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BELT CONVEYER ANALYSIS USING FAULT TREE ANALYSIS METHOD

Abstract: *Mechanical systems design aspects of load, functionality and ergonomics as well as in aspects of reliability are necessary for quality and reliable mechanical system operation. A commonly used method for getting a full picture of reliability is certainly the fault tree analysis. In this paper a fault tree analysis of a belt conveyer is shown, which is part of a potato sorting and packing machine. The given fault tree analysis is conducted on all belt conveyer assembly and subassembly levels. The highest level of belt conveyer reliability is necessary for proper operation of the potato sorting and packing machine. After all of the analyses are conducted, measures for improving the machine's first revision are given. The paper concludes with a result discussion and further directions of research.*

Keywords: *Belt conveyer, fault tree analysis, reliability.*

1. INTRODUCTION

Mechanical systems design aspects of load, functionality and ergonomics as well as in aspects of reliability are necessary for quality and reliable mechanical system operation. Getting of a reliability picture of the system is most commonly performed by fault tree analysis. The essence of fault tree analysis is translating the mechanical system into logical diagrams, [1, 2, 3]. Fault tree analysis is starting by picking failure of the mechanical system for main event. The next step in creating fault tree analysis is expanding the system into subsystems, assemblies, subassemblies and parts. Depending on the system components complexity and their influence on the system a fault tree is created. In this analysis, all of the failure events in the system structure is taken into consideration for creating of fault tree analysis. Considered events on the subsystems, assemblies, subassemblies and parts does not necessarily mean permanent failure of the mechanical system.

Using of the fault tree analysis is very important as well as in the designing phase as in exploitation. By this method the whole life cycle of product is covered. In papers [4, 5, 6] authors are, using this method and exploitation data, determinate reliability of the vehicle steering system. As well as determination of current system reliability, using of the fault tree and logical diagrams, it is possible to give forecast of sound system operating. In paper [7] analysis of the complex technical military system is given in the phase of design. In this paper, fault tree is adapted to system parts functions before final designing.

In the guidelines of this paper the belt conveyer fault tree analysis of sorting and packing potato machine is given. The paper concludes with resulting analysis and proposals for a potato sorting and packing machine revision. Guidelines for future research are also given.

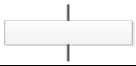
2. DESCRIPTION OF FTA METHOD

In order to have a full understanding of the fault tree analysis a short description of translating system into logical diagrams is given. Translating mechanical system into logical diagrams implies consideration of all possible faults, which affects the system directly or indirectly and causes its permanent or partial failure.

2.1 Basic event meaning

There are five types of possible events in fault tree analysis: main event, primary basic event, secondary basic event, expected event and conditional event. Three types of events have been assumed in belt conveyer analysis. Symbols and and descriptions of those events are given in table 1.

Table 1 - Used events in FTA method

Top event	
Basic fault event	
Undeveloped event	

Events represented by a rectangular on the exit of logical gate (main or indirectly) means a consequence of logical gate input events. This event also has a short description of the event meaning.

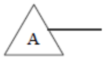
A basic event is represented by a circle and it doesn't require further developing. That is an independent event, which has been used just as logical gate input. This event also represents the end of the fault three at this point.

A rhombus is the symbol for an event, which is not developed to the smallest detail because of a lack of information or its low influential importance. The circle and rhombus both have event descriptions in them.

2.2 Logical gates and trasfers

In analysis of the belt conveyer logical gate „OR“ has been used as well as trasfer gates „IN“ and „FROM“. Symblos which is used in this analysis are given in table 1.

Table 2 - Used events in FTA method

“OR” gate	
“In” transfer	
“From” transfer	

Logical gate „OR“ produces an exit parameter if one or more events happens. The symbol for this logical gate is „+“ or „OR“.

Transfer “IN” represents the developing of a sub three because of analysis appearance simplification. The sub three for this transfer is marked by a symbol as shown in the main fault three.

Transfer “FROM” means a connection between the sub three and main fault three with the same symbol in the transfer gates.

3. DEVELOPING OF TRANSPORTER FAULT TREE

In order to prepare the belt conveyer for the fault three analysis it is unnecessary to make structure diagram with all assemblies, subassemblies and parts. Developing of this diagram is required to a determinate the analysis depth. If there is, a large-scale structure diagram lowering the depth of the analysis is required. If a lowering of the analysis depth is not performed, it becomes impossible to control it. One of the future researches on this topic is automation of the analysis, that it can go into deep and detail with large-scale systems. In this case, because of a relatively low number of the system components, full depth and detailed analysis is performed. The structure diagram of the belt conveyer is given in figure 1.

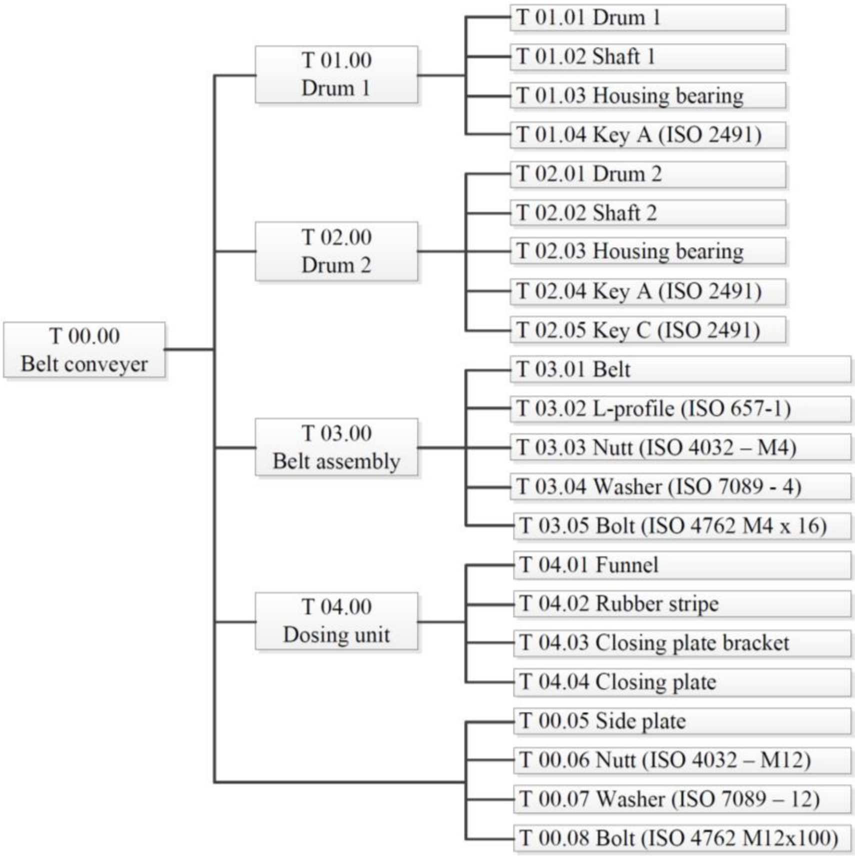


Figure 1 - Structure diagram of transporter assembly

Figure 1 shows that the belt conveyer consist of four subassemblies. Subassemblies have been expanded to components. Aside from four subassemblies, the side plates and connecting elements are also taken into consideration. Developing of this structure diagram is important to show that full depth and details analysis can be conducted. Elements have been taken into consideration from parts to belt conveyer assembly. The belt conveyer is shown in figure 2.

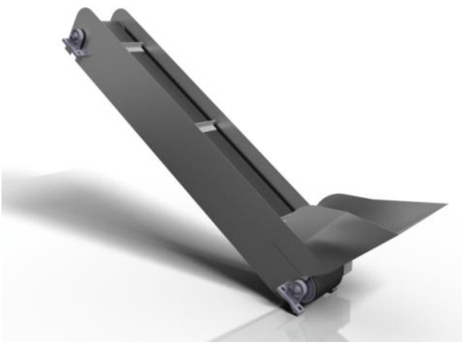


Figure 2 - Analyzed transporter

3.1 Transporter main fault tree developing

In order to simplify the appearance of the fault three, a main fault three is formed and sub threes, where the Main (top) event is failure of the belt conveyer. Further three developing is performed by subassemblies three developing. The transfer symbol has been used, and all of the subassemblies have been developed as separate fault sub three. Main fault three is shown at figure 3.

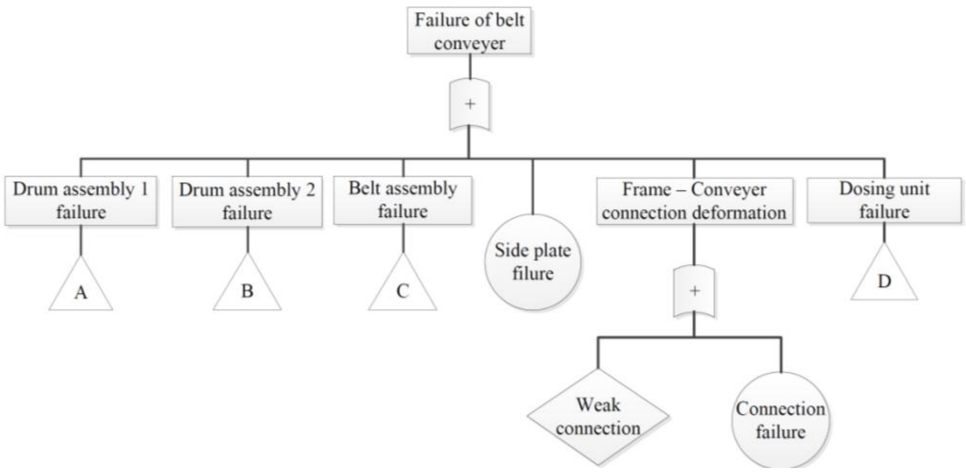


Figure 3 - Transporter main fault tree

From figure 3 it can be seen that the analyzing order follows the form from figure 1. In the main fault three, failure of side conveyer plates, as an initial event, is possible. The failure of the conveyer side plate would mean permanent conveyer failure. Failure of the conveyer – machine frame connection is taken into consideration as a separate event. This event would also have permanent failure of the conveyer as a consequence. However, the probability of this event occurring is very low, especially breaking of the bolts.

3.2 Drum assembly fault tree developing

Failures threes of the drum assemblies are very similar for this analysis. The only difference is in the connection to the power unit at the powering drum. For this reason, only the powered drum has been taken into consideration. Full failure of the drum could provide belt conveyer failure, while with partial drum failure machine operation could be continued with downsized capacity. From figure 4 it can be seen that failure of the bearing would provide full belt conveyer failure.

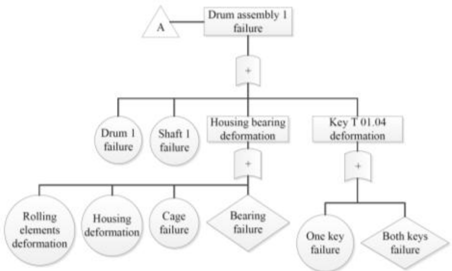


Figure 4 - Drum fault tree

Drum and drum shaft failure would have the same consequence as the bearing, but their event possibility is low. Key failure, which is the connection between drum and drum shaft, is possible because of unequal key loading. That is the reason why two keys were installed, at 180^{o} degrees one relative to another.

3.3 Belt assembly tree developing

Belt assembly is the most important

part of the belt conveyer. It consists of rubber belt with L-profiles bolted to belt. Belt assembly developed fault three is shown on figure 5.

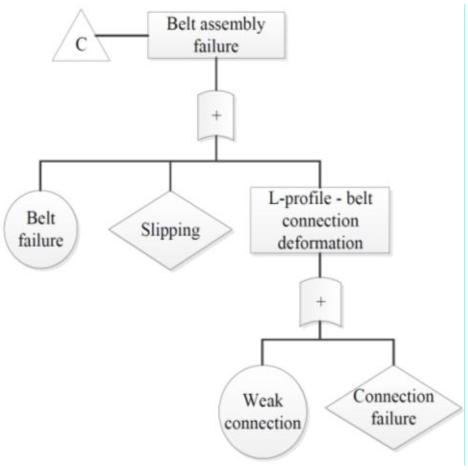


Figure 5 - Belt assembly fault tree

Based on exploitation data most critical event at this fault three is bolted connection L-profiles to rubber belt. Other events, which can cause belt assembly failure, are belt slipping and attenuation of L-profiles bolted connection. In case of happening of one or both of these events, it is possible to complete the started series of packing. After finishing packing series, fastening of the belt and bolts is necessary.

3.4 Dosing unit tree developing

In the belt conveyer the second most important is the dosing unit. It consist of a sheet metal funnel on which a sheet metal plate is placed for opening and closing. Developed fault three for dosing unit is given at figure 6.

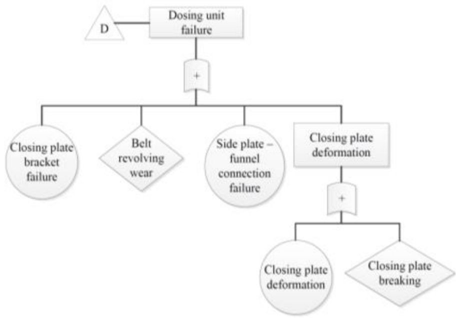


Figure 6 - Dosing unit fault tree

The top event for the dosing unit is expected by failure of any element. For this reason the dosing unit is the most critical subassembly in this belt conveyer. On the dosing unit, initial events are: fracture of the closing plate, bolting connection failure between side plates and funnel and fracture of closing plate carrier. Other events could cause partial failure. With partial failure, started packing series can be completed, after what should approach the repairing.

4. CONCLUSION

By using fault three analysis detailed analysis of belt conveyer as well cause as well as mode is conducted. By using of this method all possible failures in exploitation have been determinate. Any fault of belt conveyer, which would mean partial and full failure, is a direct potato sorting and packing machine failure. In order to avoid these events is necessary to follow maintenance measures:

1) belt fastening;
2) belt L-profiles fastening;
3) assessment of dosing unit before all packing series;
4) orderly lubrication of belt conveyer housing bearings;
5) visual inspection of the belt conveyer before its starting.

In guidelines for future research, it would be very useful to analyze oscillating system. For this further research a good method would be dynamic fault analysis.

In area of fault three analyses, the most useful would be to automate the process. This would be performed in order to get results easier and less time wasting for very complicated mechanical systems.

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