ASSESSMENT OF SELECTED EQUIPMENT BY METHOD FTA

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Abstract

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The aim of my research was to qualitatively and quantitatively evaluate the potential risks on Extruder, detect the probability of occurrence and therefore take reformation measures for their elimination or minimization. Throughout the research, we focused on the process compounding and recycling of plastic waste, production stage of secondary processing with plastic waste. We have reviewed the extruder machine. First, we qualitative consider the device by constructing fault tree. First, we consider qualitative data of the device with constructing fault tree, Subsequently, we use quantitative analysis and we specify the probability of a negative phenomenon. The result is more accurate and objective determination of probability and risk itself. The result is more accurate and more objective determination of probability and the actual risk.

Keywords: qualitative analyse, quantitative analyse, fault tree, measures, extruder

INTRODUCTION

Risk management is the identification, assessment, and prioritization of risks (defined in ISO 31000 as *the effect of uncertainty on objectives*) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities. Risk management's objective is to assure uncertainty does not deflect the endeavour from the business goals [Hubbard, 2009; Korenko *et al.,* 2015, Bujna *et al.,* 2015].

Risk management is the process of identifying, assessing and controlling threats to an organization's capital and earnings. These threats, or risks, could stem from a wide variety of sources, including financial uncertainty, legal liabilities, strategic management errors, accidents and natural disasters. IT security threats and data-related risks, and the risk management strategies to alleviate them, have become a top priority for digitized companies. As a result, a risk management plan increasingly includes companies' processes for identifying and controlling threats to its digital assets, including proprietary corporate data, a customer's personally identifiable information and intellectual property [Antunes *et al.,* 2015; Korenko *et al.,* 2015; Prístavka *et al.* 2014,2015].

Elements of Fault Tree Analysis (FTA):
- FTA is a deductive analysis approach for resolving an undesired event into its causes.
- FTA is a backward looking analysis, looking backward at the causes of a given event.
- Specific stepwise logic is used in the process.
- Specific logic symbols are used to illustrate the event relationships.
- A logic diagram is constructed showing the event relationships [Virčíková, Šolc, 2012].

Why FTA is carried out:
- To exhaustively identify the causes of a failure.
- To identify weaknesses in a system.
- To assess a proposed design for its reliability or safety.
- To identify effects of human errors.
- To prioritize contributors to failure.
- To identify effective upgrades to a system.

- To quantify the failure probability and contributors.
- To optimize tests and maintenances (Bujna *et al.*, 2014; Vesely, 2002).
  Role of FTA in System Safety Analysis:
- FTA is used to resolve the causes of system failure.
- FTA is used to quantify system failure probability.
- FTA is used to evaluate potential upgrades to a system.
- FTA is used to optimize resources in assuring system safety.
- FTA is used to resolve causes of an incident (Vesely, 2002).

The method of FTA can build multiple methods. FMEA determine the causes and consequences of failures. We can determine the probability of statistical methods [Polák *et al.*, 2014]. Regular auditing review the effectiveness of the method [Bujna *et al.* 2013; Kaplík *et al.* 2013]. FTA is a living project that is constantly monitored and renewed [Žitňák *et al.*, 2014; Žitňák *et al.*, 2015, Kotus *et al.*, 2016; Jankajová *et al.*, 2016].

The aim of my research was to qualitatively and quantitatively evaluate the potential risks on Extruder, detect the probability of occurrence and therefore take reformation measures for their elimination or minimization.

MATERIALS AND METHODS

When is creating a fault tree is a priority to specify the risk, that is subject to examination. On the basis of the risk is determined the TOP event. For each TOP event must be based gates (Fig. 1), which correspond to situations which are attributable to the following events. Action continues to decay at the elementary (basic) event or events which are not relevant from a technological or safety risks. Thus created events, gates and roads form a sort of grid, chart, which we call the fault tree (Fig. 2)

Quantitative evaluation of the fault tree

After creating a qualitative analysis we can quantitatively evaluate the fault tree. It is necessary to know the number of adverse events and calculate probabilities for each gate individually. Gate "AND" the output occurs only if all inputs occur (inputs are independent). The resulting probability is a multiplication of these mutually independent events [Matúš, 2014].

Formula no. 1:

$$P \text{``}_{And}\text{''} = P(B_l) \cdot P(B_2) \cdot P(B_3) \cdot P(B_n) \tag{1}$$

Where:

P "$_{And}$" ... the probability of the event occurring at the output of the gate "And"
Bi .... the events entering into gates "And"
P(Bi) ..... the probability of the event occurring at the output of the gate "And"

The calculation of probabilities for gate "OR"

Hradlo "OR", the output occurs if any input occurs. This is a logical sum.

$$P \text{``}_{Or}\text{''} = 1 - (1 - P(C_1)) \cdot (1 - P(C_2)) \cdot (1 - P(C_3)) \cdots \cdot (1 - P(C_n))$$

Where:

P"$_{Or}$" ...... the probability of the event occurring at the output of the gate "Or"
C_i .... the events entering into gates "Or"
P(C_i) ...... the probability of the event occurring at the output of the gate "Or"

We evaluated the process of compounding and recycling of plastic waste, production stage of secondary processing of plastic waste. Specifically, the article is focused on the evaluation of technical causes of failure BOCOMATIC EB 80 extruder, which creates monochrome final mixture (Fig. 3).

Extruder BOCOMATIC EB 80

Parallel twin-rotating extruder is representative of high performance and capacity. The extruder is also
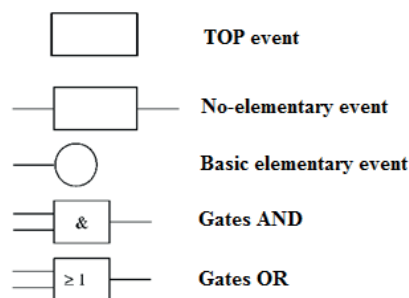
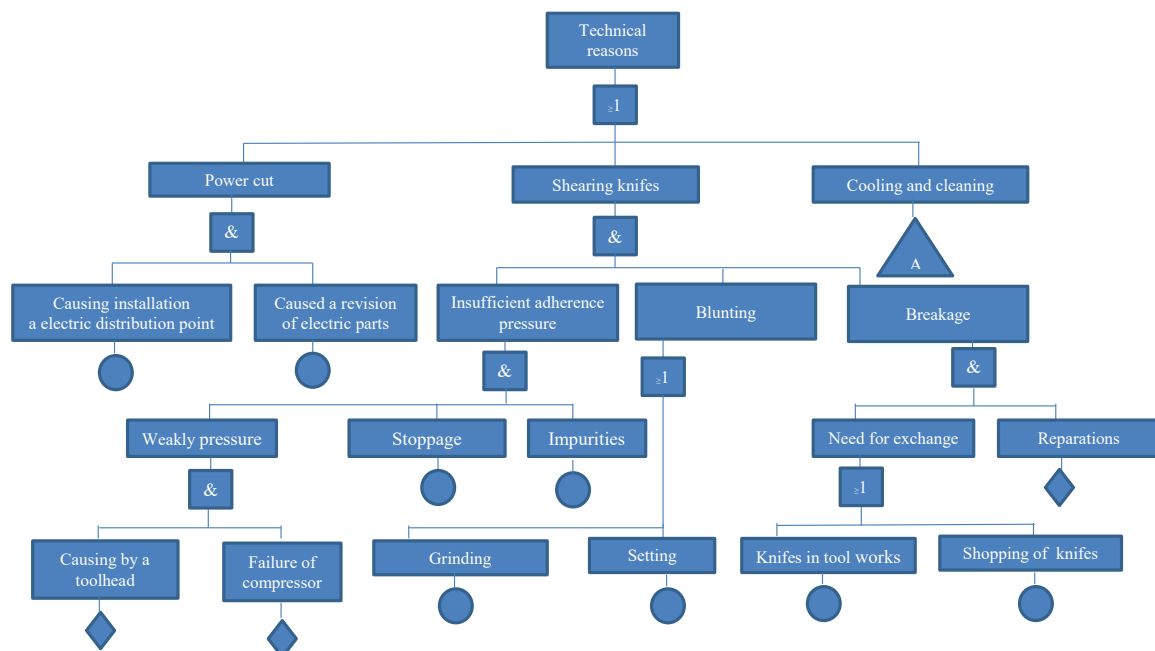1: *Basic graphical symbols for fault tree analysis*
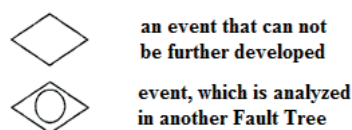
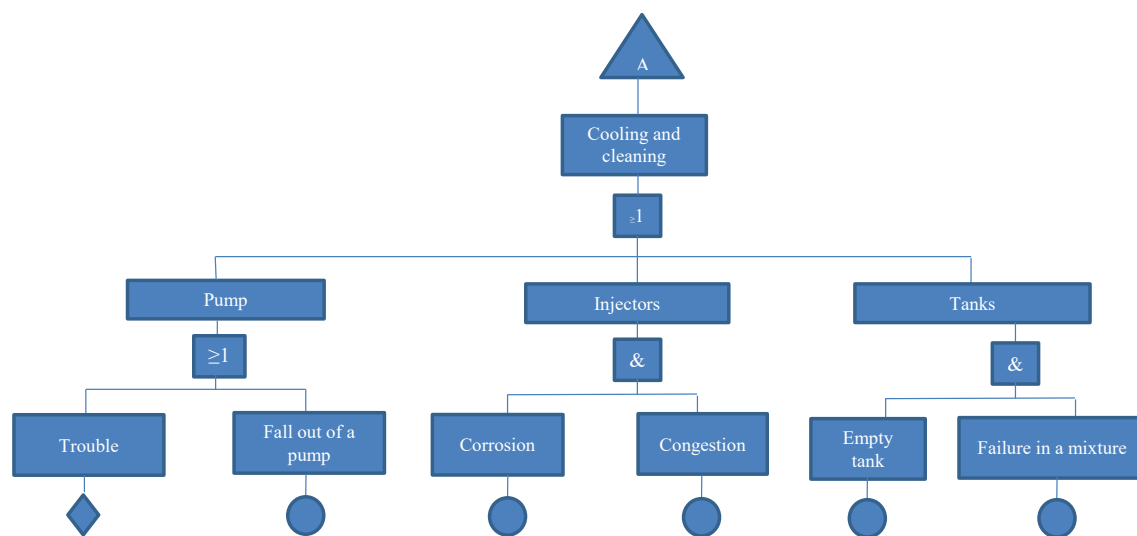2: *Basic graphical symbols for fault tree analysis*

3: *The extruded mixture*

4: *Twin-rotating extruder BOCOMATIC EB 80*

5: *Fault tree*

6: *Fault tree-continuation of Fig. 5*

a high-quality control system, by means of which the operator has a single whole. The individual parts are very flexible, making it possible to adapt to different material extruder and adjust to the desired power. Advantages of the extruder are especially high durability, high performance, minimal size, the versatility and high precision machining workshop.

Technical parameters:
Rotor diameter: 55 mm
Rotor speed: 30 rpm^{-1}
Motor power: 11 kW
Total installed power: 25 kW
Power: 70 kg.hod^{-1}
Size: 2260×1100 mm
Dimensions Height hopper: 2230 mm

RESULTS AND DISCUSSION

Figs. 5 and 6 show the fault trees. These provide a qualitative analysis of the selected TOP events to smaller levels of events that ultimately may cause TOP event. Tab. I and II provides quantitative analysis. It is determined the probability of the event, which was calculated according to the formulas in the methodology.

On the device, there are only two different types of faults. First, disturbances caused by human factors and on the other hand disturbances caused by the worsening technical condition of equipment, and reducing their technical lifetime.

Event OHS refers to halt production of the device, because the employee was forced to stop the machine in order to satisfy the requirements which are placed in the OSH policy. This mainly relates to non-use of PPE in the workplace. Often we can talk about the wrong set scroll speed, time of cooling and cleaning, cutting individual transaction. In this technical device it is mostly a programming operation, and conversely in a knife mill, wherein all the operations are carried out manually, there is a mechanical adjustment.

At extruder there were often found seated impurities, residues from previous work activity, which caused the deterioration of cutting properties of cutting knifes. When this type of knife is blunted then there was required to immediate reparation, because lack of cutting deteriorated the quality of the cut extrusion mixture. Reasons for the suspension of production, there were also a lack of basic maintenance of the machine.

To detect the weaknesses has been in organization applied method fault tree analysis (FTA). In organization has been applied method fault tree analysis for detected the weaknesses, as the graphics solution. Qualitative assessment is a graphic representation of fault trees. Quantitative and also qualitative assessments are based on mathematical and statistical operations to calculate the probability of each one of the resulting undesirable negative event.

Corrective measures taken at the production stage
- Every employee has to come to the workplace already properly prepared in accordance with the rules of occupational health and safety, in order to avoid unnecessary waiting for his treatment/adaptation.
- Every employee should be concentrated when he come to the workplace and also be in optimal mental and physical condition and properly motivated,
- Every employee has to come to the workplace without the use of addictive or psychotropic substances,
- Every employee is obliged to check the purity of their workplace before production,
- Every employee is obliged to check whether he has all the necessary tools in the workplace and also materials, which he will need in the fulfilment their functions,

I: *Quantitavie analyse FTA*

Technical reasons (formula 2)		
Name of event	**Number of discord**	**Probability**
Power cut	2	$P(C_1) = 0,036$
Shearing knifes	41	$P(C_2) = 0,745$
Cooling and cleaning	12	$P(C_3) = 0,218$
Totalling	55	$P \text{ "}_{or}\text{" } = 0,808$
Power cut (formula l)		
Name of event	**Number of discord**	**Probability**
Causing installation a electric distribution point	1	$P(B_1) = 0,500$
Caused a revision of electric parts	1	$P(B_2) = 0,500$
Totalling	2	$P \text{ "}_{AND}\text{" } = 0,250$
Shearing knifes (formula 2)		
Name of event	**Number of discord**	**Probability**
Insufficient adherence pressure	19	$P(C_1) = 0,463$
Blunting	19	$P(C_2) = 0,463$
Breakage	3	$P(C_3) = 0,073$
Totalling	41	$P \text{ "}_{or}\text{" } = 0,733$
Insufficient adherence pressure (formula l)		
Name of event	**Number of discord**	**Probability**
Weakly pressure	7	$P(B_1) = 0,368$
Stoppage	6	$P(B_2) = 0,316$
Impurities	6	$P(B_3) = 0,316$
Totalling	19	$P \text{ "}_{AND}\text{" } = 0,037$
Weakly pressure (formula l)		
Name of event	**Number of discord**	**Probability**
Causing by a toolhead	5	$P(B_1) = 0,714$
Failure of compressor	2	$P(B_2) = 0,286$
Totalling	7	$P \text{ "}_{AND}\text{" } = 0,204$
Blunting (formula l)		
Name of event	**Number of discord**	**Probability**
Grinding	7	$P(B_1) = 0,368$
Setting	12	$P(B_2) = 0,632$
Totalling	19	$P \text{ "}_{AND}\text{" } = 0,233$
Breakage (formula l)		
Name of event	**Number of discord**	**Probability**
Need for Exchange	2	$P(B_1) = 0,667$
Reparations	1	$P(B_2) = 0,333$
Totalling	3	$P \text{ "}_{AND}\text{" } = 0,222$

- Employees are obliged to check whether the technical condition of equipment in failure-free state is.
- If damaged, which caused the fault equipment extruder operator is immediately obliged to report this fact to the head of shift, who perform all the following steps for troubleshooting
- Operating staff of the extruder, in the case of technical downtime longer than 10 minutes, which need to set up the devices, extruder operator is obliged to inform the head of the shift, who perform all the following steps for troubleshooting

- Unless there is an unexpected technical effect, for example. retooling during operation, the employee have to accept all reasonable steps to eliminate this effect in order to allow the reproduction at 100% quality,
- Establishment of card production, where the employee will record data about the number of units produced, then information about the work performed, the technical inspection, the time of removal technical failures, etc., For the control of these cards is responsible head of production,

- Every employee gives machines in a quiet state after work hours
- Every employee performs a visual inspection of the technical condition of equipment, after work hours,
- Every employee leaves their workplace clean and ready for the next shift.
- Perform audits.

Control activities of compliance with the corrective action taken is given great importance, therefore this activity must take place continuously throughout the work shift. Head of shift is the main responsible for overseeing compliance with the rules, or it may be top of the organization. Internal audit should be conducted at least once every 3 months.

II: *Quantitavie analyse FTA – continuous of Tab. I*

Need for Exchange (formula 2)		
Name of event	**Number of discord**	**Probability**
Knifes in tool works	1	$P(C_1) = 0{,}500$
Shopping of knifes	1	$P(C_2) = 0{,}500$
Totalling	2	$P\,"_{OR}" = 0{,}750$

Cooling and cleaning (formula 2)		
Name of event	**Number of discord**	**Probability**
Pump	5	$P(C_1) = 0{,}417$
Injectors	3	$P(C_2) = 0{,}250$
Tanks	4	$P(C_3) = 0{,}333$
Totalling	12	$P\,"_{OR}" = 0{,}708$

Pump (formula 2)		
Name of event	**Number of discord**	**Probability**
Trouble	3	$P(C_1) = 0{,}600$
Fall out of a pump	2	$P(C_2) = 0{,}400$
Totalling	5	$P\,"_{OR}" = 0{,}760$

Injectors (formula l)		
Name of event	**Number of discord**	**Probability**
Corosion	1	$P(B_1) = 0{,}333$
Congestion	2	$P(B_2) = 0{,}667$
Totalling	3	$P\,"_{AND}" = 0{,}222$

Tanks (formula l)		
Name of event	**Number of discord**	**Probability**
Empty tank	2	$P(B_1) = 0{,}500$
Failure in a mixture	2	$P(B_2) = 0{,}500$
Totalling	4	$P\,"_{AND}" = 0{,}250$

CONCLUSION

The diagram of fault tree was created to show the relations established events in all stages of production. The qualitative analysis explained all the interrelations of events that occur at the production stage. The quantitative analysis determined the probability of negative event for each single event. Applying the method of FTA strengthens the effect of increasing the quality, not just for finished product, but also the quality and safety of its three phases. Thanks to use a method we detected all weaknesses in the organization of the manufacturing cycle, and these events have been recorded in a logical sequence of graphic assessment for better and clearer analysis. By introducing of this method there is increasing demands for the implementation of TQM.

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