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Improvement of the chosen process based on the occupational health and safety criterion

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ABSTRACT

Purpose: of the paper has been an attainment of the confirmation that improvement of the effectiveness and efficiency of the processes is indirectly connected with the definition and assurance of the human recourses, infrastructure and work environment needed and reflecting directly assurance of the occupational health and safety.
Design/methodology/approach: used for the analysis has included: collection of the information necessary for the risk assessment, identification of the occupational threats and their results, occupational risk assessment using standard method and intermediate events tree method as well as determination of risk acceptability and the proposition of improving actions in the process.
Findings: of analysis, which have been conducted, are as follows: the input of the improvement of every process is being determined by the choice of proper methods of analysis and assessment; in the aspect of the occupational health and safety management - methods of the occupational risk assessment.
Practical implications: can apply in case of any organisation, which manages the occupational risk by usage of both: standard general method taking into account probability of the threats occurrence and severity of their results and improving detailed method taking into consideration probability of the initiating, intermediate and ending events occurrence and their results.
Originality/value: of the presented paper has been constituted by the methodology using the standard method fulfilling legal requirements connected with the obligation of the occupational health and safety assessment and the intermediate events tree method satisfying expectations linked up with the improvement of the process.
Keywords: Improvement of process; Occupational health and safety management; Occupational risk assessment

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1. Introduction

Contemporary organisations, participating in the competitive fight on the market, has to fulfill not only customers' expectations in the reference to the quality of the delivered products and services, but also, or even first of all, the requirements connected with the environmental protection as well as the workers' requirements connected with the occupational health and safety.

Assurance of the occupational health and safety reflects directly assurance of the human recourses, infrastructure and the work environment, and at the same tame – assurance of improvement of the effectiveness and efficiency of processes.

Therefore, in the aspect of the occupational health and safety management systems, organisation voluntarily undertakes the improvement actions. On the other hand, the improvement of the processes is forced on the workers by the legal requirements including the necessity to estimate the occupational risk, and as the result – undertaking the corrective and preventive actions to minimise the risk. The effectiveness and efficiency of those actions indicates the effectiveness and efficiency of the improvement process

Always the starting point to improve the processes is the choice of proper methods of analysis and assessment; in the range of the occupational health and safety management – methods of threats identification and the occupational risk assessment.

2. Improvement of the processes in the Deming cycle

Process can be considered as a "set of interrelated or interacting activities, which transforms inputs into outputs [1]" (Fig. 1). As an input one can classify: human resources, information, fittings, energy, materials and raw materials. An output can be: products, services, information, documents, etc. Both inputs and outputs can be material and intangible [2-5].

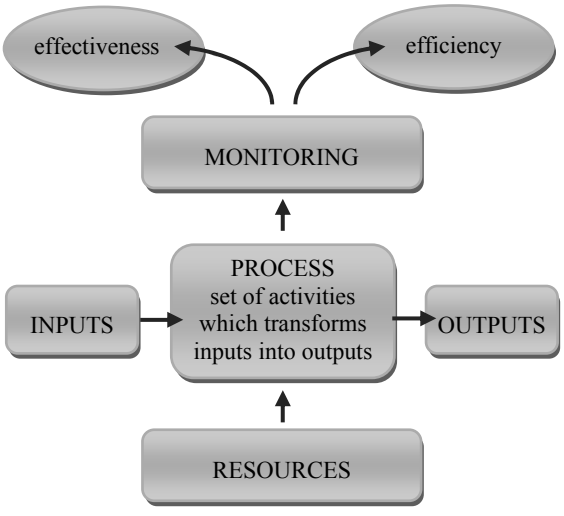

Fig. 1. Scheme of the process in the "process approach" [2]

When the process is realised, it should be checked if functions properly and if the planned results are reached, what is called monitoring and is being based on measurement and information's analysis. Dependently on the aims of the process are attained or not, the proper corrective actions are undertaken. The results of monitoring enable to determine the effectiveness of the processes, so – what the percent of the planned activities realisation and the planned results achievement is. It shows the relation between the results, that are achieved, and the recourses, that are used [4,6,7].

An improvement is the continuous process; because of its continuity one of the practical possibilities of improvement realisation is Deming cycle. The cycle, so called PDCA cycle (Plan - Do - Check - Act), consists of chronological, put in order, activities, typical for control arrangement with feedback and continuously repeated [3,5-8].

Improvement of the processes, improvement of their effectiveness and efficiency is possible only while the organisation defines the human recourses, infrastructure and the required work environment. Assurance of those resources reflects directly assurance of the safety and hygiene of work.

3. Occupational heath and safety management

Occupational health and safety can be understood as a whole of legal regulations as well as organisational and technical means having on aim creation of the conditions for work without exposing workers to the risk of accident or occupational disease. Effective management of those areas of organisation is one of the main conditions that makes the functioning efficiently [4,9-11].

In the traditional approach to occupational heath and safety management, organisations usually reduced their activities to the actions required for the assurance of the conformity with the requirements of the law, and especially qualified persons were obligated to achieve that aim. Unfortunately such an attitude didn't give acceptable results; even in case of more active actions connected with continuous analysis of occupational diseases and work according to the health and safety standards, one couldn't say about effective system, only about safety practice [4,12].

The change of sentiment towards occupational health and safety took place together with the process of adapting Polish law to the European Union law requirements as well as with expansion of quality and environmental management systems [4,12].

The effect of the common activities of certification and notification bodies was publishing the OHSAS 18001 standard, in the year 1999, giving the fundaments for certification of the occupational health and safety management system, unfortunately being not accepted as the international standard [4,12].

In Poland, some years later, the occupational health and safety standard was accepted as the PN-N-18000 series consisting of: PN-N-18001, PN-N-18002 and PN-N-18004. First of them specifies the requirements setting conditions for functioning the system, the other two have the character of practical programme adding the occupational risk assessment and implementation of the occupational health and safety management system in organisations [4,12,13].

The main aim of the PN-N-18001 standard is supporting the activities in the aspect of the occupational health and safety improvement by defying the requirements connected with the effective occupational health and safety management system. The standard includes specifications, which can be used during the implementation of the system, with regard to the legal requirements and the other ones in the occupational range. The standard neither determines the manner of realisation of the system requirements nor defines absolute requirements connected with the results of the undertaken activities [4,12,13].

4. Occupational risk assessment

Risk is an element of every human activity and, in general meaning, it is connected with the possibility of suffering losses. In the aspect of human taking part in any productive process risk is usually called occupational risk [14-16].

In the PN-N-18001 standard occupational risk is defined as the probability of occurrence of undesirable events connected with the work performed and creating the losses; especially manifestation of unfavourable health changes as a results of threats in the work environment or a manner of work performance [13,17].

Starting point for occupational risk assessment should be: the definition of the legal requirements and the assessment aims as well as the used methods.

4.1. Legal requirements connected with the occupational risk assessment

Decisions of the Directive of Council of European Communities on implementing the means allowing for increase of the safety and improve employees' health during their work oblige employer to [18]:

- assessment of the occupational health and safety risk connected with the workplace and, what results from it, choice of preventing means, production methods and work organisation,
- consideration of the worker's opportunities in the aspect of his safety and health during mandating services to him,
- assurance of consulting the environmental conditions of the workplace connected with the safety of workers during the implementation of new techniques,
- assurance that only properly informed workers will have access to the areas of potential serious danger.

In accordance with the Labour Code employer should [19]:

- undertake the actions preventing the risk, if he carries out activity contributing to the occurrence of sudden danger for workers' health and life (Art. 224),
- inform workers about the occupational risk connected with the work performed and about the rules defining scope of protection against the threats (Art. 226),
- use the means preventing the occupational diseases and other illnesses connected with the work performed and conduct the research and measurements of the health threatening factors (Art. 227),
- analyse systematically reasons of the accidents at work, occupational diseases and others connected with environmental conditions of workplace and application, on their basis, the proper preventing means (Art. 236).

Requirements of the Regulation of the Minister of Labour and Social Policy on the general regulation towards the occupational health and safety include [20]:

- assessment and documentation of the occupational risk and usage of indispensable preventive measures reducing the risk,
- assurance of the workplaces securing against the threats connected with accidents at work and influences of factors harmful to health,
- liquidation of the threats to health and life by the usage of the technologies, equipment, materials and substances that don't cause such threats,
- usage of the organisational and technical solutions, also collective protection measures limiting the influence of those threats on health and life, if the liquidation of them is not possible,
- making use of individual protection measures, if the usage of organisational and technical solutions is not possible.

The voluntary tool improving the occupational risk minimisation is the PN-N-18001 standard – Occupational health and safety management systems, Requirements – providing formal grounds for the necessity of the occupational risk assessment [13].

So, every employer is obliged to the regular estimation of the occupational health and safety environment, taking into account first of all the realised processes, methods of registration of incompatibilities as well as undertaking the preventive and corrective actions as the aim of continuous improvement of processes [13,18-20].

4.2. Occupational risk assessment

According to the requirements of the PN-N-18000 series standard, policy of organisation connected with the occupational health and safety should include the declaration of preventing the accidents and diseases at work. Its realisation is possible by the thorough occupational risk assessment. The results of the assessment should be the ground to determine the aims of organisation in the range of the occupational safety and plan the realisation of those aims. Usage of results of the occupational health and safety assessment should lead to continuous improvement of processes and the same – to the continuous improvement of workplace conditions [3,12].

The assessment covers all of the workplaces, both stationary and non-stationary and it should be carried out by the team, which has been called into being by the top management [3,12,15,21].

The occupational risk assessment should be always carried out after [3,12,15]:

- creation of the new workplace,
- implementation of the organisational and technical changes at the workplace,

- implementation of the new requirements connected with the workplace,
- usage of the new protection measures.

Occupational risk assessment is a multi-stage process, but the most important areas are: the occupational risk analysis and the proper assessment completed by the decision if the risk estimated is permissible [3,12,15].

First stage of the assessment is collecting the information necessary to conduct the occupational risk assessment; the information needed on that stage are [3,12,15]:

- location of the workplace, the realised duties and technological operations,
- means of the work,
- manner of the performed job,
- legal requirements and other standards connected with the workplace,
- threats that have been identified at that workplace, their causes and results,
- accidents at work, occupational diseases,
- preventive measures that are used.

Second step in the occupational risk assessment is an identification of the threats, which means – identification of the existing and the previous possible risky situations [3,12,15].

The next step is the real occupational risk assessment involving mainly setting the probability of the threats occurrence (low probability, medium probability, high probability) and the severity of the results (low severity, medium severity, high severity) [3,12,15].

After the occupational risk assessment the next stage is determination of its acceptability. The main criterions of the occupational risk acceptability are legal requirements and other standard documents [3,12,15].

Occupational risk can be found as an acceptable if, in the result of estimation, one can state, that legal and other adequate requirements are fulfilled and the principles of risk minimisation are properly used [3,12,15].

The most popular methods of the occupational threats identification and occupational risk assessment are [3,12,15]:

- Checklist Analysis,
- „What if" Analysis,
- Fault Tree Analysis – FTA,
- Intermediate Events Tree Analysis – ETA,
- Preliminary Hazard Analysis – PHA,
- Hazard and Operability Studies – HAZOP,
- Risk Score,
- Failure Mode and Effects Analysis – FMEA.

5. Own research

The analyses have been led to improve the chosen process of heat treatment based on the occupational health and safety criterion with the usage of PN-N-18002 standard (Occupational health and safety management system. General principles to the occupational risk assessment) and Intermediate Events Tree Analysis [8,9,12,15].

5.1. Methodology

Methodology used for the analysis has included:

1. collection of the information necessary for the risk assessment – technological procedures, manuals, documentation of occupational accidents and diseases, observations, literature,
2. identification of the occupational threats and their results – checklist analysis,
3. occupational risk assessment – standard method taking into account probability of the threat occurrence that has been determined as (Table 1):
   - low probable (that shouldn't occur during the all time of the occupational activity of the worker),
   - probable (can occur no more than several times),
   - highly probable (can occur a lot of times),
   - severity of the results that has been defined as:
   - low severity (injuries and diseases that don't cause long-lasting troubles and absence at work),
   - medium severity (injuries and diseases that cause minimal, but returning troubles and are connected with short-time absence at work),
   - high severity (injuries and diseases that cause serious and long-lasting troubles and/or death),

Table 1.
General principles of the occupational risk assessment

probability of occurrence	severity of the results		
	low	medium	high
low probable	low (1)	low (1)	medium (2)
probable	low (1)	medium (2)	high (3)
highly probable	medium (2)	high (3)	high (3)

4. determination of the risk acceptability – requirements of the standard (Table 2),

Table 2.
General principles of the occupational risk acceptability determination

risk assessment	risk acceptability	necessary actions
high	unacceptable	immediate action to minimise the risk by usage of the individual protection means
medium	acceptable	planning and undertaking the actions to minimise the risk
low	acceptable	assurance that the risk assessed will be not higher than on the actual level

5. preparation of the intermediate events tree – identification of the initiating event and the chain of the intermediate events leading to the injure and assessment of its probability; during calculation of the probabilities of intermediate events one has taken into account that the sum of probabilities of the occurrence of events in one "node" is always one, it means: PN +(1-PN) = 1;
   - probability of the initiating event has been defined for all the time of the occupational activity of worker on the base of the frequency of its occurrence in the time of 14 days,
   - probability of the ending events has been defined as a product of the probabilities of intermediate events, using the formula:

     $PW1 = P1 \cdot P2 \cdot P3 \cdot P4 \cdot P5 \cdot W1P6$ (4)

     $PW1 = P1 \cdot P2 \cdot P3 \cdot P4 \cdot P5 \cdot W2P6$ (5)

     $PW1 = P1 \cdot P2 \cdot P3 \cdot P4 \cdot P5 \cdot W3P6$ (6)

     $PW1 = P1 \cdot P2 \cdot P3 \cdot P4 \cdot P5 \cdot W4P6$ (7)

     $PW1 = P1 \cdot P2 \cdot P3 \cdot P4 \cdot P5 \cdot W5P6$ (8)

   where PW1 - probability of occurrence of the injury defined as W1.

   One has also assumed that sum of the probabilities of occurrence of all kind of injuries amounts to 1, according to the formula: W1P6 + W2P6 + W3P6 + W4P6 + W5P6 = 1.

   Stage three has been reflected by the graphical "events tree".

   On the basis of "events tree" one has chosen the worst possible injure for the analysed threat and defined the probability of occurrence of that injury. As a limit of the neglectable risk, according to the "alarp" principle, one has accepted the probability of occurrence of injury causing death on the level of $2.55 \cdot 10^{-5}$.

   Quality assessment of the foreseen injury has been done on the basis of the classification included in Table 3.

   Quality assessment of the probability of occurrence of injury during all the time of the occupational activity of the worker has been done on the basis of Table 4.
6. determination of the risk acceptability – requirements of the standard method.

The operations of the heat treatment at the analysed workplace has included:

- operations realised in the universal chamber furnace RTPFQ11EM type (Fig. 2),
- operations realised in the chamber furnace DLR type (Fig. 3).

Table 3.
Classification of the kinds of injuries of worker's health

kind of threat	symbol	description of the injury	quality assessment of the injury according to the PN-N-18002 standard
threats of the occupational accidents	W1	inability to work till 28 days	low harmfulness
	W2	inability to work over 29 days without disability	medium harmfulness
	W3	accident causing disability	high harmfulness
	W4	accident causing death	
	W5	accident causing death of more than 1 person	
threats of the occupational diseases	W6	occupational disease without disability	medium harmfulness
	W7	occupational disease causing disability	high harmfulness

Table 4.
Interpretation of probability of occurrence of injury during the occupational activity of worker

probability of occurrence during 25 years	probability of occurrence during the occupational activity of worker	quality assessment of probability of occurrence according to the PN-N-18002 standard
under 0.0000255	neglectable risk	
0.0000255 – 0.025	it shouldn't occur	low probable
0.0251 – 0.999	several times	probable
over 0.999	many times	highly probable

Fig. 2. Picture of the workplace covering the universal chamber furnace RTPFQ11EM type

Fig. 3. Picture of the workplace covering the universal chamber furnace DLR type

Table 5.
Part of the checklist to identify the occupational threats and their results

	questions/problems	yes	no
	occupational health and safety trainings, qualifications, medical check-ups		
1.	Did the workers take part in up-dated courses connected with the occupational health and safety required at the particular workplace?	X	
2.	Do the workers employed on the workplace have current medical preventive check-ups?	X	
3.	Do the workers employed on the workplace possess qualifications required to perform the particular work?	X	
	preventive measures		
1.	Did the employer provide the workers with the preventive clothing?	X	
2.	Are there markings ordering the usage of individual preventive measures on the workplace?		X
3.	Do the workers use individual preventive measures at the workplace?	X	
4.	Is there necessary extinguishing equipment near the workplace?	X	
5.	Is there necessary first-aid kit properly equipped?		X
	vent, heating, lighting		
1.	Is there effective ventilation assured at the workplace?	X	
2.	Is there proper temperature assured – adequate to the kind of work and preventive clothing on the workplace?	X	
3.	Is there natural lighting on the workplace?	X	
4.	Is there artificial lighting on the workplace?	X	

Table 6.
Specification of the chosen identified threats, their causes and results for heath and safety of the workers

identified threat	source of threat	possible effects of threat
fall during motion on the footways, stumble, slip on the surface	haste during work performance, complicated system of ways in the area of furnaces DLR and RTPFQ11EM type	contusion, fracture
stroke or crush by mechanically or manually transported materials	bad cooperation with the operator, incomprehensible and contradictory orders given to the operator during transportation process	contusion, crushing, fracture, death
stroke or crush by falling materials	loss of balance of the stored materials, overloading of the stored materials, badly prepared ground, fall of the wrongly stored or wrongly put aside tools	contusion, fracture, serious injuries, death

5.2. Practical analysis

Collection of the information necessary for the risk assessment

Workplace description. The workplace is equipped with the chamber furnaces to heat treatment as well as with other equipment appropriate to transport of the materials. The production room is very well lighted by the natural and artificial light. It is also equipped with ventilation and central heating.

Range of duties realised on the workplace. The main activities undertaken by the worker are: realising the processes according to the technological card, supervision over the technological processes, service of the used equipment, proper transport of materials.

Protective measures. The worker, after workplace instruction in the range of occupational health and safety, is equipped with the individual protective measures (e.g. glasses, half-mask, gloves, protective clothing).

Identification of the occupational threats and their results

Checklist to identify the occupational threats and their results has been show in Table 5.

Identified threats, their causes and results for heath and safety of the workers have been show in Table 6.

Occupational risk assessment and determination of the risk acceptability

The results of the occupational risk assessment and determination of the risk acceptability has been presented in Tables 6 and 7.

Table 7.
Record of the chosen occupational risk estimation results done at the analysed workplace; s - severity of the results of threats, p - probability of the threats occurrence, r - risk level (l - low, m - medium, h - high/highly)

identified threat	source of threat	possible effects of threat	s	p	r	corrective and preventive actions lowering the risk level
stroke or crush by falling materials	loss of balance of the stored materials, overloading of the stored materials, badly prepared ground, fall of the wrongly stored or wrongly put aside tools	contusion, fracture, serious injuries, death	hs	lp	m	safekeeping of the products, semi-finished products, materials, tools, during their storage time, in stable way and accordingly with the law regulations; preventing from an uncontrolled displacement, in the place designed for that purpose, safety hard hat usage
hot working conditions	not using or lack of the proper protective clothing eliminating the effect of working in a high temperature.	faints lost of consciousness, overheating of the body	ls	mp	l	usage of the proper protective clothing – heat-proof working clothes, which at the same time should be respiring ones
contact with extremely high temperature objects	contact with the equipment and materials having high temperature due to the technological processes	death due to first, second and third degree of the skin burns, skin burn due to the contact with the burnt clothing, temporary or permanent eyesight injury	hs	mp	h	heat-proof working clothes for the workers, anti infrared-radiation covers and glasses, life-saving equipment (showers) and fire equipment at the work stand, systematic eyesight check-up of the workers

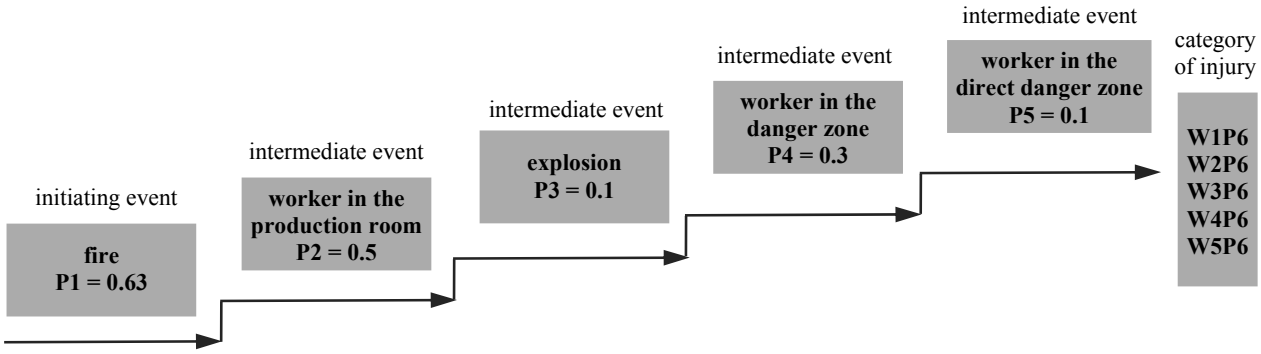

Fig. 4. Chosen part of the intermediate events tree for the fire threat

Preparation of the intermediate events tree

The chosen part of the intermediate events tree for the chosen threat has been shown on Fig. 4.

Category of the injury has been estimated as: W1P6 = 0.4 (PW1 = $37.80 \cdot 10^{-5}$), W2P6 = 0.3; (PW2 = $28.35 \cdot 10^{-5}$),W3P6 = 0.2; (PW3 = $18.90 \cdot 10^{-5}$), W4P6 = 0.1; (PW4 = $9.45 \cdot 10^{-5}$), W5P6 = 0; (PW5 = $0.00 \cdot 10^{-5}$).

Improving actions

In the range of usage of preventive means workers should:

- use the individual protective means properly to the kind of the threats,
- use the safety methods,
- obey the recommendations included in the equipment manuals,
- use the principles of the occupational health and safety,
- keep the proper attention during the activities,
- react properly to the sound signalling used in the organisation.

6. Conclusions

Solid ground for the improvement of every productive organisation is today processes' improvement, also technological, not only in the aspect of products' quality criterion, but first of all taking into account their influence on workers, so – in the scope of the occupational health and safety.

Starting point for the processes' improvement is the choice of proper tools for their assessment allowing for the definition of the actions orientated towards the principle "why do we assess – what for do we assess – how do we assess". In the area of the occupational health and safety the most complex and effective improvement tool seems to be the combination of the occupational risk assessment based on the PN-N-18002 standard and the intermediate events tree analysis. It enables to assess – precisely and effective – first of all in the event of the occupational risk assessed as higher then small one.

In the analysed processes of heat treatment risk for the life and health of workers were connected mostly with the occurrence of the mechanical factors. Their existence has been accompanied by the threats, for which the occupational risk was assessed as a medium with the recommendation for an acceptance. The other threats were assessed as small ones, and simultaneously also as acceptable.

The proposed improvement actions in the analysed processes were: taking proper care of the condition of individual protective measures and the technical condition of the used machines and other equipment, enforcing by the superiors the implementation of the individual protective measures as well as complying with equipment manuals, usage of the safety work methods.

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