institution The decision of how to make harm, the analysis of risks, the decision to be taken, the implementation of these measures and the monitoring of hazards, risks and precautions if necessary, the whole process is called Risk Assessment Analysis. The risk assessment aims to anticipate in advance how, where, and how negativities that come to health from injuries or illnesses and take precautions at the forefront [6].

Risks in the workplace arise from the work done, the processes carried out and various methods, the materials used, all kinds of machinery and equipment, the employees working at or around the workplace, the environmental conditions from the organizations created at the workplace and the interaction of various elements with each other [7]. Underground minerals and mines are used as raw materials or intermediates in many industries. There are about 30 million people work in the mines around the world. One of the sectors with the highest risk of accident and death is in the mining sector [8].

Despite the fact that only 1% of the world's workers are working in the mines, 10% of the serious accidents that take place are in the mining sector. Major accidents such as explosions, fires and dents in mines result in death of many people [9]. High technology used today is a big way to prevent such accidents, but it is one of the sectors with the highest risk of mining, accident and death.

From search to production and transportation, mining is a very risky industry due to the nature of the work. It has high job loss figures as a result of these risks being avoided and becoming undesirable [10]. Mining differs in basic structure from other works, because it is essential to work in the constantly changing environment conditions in mining, to produce at the limits that nature constantly changes. It shows how important the perception and assessment of the risks in mining are [11].

II. DETERMINING THE STATISTICAL SURVEY OF OCCUPATIONAL INJURIES IN MINES

The reasons of the accident in mines are accidental poisoning, accidental falls, accidents caused by machines, accidents. They caused by flammable and explosive, materials, accidents from hot material, from fire, flame, trauma that makes a falling object, compression of the body or a limb by staying between two bodies. In the event of an object strike, being injured by falling under a falling object, accident caused by a cutting and sinking tool, accident caused by electric current, the accident that came out of a cabin burst under pressure. The injuries caused by the force of the body in any way, a foreigner in the eye or in a vent, the obstruction of the breath tube with a food material, the subsequent fate of the crashes, accidents. They occur when welding, self-injury and killing, according to the reasons of the accident, if the motor vehicle is hit by another vehicle, an object or a human. The accidents took place on a motor-driven platform, motor vehicle overturning injuries, accidents caused by or due to a stationary motor vehicle, all kinds of accidents and falls during watering, water fall, trauma of all kinds of plane accidents, other rail vehicle accidents. They also took place in the gas from the firearms, accidental drowning and submersion, accident caused by any vehicle, bites or stings of animals, toxic insect stings, excessive hot or cold ambient influences, natural disasters, treatment accidents and vaccination complications, murder and injury by someone else, trauma from warfare and other reasons [12].

The location of the research has been ten mining sites in the provinces of Adana and Mersin. The 500 employees who extract mining from mines make up the universe of researchers. These 10 mines were selected by simple random sampling method and taken into the scope of the research. In order to give objective answers to the questionnaires and interviews made at the workplace, the names of the workplaces were given a commitment to use only occupational health and safety data to keep all information confidential.

In this study, data were obtained by questionnaire method. Some responses to the questionnaire were supported by observation techniques. Survey form; work safety specialists, from domestic and foreign sources, in the mines, the approach of workplace to work safety, the approach of workers to work safety. The 30 questions that are considered for the emergence of workplace accidents at workplace. Findings obtained in this study are given in Figure 1.

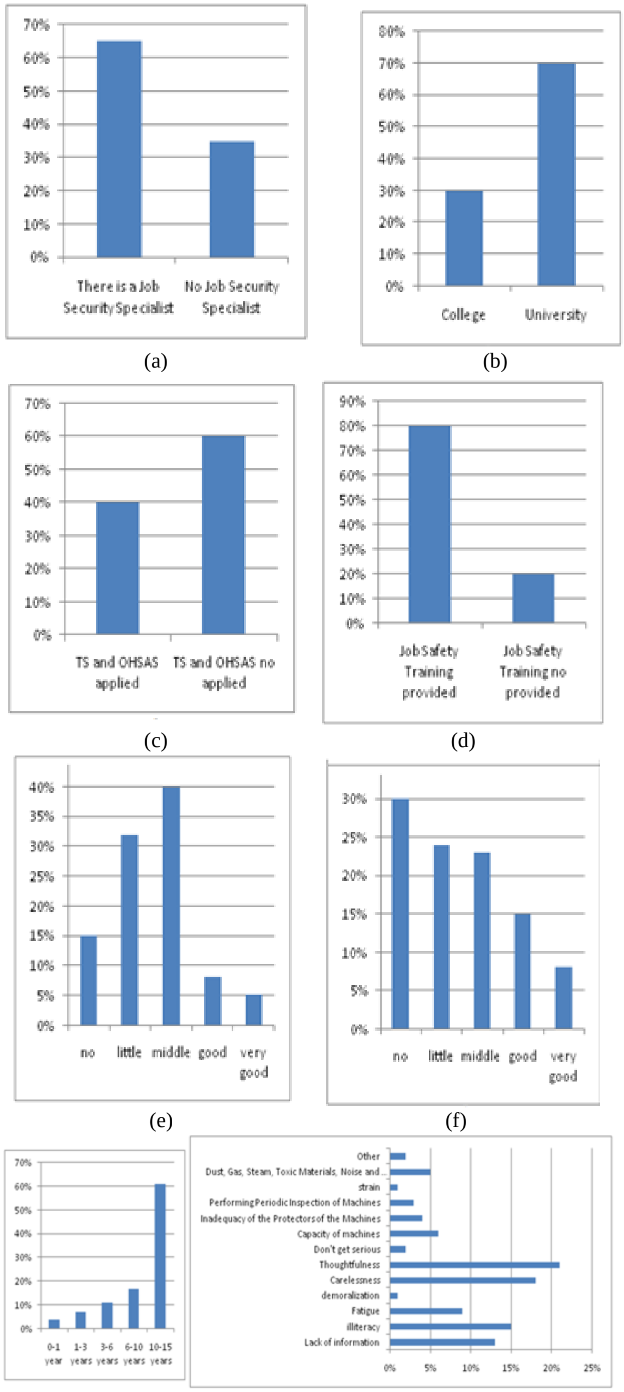

Figure 1. Findings obtained in this study, (a) having a job security specialist, (b) educational status of the job security specialist, (c) TS and OHSAS application, (d) job safety trainings are given or not, (e) adaptability to employees' job safety rules, (f) employees' protective equipment usage habits, (g) rate of accident coming to market in a year, (h) causes of accidents in the square in a year

The 40% of workplaces operating in mines do not employ a job security specialist. Work safety specialists are the most important factors for preventing the accident in the workplace. Again, TSE-OHSAS 18001 has not been observed in the majority of mines. It is understood that 20% of the workers in the mines have not been trained in occupational safety at work. Half of workers have not been able to adhere to the rules of work safety.

The vast majority of them are personal hoods, although they are not habitual to use it. It shows that the application of the work safety rules in the mining sector is not fully established. When the reasons for these accidents were asked, the majority of the workers seemed to be involved in the business accidents due to the lack of employees. But the employers did not explain the underlying reasons for the absurdity. In addition, a large number of employers are trying to show that the cause of the job accident has come from the mistakes of the employees. So a large number of employees should be informed that the work accidents have come to the conclusion of the employees' thoughtfulness. Number of employers are trying to show that the cause of the job accident has come from the mistakes of the employees. So a large number of employees should be informed that the work accidents have come to the conclusion of the employees' thoughtfulness.

III. FUZZY LOGIC CONCEPT

Fuzzy logic is the ability of the human thought mechanism to mimic the mode of conclusions that it applies effectively [13]. The blurring of the human thinking process suggests that the rationale behind thinking is much more than the classical two-valued logic [14].

Fuzzy logic proposes multiple values from 0 to 1 instead of the 0 and 1 values of the classical logic. An important concept in fuzzy logic is the concept of linguistic variable. The values of a linguistic variable are expressed by fuzzy sets [15]. For the linguistic variable 'very hot, hot, cold, too cold', 'very fast, fast, slow, very slow' and 'very old, old, middle-aged, young, very young' can take the expressions. Each of these expressions is modeled separately with fuzzy sets. This has led to the development of fuzzy logic controllers and applications [16].

Processes for fuzzy sets are similar to those for conventional clusters. In logic operations for fuzzy sets, standard logic operations can be applied if the maximum and minimum values of fuzzy values are set to 0 and 1. In fuzzy logic, there is a rating in the accuracy of any situation. The basic cluster operations are replaced by min, max and complementary operations [17]. Fuzzy inference systems have if-then rules that determine the relationship between input and output. Fuzzy relationships determine the extent or absence of the relationship between the elements of two or more clusters [18].

IV. RISK ASSESSMENT ANALYSIS IN MINES

The risk assessment effort is a big deal for the mining industry. In the mining sector, even the slightest win is more likely to result in disaster. For this reason, in addition to the basic measures applied, the requirements of the business and the operator during the activity; the necessity of regular monitoring of constantly changing conditions and the assessment of new risks to be introduced reveals once again the importance of risk analysis work for this sector.

The risk analysis work in the mining sector is mainly based on the identification of existing and probable hazards in the vicinity of the mine, the assessment of the risks created by these hazards and consequently the determination of the measures to be taken in order to bring the risks into an acceptable risk level. Analysis of the following issues in the mining sector will facilitate the identification of existing and potential hazards. Potential hazards in the mines are mineral gases, ventilation conditions, excavation works, temperature, fire, dust level, vibration, lighting, support and dentures, use of explosives, electrical installations, mechanical installations, materials and human transport and flooding.

The lighting, grounding and lightning rod installation in the mines must be checked periodically and necessary measurements must be made. Compressor air tanks and similar pressure vessels should be periodically inspected and maintained for boilers used to generate heat. Protectors of moving parts belonging to all equipments must be available. All electrical equipment used in the mine should have the ex-proof feature. Work machines such as forklifts and loaders should have an audible warning system in the reverse gear. There must be protective bars in front of the bunkers used for material transfer.

In addition, there should be a grill in the bunkers and silo nozzles. The conveyor belts must have automatic stop buttons at the beginning, middle, and end of the conveyor, belt or chain conveyor. There must be a generator in order to support the ventilation and lighting system at first. A system must be installed that does not allow production machines to operate without an automatic audible alarm before starting work. The required engineering calculations should be made in the mines and adequate support should be made. The pigs used as fortifications in the inside of the foot should be clamped between the ceiling and the floor.

The necessary places should be supported using a wedge and a brush. The hydraulic pylons used in the support must be checked regularly. In case of natural ventilation in the hearths will be inadequate, the ventilation system must be installed absolutely. The torn areas should be repaired by regular checks of the vents that allow air to flow into the furnace. At certain points in the mine, there must be fixed gas measuring devices used mobilely on top of occupational safety experts. Periodic control of portable fire extinguishers must be provided where necessary training has been given to the fire intervention team, equipment and conventional alarm system.

Explosives should be prevented from using explosives other than those allowed in mines. Personnel using explosive materials should be the ignition certificate. The location of the storage area of explosive substances should be selected in accordance with the legislation. At the entrance of the explosive material store, there should be copper plates where the personnel will touch and earth them. Dry herbs and flammable substances around the explosive storage area must be removed.

A certified first aid team must be present at the operation every train. There should be a rescue station in the furnace where the necessary equipment is located. The rescue team should be trained periodically. A rescue plan should be prepared to indicate the escape routes and points of collection. Vehicles used for internal transport in the furnace must have an exhaust gas prevention system and spark arrester. Belt and chain conveyors must have an automatic warning system on them. It must be thrown out by the suction fans from the furnace of the methane gas to reduce the percentage of gaseous air present in the furnace and keep it at minimum level.

A ventilation system to reduce the rate of grizzly to less than 1% and a system to detect the discharge of the grizzly should be established. The temperature inside the furnace should be kept well below 500 °C to prevent ignition. The hob safety lamp must be used. This lamp is one of the standard instruments to detect the methane content and oxygen deficiency in the air in the furnace.

The basic rule that the lamp applies to the detection of methane is the flame extinguishing when the burning gas in the lamp is cooled below the methane gas ignition level. Electrical equipment and technical equipment should be used with ex-proof features that will not cause sparking and ale. Grizzly meters should be used at various points in the oven to measure the amount of air and the amount of air in the air and to alarm in the event of a rise. A replacement ventilation system must be provided for a possible failure in the ventilation system. The non-flammable materials such as dolomite, gypsum and limestone should be made into powder and sprayed on the walls and surface of the coal furnace to reduce the risk of explosion.

The analysis of the risks is based on the analysis of the risk factors such as Matrix Method, Fine-Kinney Method, Energy Analysis, Hazard and Operability Method (HAZOP), Fault Tree Analysis, Fault Type and Effectiveness Analysis (FMEA), Event Tree Analysis, Cause and Effect Diagrams, Deviation Analysis, Checklists, If-Then Analyzes, and so on [21]. There are many methods available.

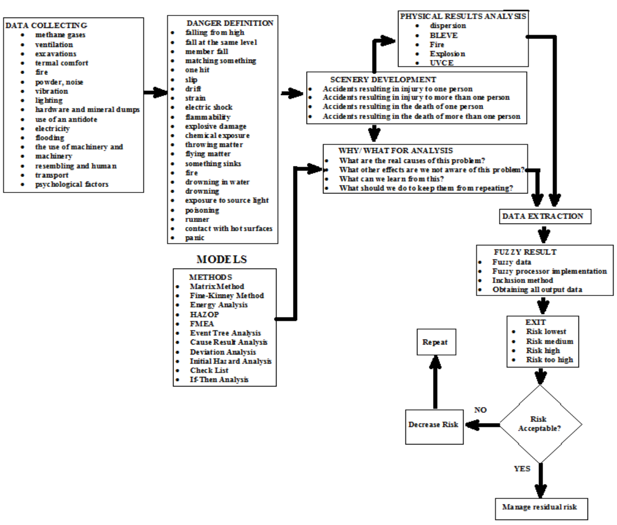

Figure 2. Creating risk analysis modelling in mines

The matrix method, which is widely used in these methods, is a method of analyzing the severity of risk and the possibility of its components. Determination of hazards that may or may not be present in mines is defined as a functional Risk Assessment Analysis which should be done to assess the risks arising from hazards and to determine, implement and monitor control measures [22].

Figure 2 shows risk analysis modelling in mines, how risk Assessment and analysis in mines can be done. In this method; the risk that a danger will arise is analyzed by how often the likelihood of emergence can be seen and how serious the negative consequence of violence may be occurred.

Harmful parameters in the workplace;

h: hazard (up to 1 hazard number H),

d: danger value,

$dh_{\max}$: max value of danger,

nd: non-hazardous (membership level $u_{violence}$=0),

ld: very low dangerous (membership level $u_{violence}$=0.2),

Ld: low dangerous (membership level $u_{violence}$=0.4),

Md: moderate danger (membership level $u_{violence}$=0.6),

hd: high dangerous (membership level $u_{violence}$=0.8),

Hd: very high dangerous (membership level $u_{violence}$=1.0).

As a business environment;

$h(1)$: workplace ambient temperature (when it drops below 15 °C and exceeds 25 °C)

$h_1^{\min}$ =10 °C, $d_1^{\max}$ = 35 °C,

$h_2^{\min}$ = 0.4 m/sec, $d_2^{\max}$ = 1.1 m/sec,

$h(2)$: the air flow rate (when the speed drops below 0.5 m/sec and rises above 1 m/sec),

$h(3)$: relative humidity (over 60%), $d_3^{\max}$ = 60%,

$h(4)$: carbon monoxide, $d_4^{\max}$ = 50 ppm,

$h(5)$: carbon dioxide, $d_5^{\max}$ = 1000 ppm,

$h(6)$: hydrogen cyanide, $d_6^{\max}$ = 10 ppm,

As harmful metals in the workplace environment;

$h(7)$: lead, $d_7^{\max}$ = 0.15 mg/m^3 ,

$h(8)$: mercury, $d_8^{\max}$ = 0.075 mg/m^3 ,

$h(9)$: arsenic, $d_9^{\max}$ = 0.5 mg/m^3 ,

$h(10)$: hydrogen sulphide, $d_{10}^{\max}$ = 20 ppm ,

$h(11)$: beryllium, $d_{11}^{\max}$ = 2 mg/m^3

As irritant gas in the workplace environment;

$h(12)$: ammonia, $d_{12}^{\max}$ = 25 ppm,

$h(13)$: chlorine, $d_{13}^{\max}$ = 1 ppm,

$h(14)$: nitrogen dioxide, $d_{14}^{\max}$ = 5 ppm,

$h(15)$: sulphur dioxide, $d_{15}^{\max}$ = 0.1 ppm,

$h(16)$: ozone, $d_{16}^{\max}$ = 0.1 ppm

$h(17)$: arsine, $d_{17}^{\max}$ = 0.05ppm,

$h(18)$: phosphine, $d_{18}^{\max}$ = 0.3 ppm,

$h(19)$: stibine, $d_{19}^{\max}$ = 0.1 ppm,

$h(20)$: high pressure,

$h(22)$: chemical substances,

$h(23)$: noise,

$h(24)$: hand-arm vibration,

$h(25)$: whole body vibration,

$h(26)$: lighting,

$h(27)$: harmful rays and radiation,

$h(28)$: electromagnetic fields,

$h(29)$: hot or cold climate,

$h(30)$: irregular and slippery surfaces,

h(31): movement of vehicles and machines,
h(32): machine movements and parts,
h(33): hazardous surfaces,
h(34): hot or cold surfaces,
h(35): hand tools,
h(36): electrical installations and equipment,
h(37): fire,
h(38): explosion,
h(39): lifting and handling,
h(40): stopping faults,
h(41): biological hazards,
h(42): stress, violence.

The probability of emergence of danger is given in Table 1. In similarity, the severity rating is shown in Table 2. The score matrix is shown in Figure 3. Two hazard factors and sub criterions are compared and are shown in Figure 4. The linguistic variable membership function, triangular fuzzy number membership functions in Figure 4 as a score table are shown in Table 3.

Table 1. Probability chart of emergence of hazard

Probable Value	Possibility of Leaving
Very Small (1)	Hardly ever
Small (2)	Very few (once a year), only in abnormal situations
Middle (3)	Little (once every three months)
High (4)	Frequently (once a year)
Very High (5)	Very often (every day), under normal working conditions

VH(5): daily hazard potential (membership level $u_{probability}$ =1.0),
H(4): weekly hazard potential (membership level $u_{probability}$ =0.8),
M(3): monthly hazard potential (membership level $u_{probability}$ =0.6),
S(2): three-month hazard potential (membership level $u_{probability}$ =0.4) ,
VS(1): possibility of danger years (membership level $u_{probability}$ =0.2),
N(0): never appear dangerous (membership level $u_{probability}$ =0.0).

Table 2. Violence rating table

Probable Value	Possibility of Leaving
Very Small (1)	Hardly ever
Small (2)	Very few (once a year), only in abnormal situations
Middle (3)	Little (once every three months)
High (4)	Frequently (once a year)
Very High (5)	Very often (every day), under normal working conditions

'Death, incapacity to work permanently in mines' (membership level $u_{violence}$=1.0),
'Serious injury, long-term treatment, occupational disease in mines' (membership level $u_{violence}$=0.8),
'Light injury, inpatient treatment/injury in mines' (membership level $u_{violence}$=0.6),
'There is no loss of work day, outpatient treatment without permanent effect in mines' (membership level $u_{violence}$ = 0.4),
'No business hours lost, need immediate relief, first aid in mines ' (membership level $u_{violence}$= 0.2),
'The danger does not emerge at all in mines' (membership level $u_{violence}$ = 0.0).

PROBABILITY / VIOLENCE	1 VERY LOW	2 LOW	3 MIDDLE	4 HIGH	5 VERY HIGH
1 VERY LOW	NEGLIGIBLE 1	NEGLIGIBLE 2	LOW 3	LOW 4	LOW 5
2 LOW	NEGLIGIBLE 2	LOW 4	LOW 6	MIDDLE 8	MIDDLE 10
3 MIDDLE	LOW 3	LOW 6	MIDDLE 9	MIDDLE 12	HIGH 15
4 HIGH	LOW 4	MIDDLE 8	MIDDLE 12	HIGH 16	HIGH 20
5 VERY HIGH	LOW 5	MIDDLE 10	HIGH 15	HIGH 20	EXTREMELY HIGH 25

Figure 3. Score matrix in mines

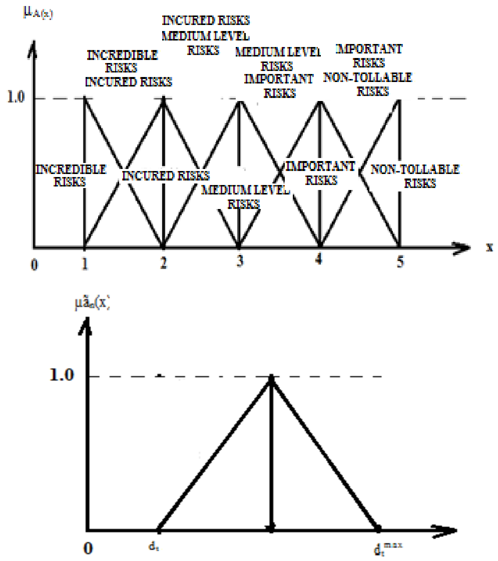

Figure 4. Two risk factors and subcriteria comparative linguistic variable membership function and triangular fuzzy number membership function in mines

Table 3. Score table in mines

Non-Tollable Risks (25)	The business should not be started until the risk is reduced to an acceptable level. If there is an ongoing activity, it should be stopped immediately. If it is still not possible to reduce the risk despite the precautionary measures, the activity should be cancelled.
Important Risks (15,16,20)	The business should not be started until the specified risk is reduced. If there is an ongoing activity, it should be stopped immediately. Emergency measures should be taken if the risk is to continue, and as a result of these measures, the continuation of the activity should be decided.
Medium Level Risks (8,9,10,12)	Activities should be initiated to reduce the identified risks.
Incurred Risks (2,3,4,5,6)	Additional control processes may not be needed to remove the identified risks. However, existing controls should be maintained.
Incredible Risks (1)	It may not be necessary to plan the control processes and to keep records of the activities to carries out in order to eliminate the identified risks.

Risk assessment score and membership level; Risk = Violence x Probability.
The risks with a score of 25 are very high and the membership rate is u_{risk}= 1.0.
Risks between 15 and 25 are high risk and membership level is u_{risk}= 0.8.
Risks between 8 and 12 are medium risk and membership level is u_{risk}= 0.6.
The risks ranging from 3 to 6 are low, and the membership grade is u_{risk}= 0.4.

Risks with a score of 1 and 2 are very low, and the membership level is u_{risk}= 0.2.
If the score is 0, there is no risk and the membership grade is u_{risk}= 0.0.

Firstly, perunit values of the defined hazards are calculated as $d_t^n=d_t/d_t^{\max}$, t=1, ……T', then perunit values of the undefined hazards are calculated as $\underline{d}_t^n = \underline{d}_t/\underline{d}_t^{\max}$, t=T'+1,…,T, a fuzzy number scale is defined by the maximum method, $\underline{d}_t^n$, r_t, t=T'+1,…,T, the fuzzy definition of each defined hazard being $\underline{c}_t=\underline{W}_t$. The $\underline{d}_t^n$ is calculated and all linguistic hazards are $c_t=\underline{W}_t$. The $r_{\underline{t}}$ for each t=T'+1,..,T is calculated on the basis of the comparison method of the blurred numbers in the order of the hazards.

Table 4 shows the linguistic variable table, the fuzzy decision-making approach in Table 5a, and the probability-risk assessments determined by three different job security experts using the matrix method and the risk membership ratings of these assessments in Table 5b, conversion of the risks obtained in Table 6a into linguistic variables of probability-severity membership ratios is given in Table 6b.

Once the blur sets are defined and their membership functions are assigned, the rules are written for each combination of control variables. These rules relate input variables to output variables by using If-Then expressions in decision-making. The condition 'If' is a prelude to the result of each rule.

Table 4. Linguistic variable table in mines

Language Variables	Fuzzy Value
nd: non-hazardous	(0,0,0)
ld: very low dangerous	(1,1,2)
Ld: low dangerous	(1,2,3)
Md: moderate dangerous	(2,3,4)
hd: high dangerous	(3,4,5)
Hd: very high dangerous	(4,5,5)

Table 5. (a) Fuzzy decision making approach in an applied mine and probability-severity evaluations of risk using matrix method in mines
(b) Fuzzy decision making approach in an applied mine and risk rating of risk assessments using the matrix method in mines

Risks		(a) Odds	(a) Violence	(b) Risk Membership Level
1	Dent	0.6, 0.6, 0.4	1.0, 0.8, 0.8	0.60, 0.32, 0.32
2	Shipping	0.4, 0.6, 0.6	1.0, 1.0, 0.8	0.40, 0.60, 0.48
3	Falling from High	0.4, 0.6, 0.4	0.8, 0.8, 0.8	0.32, 0.48, 0.32
4	Fall at the Same Level	0.2, 0.2, 0.2	0.2, 0.2, 0.2	0.04, 0.04, 0.04
5	Material Drop	0.6, 0.6, 0.4	0.8, 0.6, 0.8	0.48, 0.36, 0.32
6	One Hit	0.4, 0.6, 0.4	0.6, 0.6, 0.8	0.24, 0.36, 0.32
7	Matching Something	0.4, 0.6, 0.6	0.4, 0.6, 0.4	0.16, 0.36, 0.24
8	Soil Shifting	0.8, 0.6, 0.8	1.0, 1.0, 1.0	0.80, 0.60, 0.80
9	Drift	0.2, 0.4, 0.2	0.4, 0.2, 0.6	0.08, 0.08, 0.12
10	Strain	0.4, 0.2, 0.2	0.2, 0.2, 0.2	0.08, 0.04, 0.04
11	Electric Shock	1.0, 1.0, 1.0	1.0, 1.0, 1.0	1.00, 1.00, 1.00
12	Flammability	0.4, 0.6, 0.6	0.6, 0.6, 0.8	0.24, 0.36, 0.48
13	Explosive Damage	0.4, 0.6, 0.6	0.6, 0.6, 0.8	0.24, 0.36, 0.48
14	Chemical Exposure	0.4, 0.4, 0.6	1.0, 0.8, 0.8	0.40, 0.32, 0.48
15	Throwing Matter	0.4, 0.2, 0.2	0.2, 0.2, 0.4	0.08, 0.04, 0.08
16	Flying Matter	0.6, 0.6, 0.4	0.4, 0.2, 0.2	0.24, 0.12, 0.08
17	Something Sinks	0.2, 0.2, 0.2	0.2, 0.2, 0.2	0.04, 0.04, 0.04
18	Fire	0.2, 0.4, 0.2	1.0, 0.8, 0.8	0.20, 0.32, 0.16
19	Drowning in Water	0.2, 0.4, 0.2	0.8, 0.8, 0.8	0.16, 0.32, 0.16
20	Drowning	0.4, 0.4, 0.6	1.0, 1.0, 1.0	0.40, 0.40, 0.60
21	Poisoning	0.4, 0.4, 0.6	1.0, 1.0, 1.0	0.40, 0.40, 0.60
22	Eye Entry	0.2, 0.2, 0.2	0.2, 0.2, 0.2	0.04, 0.04, 0.04
23	Contact with Hot Surface	0.6, 0.4, 0.4	0.2, 0.2, 0.4	0.12, 0.08, 0.16
24	Panic	0.6, 0.4, 0.4	0.2, 0.2, 0.4	0.12, 0.08, 0.16

Table 6. (a) Converting risks into probability-severity membership removal linguistic variables using a fuzzy decision-making approach and matrix method in an applied mines
(b) Obtaining risk membership ratings using a fuzzy decision-making approach and matrix method in an applied mines

Risks		(a) Odds	(a) Violence	(b) Risk Membership Level
1	Dent	Md, Ld, Ld	Hd, Hd, hd	0.413
2	Shipping	Ld, Md, Md	Hd, Hd, hd	0.493
3	Falling from High	Ld, Md, Ld	hd, hd, hd	0.373
4	Fall at the Same Level	ld, ld, ld	ld, ld, ld	0.040
5	Material Drop	Md, Md, Ld	hd, Md, hd	0.386
6	One Hit	Ld, Md, Ld	Md, Md, hd	0.306
7	Matching Something	Ld, Md, Md	Ld, Md, Ld	0.253
8	Soil Shifting	hd, Md, hd	Hd, Hd, Hd	0.733
9	Drift	Ld, Ld, ld	Ld, ld, Md	0.093
10	Strain	Ld, ld, ld	ld, ld, ld	0.053
11	Electric Shock	Hd, Hd, Hd	Hd, Hd, Hd	1.000
12	Flammability	Ld, Md, Md	Md, Md, hd	0.360
13	Explosive Damage	Ld, Md, Md	Md, Md, hd	0.360
14	Chemical Exposure	Ld, Ld, Md	Hd, hd, hd	0.400
15	Throwing Matter	Ld, ld, ld	ld, ld, Ld	0.066
16	Flying Matter	Md, Md, Ld	Ld, ld, ld	0.146
17	Something Sinks	ld, ld, ld	ld, ld, ld	0.040
18	Fire	ld, Ld, ld	Hd, hd, hd	0.226
19	Drowning in Water	ld, Ld, ld	hd, hd, hd	0.213
20	Drowning	Ld, Ld, Md	Hd, Hd, Hd	0.466
21	Poisoning	Ld, Ld, Md	Hd, Hd, Hd	0.466
22	Eye Entry	ld, ld, ld	ld, ld, ld	0.040
23	Contact with Hot Surface	Md, Ld, Ld	ld, ld, Ld	0.120
24	Panic	Md, Ld, Ld	ld, ld, Ld	0.120

In general, each rule is shown as 'If', and then 1024 combined rules are created when identical result expressions are issued. The software was generated as shown in Figure 5 and the priority order of the risks was obtained as in Table 7.

- If *h*(1) is nd and *h*(2) is nd and *h*(3) is nd and *h*(4) is Hd and *h*(5) is nd and *h*(6) is nd and *h*(7) is nd and *h*(8) is nd and *h*(9) is nd and *h*(10) is nd and *h*(11) is nd and *h*(12) is nd and *h*(13) is nd and *h*(14) is nd and *h*(15) is nd and *h*(16) is nd and *h*(17) is nd and *h*(18) is nd and *h*(19) is nd and *h*(20) is nd and *h*(21) is nd and *h*(22) is nd and *h*(23) is nd and *h*(24) is nd and *h*(25) is nd and *h*(26) is nd and *h*(27) is nd and *h*(28) is nd and *h*(29) is nd and *h*(30) is nd and *h*(31) is nd and *h*(32) is nd and *h*(33) is nd and *h*(34) is nd and *h*(35) is nd and *h*(36) is nd and *h*(37) is nd and *h*(38) is nd and *h*(39) is nd and *h*(40) is nd and *h*(41) is nd and *h*(42) is nd then RISK is VERY HIGH else
- If *h*(1) is nd and *h*(2) is nd and *h*(3) is nd and *h*(4) is nd and *h*(5) is Hd and *h*(6) is nd and *h*(7) is nd and *h*(8) is nd and *h*(9) is nd and *h*(10) is nd and *h*(11) is nd and *h*(12) is nd and *h*(13) is nd and *h*(14) is nd and *h*(15) is nd and *h*(16) is nd and *h*(17) is nd and *h*(18) is nd and *h*(19) is nd and *h*(20) is nd and *h*(21) is nd and *h*(22) is nd and *h*(23) is nd and *h*(24) is nd and *h*(25) is nd and *h*(26) is nd and *h*(27) is nd and *h*(28) is nd and *h*(29) is nd and *h*(30) is nd and *h*(31) is nd and *h*(32) is nd and *h*(33) is nd and *h*(34) is nd and *h*(35) is nd and *h*(36) is nd and *h*(37) is nd and *h*(38) is nd and *h*(39) is nd and *h*(40) is nd and *h*(41) is nd and *h*(42) is nd then RISK is VERY HIGH else
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Figure 5. Creating software on a risk assessment analysis in mines

Table 7. Fuzzy decision-making approach in an applied mine and sequence of risks using the matrix method in mines

1	2	3	4	5	6	7	8	9	10	11	12
T11	T8	T2	T20	T21	T1	T14	T5	T3	T12	T13	T6
13	14	15	16	17	18	19	20	21	22	23	24
T7	T18	T19	T16	T23	T24	T9	T15	T10	T4	T17	T22

V. HARDWARE DEVELOPED ON RISK ANALYSIS MODELLING IN MINES

Areas with a limited volume, partially or totally enclosed, with a limited amount of air and designed as work area are called indoor environments [23]. Indoors contain gas, dust, vapour or smoke at a potentially hazardous or harmful level.

In these environments there is an oxygen concentration within the proportions that will cause explosion. Dirty air, dirty air, toxic air, explosive air and dusty air are examined in four groups [24]. Waste air contains less than 20% oxygen and studies in places with this type of air mixture show fatigue in a short time. Toxic air is the air that consists of harmful gasses that make human life dangerous [25]. As can be seen from this, the nasty air is harmful to the human organism due to its chemical effect and even causes deaths. Examples of these gases are carbon monoxide, nitrogen oxides, hydrogen sulphur, sulphur dioxide and radon gasses.

Explosive air is the air that contains all the flammable gases in its composition [26]. These gases are in particular hydrocarbons such as methane, ethane, propane, butane and gases such as hydrogen, carbon monoxide and hydrogen sulphur. Dusty air indicates air containing dust at a certain concentration. Occupational Health and Safety Regulations and the related regulations, it is necessary to constantly check the conformity in terms of thermal comfort and physical conditions at work places. The employer is obliged to make the necessary measurements and evaluations and to establish a healthy working environment in order to detect and prevent the elements that affect the health and safety of the employees arising from the work done in the working environment.

As shown in Figures 6, 7 and 8 the thermal comfort (temperature, humidity, air flow rate) in the work environment, particulate matter-heavy metal in the ambient air, internal noise, vibration, lighting, gasses in the environment, a centralized control system was developed.

Figure 6. Sensors used in mines

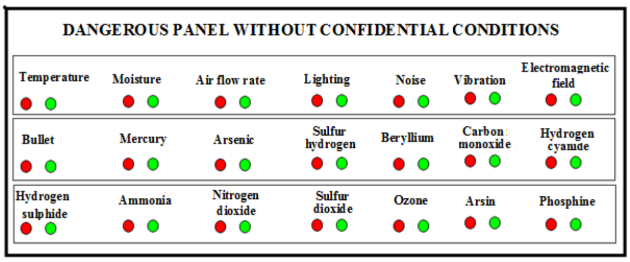

Figure 7. OSH insecure conditions control panel in mines

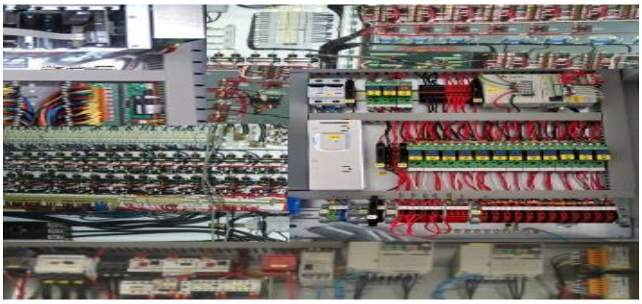

Figure 8. Established security panel

VI. CONCLUSIONS

The location of the research has been ten mining sites in the provinces of Adana and Mersin. The 500 employees who extract mining from mines make up the universe of researchers. These 10 mines were selected by simple random sampling method and taken into the scope of the research.

In this study, data were obtained by questionnaire method. Some responses to the questionnaire were supported by observation techniques. It is understood that 20% of the workers in the mines have not been trained in occupational safety at work. Half of the workers have not been able to adhere to the rules of work safety, and the vast majority of them are personal hoods, although they are not habitual to use it.

It shows that the application of the work safety rules in the mining sector is not fully established. When the reasons for these accidents were asked, the majority of the workers seemed to be involved in the business accidents due to the lack of employees. But the employers did not explain the underlying reasons for the absurdity. In addition, a large number of employers are trying to show that the cause of the job accident has come from the mistakes of the employees.

So a large number of employees should be informed that the work accidents have come to the conclusion of the employees' thoughtfulness. In this study, software was developed by creating a fuzzy logic based risk assessment analysis model in consideration of many hazards in occupational health and safety in mines. An alternative approach to risk assessment has been proposed using fuzzy decision making approach and matrix method. With this approach, occupational health and safety specialists are provided with blurred linguistic assessments before calculations are made. The inconsistencies in decision making are reduced by taking arithmetic averages of these assessments.

It has been seen that the three most important risks in the work done by creating the fuzzy logic based modeling of work safety risk analysis model, software using the fuzzy decision making approach and the matrix method to increase the job security in the mines found to be electric shock, landslide and slip. These risks have been found to be high risks in the overly wet ground where electrical wiring used in plumbing is very old and has lost its insulation properties. Cables that have been damaged or deteriorated in such a way as to cause danger through control and testing shall be promptly repaired or replaced.

The excavations in the mine shall be made from top to bottom with a slope proportional to the durability of the earth and shall be supported or appropriately reinforced by supporting the side faces on self-supporting floors such as hard rock, hard shale, concreted gravel, hard limestone, clayey schist rock, grey and conglomerate. The ramp slopes should be no more than 35 degrees to ensure. The vehicles will carry the excavated soil. The excavation can easily go into and out of the excavation area. It must be eradicated at the distance required by the soil type to prevent sliding of the excavated soil. thermal comfort (temperature, humidity, air flow rate) in the work environment, particulate matter-heavy metal in the ambient air, internal noise, vibration, lighting, gasses in the environment, a centralized control system was developed.

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BIOGRAPHY

Mehmet Zile was born in Ankara, Turkey, 1970. He received the B.Sc. degree from Yildiz University, Istanbul, Turkey, the M.Sc. degree from Gazi University, Ankara, Turkey and the Ph.D. degree from Yildiz University, all in Electrical and Electronic Engineering, in 1992, 1999, and 2004, respectively. Currently, he is an Assistant Professor of UTIYO at University of Mersin, Mersin, Turkey. He is also an academic member of UTIYO Information Systems and Information Technology Department at University of Mersin and teaches information systems and control systems. His research interests are in the area of control systems and electrical machines. He is a member of the International Electrical and Electronic Engineers.