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Risk Management in Industrial Companies

Ewa Kubińska-Jabcoń
AGH University of Science and Technology, Poland

Nowadays, in the rapidly changing world, a company's business operations require efficiency and decisiveness. However, every form of operations is connected with certain risk, a phenomenon that is common in everyone's everyday life, as well as in every business activity. That is why it is so important to apply appropriate management methods to calculate potential profits and losses. The article presents an overview of risk management methods for the needs of large industrial companies. The overview was based on the example of a steel mill.

Keywords: risk, risk management, risk control methods.

1. INTRODUCTION

Risk is a common phenomenon and covers all spheres of human life. Running any type of business activity also involves regular risk-taking. The phenomenon of risk is often associated with its negative form and is sometimes perceived as a threat. However, it also has a second aspect as conscious risk-taking can bring positive results. Every company's main goal is to increase its value for owners. High risk can effectively hinder the fulfilment of this goal. Risk management is therefore an element that is a very important part of global management of the entire company. The development of risk management methods is associated with newer and newer risk types. Thanks to skilful operation in this sphere, the company can avoid a situation when the set goals are not met, and even achieve a better result than the expected one.

In large industrial companies such as a steel mill, there are many types of risks. The presented risk analysis methods allowed the author to identify the major threats related to the analysed risk type, as well as the most effective methods of counteracting them to enable an appropriate risk management process. This also allowed for determining the level of risk in individual areas of the company's activity and for choosing the most optimal options to counteract the effects of risk occurrence.

2. TYPES OF RISK OCCURRING IN AN INDUSTRIAL COMPANY

Figure 1 shows a scheme of the main types of risk in a metallurgical company due to the criterion of their causes. It takes into account the typical types of risks found in specialist literature, as well as new, specific types of metallurgy-related threats.

The risk management methods presented in this paper will concern technical and technological risk but they can be used to test each risk type.

The technical and technological risk depends on the degree of modernity of machines, their reliability, excellence of design solutions, quality of materials used for their production, etc. It concerns the risk of failures of equipment and technological processes. It may cause financial losses resulting from contractual penalties for failing to meet the delivery date of a given product, and it can also be the cause of accidents. Anti-risk activities are undertaken by maintenance services in the scope of current inspections and preventive activities on the equipment, as well as by the steel mill management who prepare plans to protect the plant against effects of failures. Production lines operating in old-technology steel mills are excessively developed into various technological devices due to the large number of operations made. This prolongs the production cycle, which, in turn, increases the possibility of equipment damage and results in the production process being interrupted, thus the costs are increased. The solution lies in integrated steel product manufacture technologies in which subsequent technological operations are carried out directly one after another, without additional auxiliary operations of securing for the period of transport and storage, intermediate storage operations and further preparation for the next operation.

Products made using integrated technologies are definitely cheaper, their execution time is shorter, and the quality is good and repeatable for all products. Steel mills can also buy cheaper machines and equipment with unproven technological solutions for which they get a price discount, because it is a prototype. These machines and equipment can often break down, have a poor technological solution, which leads to higher costs of service and spare parts [1, 2].

3. USING THE MATRIX METHOD

The identification of risk areas is the first stage of the described method. The required data includes the most important types of risk and information on how a given company is prepared for the occurrence of this risk, as well as a list of reaction options to the anticipated or emerging risks based on which it will be possible to assess the effectiveness of anti-risk activities in a given company. For this purpose, a chart of analysis of threats and opportunities concerning the analysed risk type should be prepared (Table 1, 2) [3]. For

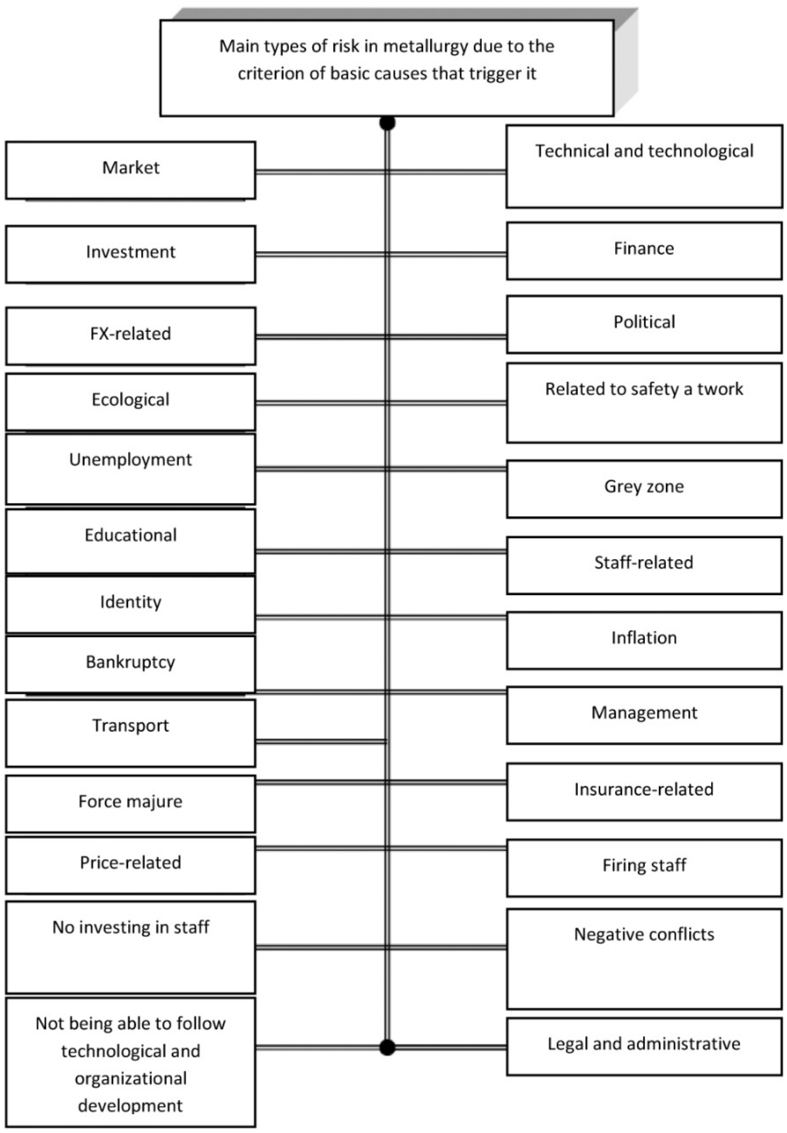

Fig. 1. Types of risk in metallurgy due to the criterion of causes - author's study.

example, Table 1 shows only five threats to show the methodology, but in practice there are many more. A three-degree scale was adopted: m - little probability, s - medium probability, d - large probability, M - little chance/small risk, S - medium chance/medium risk, D - large chance/large risk.

of tested equipment and technology only, accurate investment analysis (dD).

The next step involves risk assessment, i.e. numerical expression of the extent of threats or opportunities associated with a given risk to make an assessment. To this end, a matrix is used to strengthen the reaction between the probability of

Table 1. Analysis of threats related to technical and technological risk.

THREATS	PROBABILITY OF OCCURENCE	SEVERITY OF EFFECTS
1. Incompetent and unreliable service companies	**d**	**S**
2. Failures of machines and equipment causing long downtime	**d**	**D**
3. Old machines and equipment resulting in lower production efficiency	**d**	**D**
4. Poor quality of materials used for machines and equipment	**m**	**S**
5. Imperfection of construction solutions of machines and equipment	**m**	**S**

Source: author's study based on example [3].

Table 2. Analysis of chances related to technical and technological risk.

CHANCES	PROBABILITY OF OCCURENCE	FAVOURABLENESS OF EFFECTS
1. Selection of well-known, proven and reputable service companies	**d**	**D**
2. Inspections of machines and equipment, supervision over their proper use, insuring them, installation of control and measurement equipment to get information on leaks, gas leakage, limitation of their failures	**d**	**D**
3. Purchase of modern technology with better reliability parameters, modernization of existing technological lines, training in technological novelties	**m**	**D**
4. Purchase of equipment only from reputable companies after a careful control, purchase of tested equipment and technology only	**d**	**D**
5. Modernization or improvement of structural solutions, thorough analysis of defects of a given solution, selection of good and well-known delivery companies	**s**	**D**

Source: author's study based on example [3].

The major threats that should be addressed in the first place include the failures of machines and devices causing long downtime, their old age resulting in lower production efficiency (dD). The greatest possibilities of counteracting negative effects of threats related to technical and technological risk, in turn, are regular inspections of machines and equipment by well-known, tested and reputable service companies; supervision over proper use; insuring the machines and equipment; installation of control and measurement equipment to obtain information on leaks, gas leakage, purchase of equipment only from companies with good reputation after a thorough control, purchase

occurrence and severity or favourableness of effects in relation to the number of indications for particular relationships, using the data from tables 1 and 2. Counted, identical relations have been entered into the relevant fields of the matrix (Table 3) [3].

Then, groups of factors were distinguished: A, B, C. GR. A are events that occur between: dD, dS, sD. GR. B are events that occur between: mD, sS, dM. In turn, GR. C are events that occur between: mS, mM, sM. Then, a quantitative and qualitative comparison was made in each group to compare chances and risks.

Table 3. Matrix of relations: opportunities - probability - severity/favourableness concerning technical and technological risk.

		SEVERITY			FAVOURABLENESS		
		D	S	M	D	S	M
PROBABILITY	d	3	0	0	3	0	0
	s	0	0	0	1	0	0
	m	0	2	0	1	0	0

The quantitative analysis (Table 4) involves summing up individual events taking place in groups. For severity: $S_{DA} = dD + dS + sD = 2 + 1 + 0 = 3$, $S_{DB} = mD + sS + dM = 0 + 0 + 0 = 0$, $S_{DC} = mS + mM + sM = 2 + 0 + 0 = 2$, $S_Z = S_{DA} + S_{DB} + S_{DC} = 3 + 0 + 2 = 5$. For favourableness: $S_{KA} = dD + dS + sD = 3 + 1+ 0 = 4$, $S_{KB} = mD + sS + dM = 1 + 0 + 0 = 1$, $S_{KC} = mS + mM + sM = 0 + 0 + 0 = 0$, $S_S = S_{KA} + S_{KB} + S_{KC} = 4 + 1 + 0 = 5$.

Table 4. Quantitative analysis of severity/favourableness indicators concerning technical and technological risk.

	For severity:	For favourableness:
Gr. A	$K = \frac{S_{DA}}{S_Z} = \frac{3}{5} = 0{,}6$	$K = \frac{S_{KA}}{S_S} = \frac{4}{5} = 0{,}8$
Gr. B	$K = \frac{S_{DB}}{S_Z} = \frac{0}{5} = 0$	$K = \frac{S_{KB}}{S_S} = \frac{1}{5} = 0{,}2$
Gr. C	$K = \frac{S_{DC}}{S_Z} = \frac{2}{5} = 0{,}4$	$K = \frac{S_{KC}}{S_S} = \frac{0}{5} = 0$

Table 5. A summary of the quantitative and qualitative assessment of chances and risks.

	Favourableness		Severity	
	Quantity	Quality	Quantity	Quality
Gr. A	4	0.8	3	0.6
Gr. B	1	0.2	0	0
Gr. C	0	0	2	0.4

As shown in Table 5, for favourableness, the group of factors A which have the greatest meaning for the correct operation of the steel mill related to technical and technological risks has the value of 08; and for severity, where group A causes the most adverse effects associated with this risk has the value of 0.6. This means that actions to limit these risks can be undertaken because they are profitable.

4. THE USE OF THE MATRIX METHOD BASED ON ASSIGNING IMPORTANCE OR EFFECT VALUES TO RISK AREAS AND COUNTERACTING POSSIBILITIES

In the first stage, the most important areas of risks and counteracting possibilities are identified. The area of risks is the area of problems that afflict the company on a regular basis and are sufficient to absorb attention and energy. The area of possibilities is an area in which an enterprise recognizes a permanent presence of positive and beneficial factors. The next step is to assign importance or values of effects to areas of risks and counteracting possibilities. The areas of the major risks and the areas most promising to the steel mill's operations assume the highest values on the adopted scale. A five-point scale for the area of risks was adopted: 1-2: area of low importance, 3: moderately important area, 4-5: very important area. The adopted five-point scale for the area of counteracting possibilities: 1-2: factor which is not very helpful, 3: moderately helpful factor, 4-5: very helpful factor (Table 6, 7) [4].

Table 6. Areas of technical and technological risk and the assigned importance of effects.

RISK AREAS	IMPORTANCE OF FACTOR
1. Incompetent and unreliable service companies	3
2. Failures of machines and equipment causing long downtime	4
3. Old machines and equipment resulting in lower production efficiency	5
4. Poor quality of materials used for machines and equipment	3
5. Imperfection of construction solutions of machines and equipment	3

Source: author's study.

Explanation of the awarded score:

Ad. 1. This area is of average importance because service companies that perform their services poorly or in an untimely manner prolong the downtime of machines and equipment, enforce the need for lodging complaints, thus generating additional time and financial losses, but using the services of proven companies can minimize this problem.

Ad. 2. This area is very important because due to machine and equipment failures that cause long downtime, the entire production is halted, and consequently, financial losses increase. This problem can be minimized by regular inspection or assembly of measuring and control equipment.

Ad. 3. This area is very important because the old age of both machines and equipment reduces the efficiency of production, i.e. the steel mill offers fewer products for sale and this is associated with its lower revenues.

Ad. 4. This area is of average importance because the inferior quality of materials used for making machines and equipment may result in inferior quality of production, more frequent failures, accidents, but this risk can be minimized by using proven suppliers as well as tested equipment.

Ad. 5. This area is of average importance because the imperfection of design solutions may result in inferior quality production, more frequent failures, accidents, but this risk can be minimized by using proven suppliers as well as tested equipment.

Table 7. Areas of technical and technological risk possibilities and the assigned importance of effects.

AREA OF POSSIBILITIES	IMPORTANCE OF FACTOR
1. Selection of well-known, proven and reputable service companies	5
2. Inspections of machines and equipment, supervision over their proper use, insuring them, installation of control and measurement equipment to get information on leaks, gas leakage, limitation of their failures	4
3. Purchase of modern technology with better reliability parameters, modernization of existing technological lines, training in technological novelties	4
4. Purchase of equipment only from reputable companies after a careful control, purchase of tested equipment and technology only	5
5. Modernization or improvement of structural solutions, thorough analysis of defects of a given solution, selection of good and well-known delivery companies	5

Source: author's study

Explanation of the awarded score:

Ad.1. This area is very helpful because the selection of well-known, tested and reputable service companies will help avoid incompetence and possible repairs, which is associated with financial and time losses.

Ad.2. This area is very helpful because the control and measuring equipment informs us about an upcoming failure; inspections of machines and equipment will reduce the risk of failure but they will not completely eliminate it, while insurance of machinery and equipment allows for avoiding financial losses.

Ad.3. This area is very helpful because the purchase of modern technology with better reliability parameters or the modernization of existing technological lines will allow for reducing this problem significantly, but will entail significant costs.

Ad.4. This area is very helpful because the purchase of equipment only from reputable companies, and after a thorough control, will enable purchasing machinery and equipment with high quality and reliability.

Ad.5. This area is very helpful because the modernization or improvement of structural solutions, a thorough analysis of disadvantages of a given solution, and selection of good and well-known companies cooperating with the steel mill result in reliability of structural solutions.

The next step is to determine the probability scale (table 8.). The adopted risk model assesses the probability of how often a given situation occurs so that the area of risks or opportunities becomes relevant to the company's operations. A three-degree scale was adopted: 1 - low probability, 2 - average, 3 - high [4].

The final stage is to determine the range of numerical results. In order to establish the lowest possible score for each area of risk and counteracting possibilities, each effect value must be multiplied by the lowest probability value. Then, to obtain the lowest possible combined scores of risk and counteracting possibilities for a given risk, all obtained results need to be added. In order to determine the highest possible result for each area of risk and counteracting possibilities, in turn, each effect value should be multiplied by the highest probability value, and similarly, to obtain the highest possible combined results of risks and counteracting possibilities, all obtained results should be summed up. In the final stage, all these operations should be repeated for the results obtained to compare whether risk and possibilities are close to the minimum or maximum limit and whether the sum of counteracting possibilities exceeds the sum of risks (table 9) [4].

Table 8. Determining the scale of probability for technical and technological risks and the associated possibilities.

	PROBABILITY					
CRITERION	LOW		AVERAGE		HIGH	
AREA	RISK	POSSIBILITIES	RISK	POSSIBILITIES	RISK	POSSIBILITIES
1					X	**X**
2					X	**X**
3		**X**			X	
4	**X**					**X**
5	X			**X**		

The areas from 1-5 for risk and possibilities, respectively, source: author's study.

Table 9. Ranges of numerical results for technical and technological risks and the associated possibilities.

Item	AREA OF RISK	AREA OF POSSIBILITIES	OBTAINED RESULTS	
			RISK	POSSIBILITIES
1.	Importance of effects: 3 The lowest result: 1 The highest result: 3 Minimum risk: 3*1=3 Maximum risk: 3*3=9	Importance of effects: 5 The lowest result: 1 The highest result: 3 Minimum possibilities: 5*1=5 Maximum possibilities: 5*3=15	**3*3=9**	**5*3=15**
2.	Importance of effects: 4 The lowest result: 1 The highest result: 3 Minimum risk: 4*1=4 Maximum risk: 4*3=12	Importance of effects: 4 The lowest result: 1 The highest result: 3 Minimum possibilities: 4*1=4 Maximum possibilities: 4*3=12	**4*3=12**	**4*3=12**
3.	Importance of effects: 5 The lowest result: 1 The highest result: 3 Minimum risk: 5*1=5 Maximum risk: 5*3=15	Importance of effects: 4 The lowest result: 1 The highest result: 3 Minimum possibilities: 4*1=4 Maximum possibilities: 4*3=12	**5*3=15**	**4*1=4**
4.	Importance of effects: 3 The lowest result: 1 The highest result: 3 Minimum risk: 3*1=3 Maximum risk: 3*3=9	Importance of effects: 5 The lowest result: 1 The highest result: 3 Minimum possibilities: 5*1=5 Maximum possibilities: 5*3=15	**3*1=3**	**5*3=15**
5.	Importance of effects: 3 The lowest result: 1 The highest result: 3 Minimum risk: 3*1=3 Maximum risk: 3*3=9	Importance of effects: 5 The lowest result: 1 The highest result: 3 Minimum possibilities: 5*1=5 Maximum possibilities: 5*3=15	**3*1=3**	**5*2=10**
Sum:	Min. 18 Max. 49	Min. 23 Max. 69	**41**	**56**

As can be seen in Table 9, the minimum risk value is 18 and the maximum risk is 49. The result obtained from the research is 41, which means that threats associated with this risk should be taken into account. As for the possibilities, the minimum score is 23 and the maximum is 69. The result obtained in the research is 56, which means that this risk can be counteracted, because this action is profitable as the risk value is lower than the value of possibilities.

5. USING THE MODIFIED FMEA METHOD

FMEA method – the analysis of causes and effects, a method that companies use to prevent and mitigate the effects of defects that may occur in construction and manufacturing processes. Its purpose is to identify and assess the risk associated with weak points that occur during production planning and the manufacturing process, which significantly reduces this risk. The risk priority number - *RPN* - is a product of integral numbers from the range (1-10) that describe the frequency of a defect (risk of defect - 1 - low probability, 10 - high probability) - number (R), meaning of defect - how significant a defect will be for the client - 1 – negligible importance, 10 - significant - number (Z), detection level - describes the probability that a defect will not be detected by the manufacturer and will go to the client - 1 - easy to detect, 10 - hard to detect - number (W). The values that RPN can take are in the range from 1 up to 1000. The higher the RPN value, the greater the risk associated with a defect [5, 6]. The assessment indicator in the FMEA method - the number of priority risk is:

RPN=P*Z*T , where **P -** probability of error/defect, **Z -** meaning for the client, **T -** ease of detection (table 10).

For the needs of the risk assessment research, a modification was proposed consisting in adjusting the RPN indicator and the following designations were adopted:

$$C_R = P_R * H * T_R$$
$$C_M = P_M * H * T_M$$

where:
C_R - risk assessment indicator
C_M - possibility assessment indicator
P_R - probability of occurrence of a given risk
P_M - probability of occurrence of a given possibility
H - significance for the correct operation of the steel mill
T_R - difficulties in counteracting the risk
T_M - ease of applying given possibilities

Numbers C_R and C_M are integral numbers from the range (1.1000). If the number is significantly greater than one, preventive measures should be taken (in case of risk); or a given threat can be easily counteracted (if possible). To be able to effectively counteract the risks and to make these activities profitable, $\Sigma C_M < \Sigma C_R$. In accordance with the scale adopted below, particular types of threats related to a given risk were considered (tables 11, 12).

Table 10. Assigned scale for P, Z, T indicators based on [5,6].

P		Z		T	
Low chance of occurrence	1	No meaning	1	Very easy to detect	1
Highly unlikely to detect	2-3	Little meaning	2-3	Easy to detect	2-3
Unlikely to detect	4-6	Average meaning	4-6	Detectable	4-6
Moderately likely	7-8	Considerable meaning	7-8	Very hard to detect	7-8
Very likely	9-10	Very considerable meaning	9-10	Undetectable	9-10

Table 11. Threats related to technical and technological risk.

THREATS	P_R	H	T_R	C_R
1. Incompetent and unreliable service companies	8	4	3	96
2. Failures of machines and equipment causing long downtime	9	9	7	567
3. Old machines and equipment resulting in lower production efficiency	10	9	6	540
4. Poor quality of materials used for machines and equipment	3	4	5	60
5. Imperfection of construction solutions of machines and equipment	3	4	5	60

The sum of the CR indicator: 3263

Table 12. Possibilities related to technical and technological risk.

POSSIBILITIES	P_M	H	T_M	C_M
1. Selection of well-known, proven and reputable service companies	10	9	9	810
2. Inspections of machines and equipment, supervision over their proper use, insuring them, installation of control and measurement equipment to get information on leaks, gas leakage, limitation of their failures	9	10	6	540
3. Purchase of modern technology with better reliability parameters, modernization of existing technological lines, training in technological novelties	5	8	3	120
4. Purchase of equipment only from reputable companies after a careful control, purchase of tested equipment and technology only	10	9	9	810
5. Modernization or improvement of structural solutions, thorough analysis of defects of a given solution, selection of good and well-known delivery companies	8	9	6	432

The sum of the CM indicator: 4955

As it can be seen in Table 11, the greatest threat is posed by the failures of machines and devices that cause long downtime, old age of machines and equipment resulting in lower production efficiency. On the other hand, the greatest possibilities of counteracting are the selection of well-known, proven and reputable service companies and the purchase of equipment only from reputable companies after a thorough control, purchase of tested equipment and technology only.

After the analysis made using three methods, the threats that should be dealt with first are threats 2 and 3, because their indicators in all methods have reached the highest value. As far as counteracting possibilities are concerned, the possibilities 1 and 4 achieved the best indicators.

6. CONCLUSIONS

Risk is a common phenomenon that seriously threatens the proper functioning of companies. In every company there are many types of risk that affect its functioning in a different way. As the results of the research carried out using three methods show, threats associated with risk play a huge role in a company's proper functioning. The use of the three research methods allowed for identifying the most serious threats related to technical and technological risk and the most effective possibilities of counteracting. Based on the data obtained from the applied research methods, the so-called FTA method can be used at a later stage, and a fault tree being a graphical representation of certain conditions and other factors causing or contributing to the occurrence of a specific, undesirable event called the "peak event" can be designed to precisely find the reasons causing a given risk and distinguish basic events.

At the final stage, based on the obtained results, it is possible to create an algorithm that would monitor the analysed risk, which would aim to isolate the basic event responsible for the creation of technical and technological risk, using the FTA fault tree and the proposed solutions.

REFERENCES

[1] Nahotko S.: „Ryzyko ekonomiczne w działalności gospodarczej", Oficyna Wydawnicza Ośrodka Postępu Organizacyjnego, Bydgoszcz 2001.
[2] Kubiński W. et al: „Integracja procesów technologicznych w walcowni zimnej taśm", Hutnik – Wiadomości Hutnicze, 71, 2004, 12, p. 600.
[3] Buła P.: „Zarządzanie ryzykiem w jednostkach gospodarczych. Aspekt uniwersalny", Wydawnictwo AE, Kraków 2003
[4] Pritchard C.: „Zarządzanie ryzykiem w projektach", WIG-PRESS, Warszawa 2002.
[5] Hamrol A., Mantura W.: Zarządzanie jakością – teoria i praktyka", PWN 2002.
[6] Huber Z., Analiza FMEA procesu, Wydawnictwo Złote Myśli 2007.

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Ewa Kubińska-Jabcoń
AGH University of Science and Technology, Poland
ejabcon@gmail.com