SYSTEM SAFETY: HUMAN - TECHNICAL FACILITY – ENVIRONMENT
6(1), 2024, pp. 459-472

APPLICATION OF SELECTED METHODS IN PROCESS IMPROVEMENT

DOI: 10.2478/czoto-2024-0047
Received: 08/12/2024
Accepted: 31/12/2024

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Abstract: As customer needs and expectations change, and as competitive pressures and technological advances increase, organisations are forced to continuously improve their products and processes. The use of quality management methods and tools stimulates organisations to analyse customer requirements, to define the processes that contribute to the creation of a customer-acceptable product, and to keep these processes under control. The present paper deals with improving the manufacturing process of conveyor sorting belts, specifically the problem of opening joints on CSC belts. By forming a team and their joint efforts, the root causes of the problem in the CSC belt manufacturing process were identified using the Ishikawa diagram and action plan, and several corrective measures were proposed. The root causes that were likely related to the occurrence of the joint opening problem on the CSC belts prior to its detection include: hiring new staff for the LBWC department, purchasing four new Fonmar ALFA heat presses, rebuilding the Rodder & Piller die-cutting equipment, changing the way the belt joints are cut, implementing an unwinding system on the Rodder & Piller equipment, and changing the pressing parameters. Among the deficiencies found in connection with the monitored process are: uneven shape of the cut teeth, life of the strips - dynamic tests, presence of polyurethane in the joint. Corrective measures taken include: use of modular roller belt, inspection of joints using work lights. These corrective measures have also been implemented, with verification validating these measures.
Keywords: CSC belts; complaints; 8D report; improvement; action plan

1. INTRODUCTION

Businesses, regardless of their size and structure, are always looking for ways to increase efficiency and improve product quality. That's where process improvement comes in. Process improvement is a continuous process of analyzing wastes, finding and implementing measures in order to eliminate them and increase process performance (Boledovic, 2017). The approach can be applied to individual processes across the whole organisation. Improvement refers to all aspects of a company, starting with product quality, process improvement, technology innovation, or the introduction of measures to reduce negative environmental impacts (Binčík, 2022). The main objectives of any company are first and foremost to satisfy the needs of consumers and to generate profits. It is essential that the company's impact on the surrounding environment has the greatest possible positive effect.

An essential part of any company's improvement process is the creation of a quality management system that can effectively create, manage and control the company's objectives. Quality management consists of a set of principles that must be implemented and followed in a quality management system. Using quality management methods, we are able to effectively evaluate and identify potential risks, find the causes of their occurrence and implement appropriate measures to reduce or prevent their reoccurrence. The main objective of this paper is to find out the causes of the problem complained by the customer, take and implement corrective actions and then verify them. This was a problem with open joints in the CSC belt manufacturing process. This problem will be solved by a combination of traditional methods such as Global 8D, Ishikawa diagram, action plan and point chart. Although the methods mentioned above are traditional, the uniqueness of combining these methods also provides novelty in solving problems of similar nature for other processes or for other organizations.

2. MATERIALS AND METHODS

Global 8D is a methodology to identify and eliminate the root causes of failure and then implement permanent corrective actions to prevent a recurrence. The method is also designed to evaluate the effectiveness of control mechanism failures that allowed the problem to escape undetected in the first place (Aikens, 2011). The method is typically used within the organization and its results can be presented to the customer as quality control (Andrássyová et al., 2011; Kumar and Adaveesh 2017). The output of 8D method is 8D Report based on the multi-stage work of the entire team,. which uses effective methods and tools for quality management or improvement (Dziuba et al., 2021).

The 8D methodology includes an 8D report consisting of eight steps, as shown in Fig. 1:

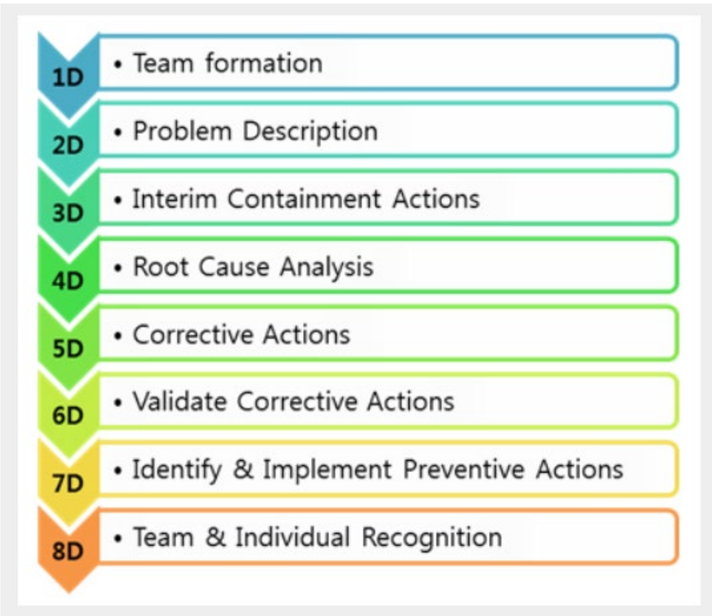

Fig.1. 8D Problem solving approaches (www.whatissixsigma.net, 2024)

Method 5WHY (5W) is a method that detects the causes of quality problems or failures by asking a few questions, "Why?" It allows to get to the root of the problem, thoroughly analyse the cause and focus on the efficient solving (Dziuba et all, 2014). By asking more questions, "Why?" problem becomes more understandable, so that can apply remedial measures to eliminate a particular non-compliance. The main advantages of this method are its efficiency and uncomplicated nature. The method can be used in every company. However, it requires logical thinking and independent problem identification by the research team (Borkowski et all, 2012).
An action plan is a definitive checklist of tasks and resources needed to complete a project or achieve a goal. You can think of it as a visual countdown to the project delivery or a breakdown of the list of tasks needed to achieve desired result and focus on achieving a specific goal. action plans are powerful tools for goal setting and project execution. Action plans help teams manage necessary resources, adhere to schedules, and track progress toward specific goals and project initiatives. It helps order project tasks in a sequential and timely manner to achieve a goal. Project managers and individuals can use action plans to achieve their work and personal project goals (Udoagwu, 2024).

3. RESULTS
The subject of this paper is the identification and correction of a problem that first appeared in the organization in March 2022, and that was damaged sorting belts (Fig. 2).

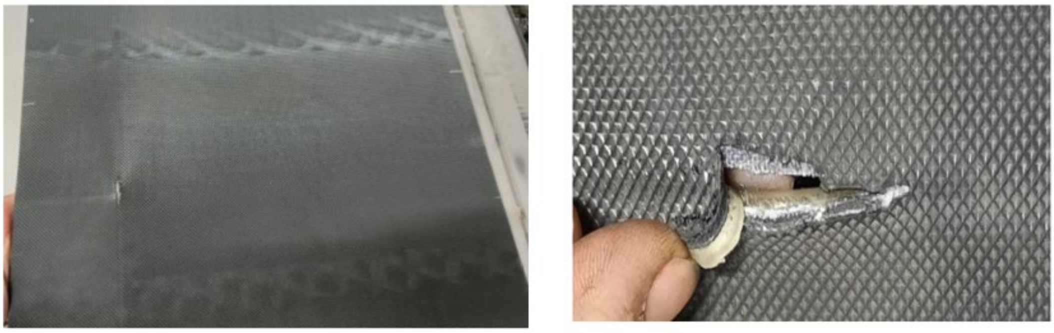

Fig. 2. Visible crack at the joint and complete loosening of the joint tooth at the point of profile welding (Binčík, 2022)

A team was set up to address the problem using the structured approach of the 8D claims management method. The team consisted of Quality Manager (Malacky), Global Quality (Hannover), Quality Department (Malacky), Sales Department (both Netherlands and Malacky), R&D (Hannover), Director Global Fabrication. The team created an action plan. The primary objective of which was to identify the root cause of the problem. The first step in the action plan was to send the samples needed to carry out the comparative tests at the Forbo Hannover laboratories. The samples were produced at the Forbo Malacky plant. At the same time, they were compared with the belts supplied by the customer Vanderlande. Later in the analysis, the joints from the Forbo Garbsen and Forbo Pinghu plants were tested and compared. The samples were used for static tensile testing. The results of the tests were already known at the end of March 2022. The values from the tests were comparable on the samples delivered from the Malacca plant and the belts returned from the customer in the Netherlands. The samples were tested at three different splice positions. The joint to the right of the profile, the joint with the welded profile and

the joint to the left of the profile. However, the results showed no significant difference in joint strength from the standard samples from the R&D department.
A meeting was arranged in late April 2022 with members of the Vanderlande team to assess the risks and summarise the information available regarding damage to the strips. During the discussion with the Vanderlande team, critical information was shared to assist in the further process of analyzing the claim and expanding the action plan. The plant that first reported the problem of cracking on the belts was located in Germany and bears the BRE4 designation. Sometime later, the problem was also reported by team members from the UK who observed the same problem at a plant designated LCY3, in London. The problem was identified by a CCTV system used to check the goods being transported. In this case, it was a conveyor system that transported packages of various shapes and sizes. The camera system erroneously reported that some of the conveyors in the system were transporting goods, even though the system was not in live operation at the time. During a physical inspection of the conveyor system, it was discovered that a crack of varying dimensions in the joint was present on approximately 10% of all installed belts. The crack was always only at the joint and the welded profile. Particles of transparent material, probably polyurethane profile, were observed on the surface of some strips. The customer believed that the crack would continue to widen until the joint was completely ruptured. In such a case, a substantial part of the operation would be stopped and penalties would be threatened by the end user of the conveyors. The Forbo team shared the results from the static tensile tests and informed the customer that the joints were sufficiently strong at all points tested. Given the magnitude of the risk, the Forbo team decided to take immediate action to create an insurance stockpile for the customer of 250 CSC belts to be distributed to the BRE4 and LCY3 logistics centres.

3.1. Creating an action plan

Agreed tasks in the action plan:

- Identification of project leader - Global Quality Department Forbo Hannover o Creation of activity table - MSX Activity Charter created. o Creation of a team (must be a designated person from the R&D department).
- Delivery of samples from Forbo Garbsen plant - escalation due to delay in delivery of samples since April 6.
- R&D representative will organize a tensile test at the joint overlap and welded profile location.
- Dynamic belt running test on 2 rollers - R&D representative responsible.
- Sharing reports from Vanderlande for further analysis - need to find out order numbers, batch numbers etc.
- Presenting potential risk at CHF to VP of Global Quality.

In the next step, a team consisting of a QM, MSX coordinator, TR production coordinator, technologist, press department foreman, and quality control foreman assessed the entire CSC belt manufacturing process to determine the causes of non-conformance. Conclusions from the Ishikawa diagram were used in the compilation of the MSX Activity Charter. The results are shown in Table 1.
After creating an action plan, defining the team, and creating a strategy to identify the root cause, regular meetings began on 5/17/2022. At the initial meeting, the origin of the strips was clarified. It was possible to trace when the belts were manufactured from the printing on the underside of the belts, which includes the dimensions, the production order, the position of the production order and the serial number of the belt.

Table 1
The MSX Activity Charter document used to record the individual tasks and results determined during the problem analysis (Binčík, 2022)

Forbo MOVEMENT SYSTEMS — msx Action List — msx OPERATIONAL EXCELLENCE

Project name	CrossSorter-Problem Vanderlande/Amazon	Updated:	4.10.2022

No	Topic / Area	Action	Initial Due Date	Final Completion Date	Responsible	Status	Result / Comment
1	Sales	Information about problem at site by Stefan Reusen in mid of March 2022	11.3.2022	11.3.2022	[redacted]		Sending returned samples fromcustomer to Hanover
2	FS Hanover	Discussion about root cause in FS Hanover internally at KT Hanover: P. Meyer, V. Molochnikov, J. Wesemann, B. Geffers, M. Guenther, E. Krueger	18.3.2022	18.3.2022	[redacted]		Decision to test splice for bad samples and to order 1 sample with 8 splices from FS Malacky, P. Meyer will make drawing
3	FS Malacky	Fabrication according to drawing and send sample to FS Hanover	25.3.2022	29.3.2022	[redacted]		
4	FS Hanover	Tensile load tests (static) of returned belts by QC Hanover	30.3.2022	30.3.2022	[redacted]		Results show no big deviation, but the position of profile is not tested yet. Beside the profile results has no anomalies.

The belts that the customer assessed as non-conforming were from the same time period. They were manufactured in the timeframe September to November 2020. All the belts were delivered to the customer's subcontractor at a conveyor machine plant in Hungary. The largest volume of CSC belt orders produced was recorded during this period. The increase in orders was related to a number of changes in the production process, which were implemented to increase production efficiency and ensure on-time delivery. The main changes in 2020 include:

- Recruitment for the LBWC - Large Batch Work Center.
- Purchase of four new Fonmar ALFA heat presses.
- Rebuilding of Rodder & Piller die-cutting equipment.
- Change in the way belt joints are punched.
- Implementation of an unwinding system on the Rodder & Piller machine.
- Change of pressing parameters

3.2. Optimising the chopping on the Rodder & Piller

Initially, the workplace produced 80 strips per shift (Fig. 3). After applying the changes, the output increased to 250 pieces per shift. One of the significant changes to the equipment was to rotate the material when chopping with the polyester side with the rolled profile facing downwards, due to the reduction of the coefficient of friction and improved handling (Fig. 4).

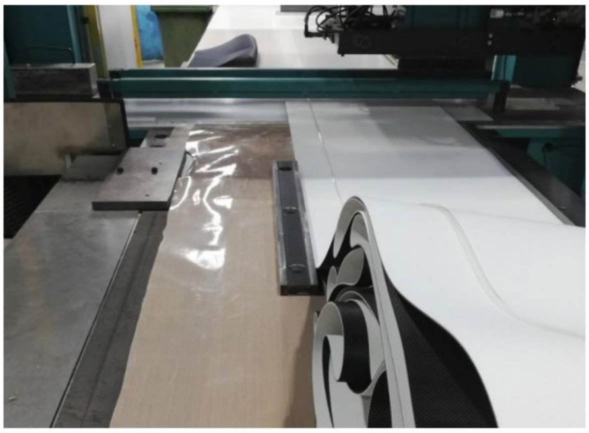

Fig. 3. The original placement of the material when cutting out the joints before the changes were introduced (Binčík, 2022)

Fig. 4. New placement of material when cutting out joints after the introduced changes (Binčík, 2022)

3.3. Changing the width of the press plates

The change in the width of the press plates was implemented due to previous issues reported from a subcontractor in 2020. There were unevenness in the profile at the joint that was caused by the combination of temperature, pressure and narrow press plates during the pressing operation. This defect did not appear when wider press plates were used. In Fig. 5, we can see the deposition of the material in the press. The original pressing platen width was 300 mm, the new pressing platen is 400 mm wide.

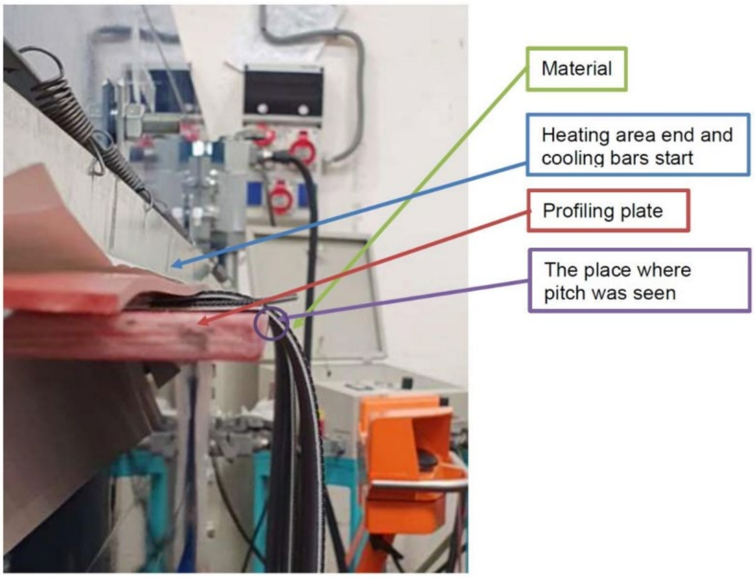

Fig. 5. Placing the material in the press (Binčík, 2022)

3.4. Chemical analysis of the material

The customer reported white particles of unidentified material on the surface of the material at the tooth opening. At approximately 10 % of the joints, a transparent material was visible using a lamp, ranging from 1 mm2 to approximately 10 mm2 . The material was subjected to chemical analysis in the laboratories of Forbo Siegling Hannover.

Chemical tests have confirmed that these are polyurethane particles that originate from the profile. Polyurethane differs from polyvinyl chloride in chemical structure, which causes no integration of plastics. PU in this case acts as a separator and it is assumed that wear may occur when the belts are used in harsh environments. After sharing the results of the chemical tests, the Malacca plant started to inspect all CSC belts using backlighting. The inspection was first implemented on an order of 250 CSC belts to be delivered as safety stock, in case of a joint break, to the BRE4 and LCY3 logistics centres. The occurrence of PU material in the joint was identified on 3 pieces of approximately 1.2%. Backlight inspection continued on an order of 426 CSC belts which were produced in parallel with the replacement supply. In this case, 19 pieces of belts were identified at approx. 4 %. Some of the belts were later sent to the Forbo Siegling Hannover plant for dynamic tests. Based on the different inspection results, team members from the Malacky plant decided to investigate the joint preparation and pressing process.

3.5. Analysis of the possible causes of a problem in a joint chopping operation

In the process of analysis, it was found that the joint did not lie flat under the punching head when the teeth were punched out. The material was tilted at the point of the profile welding. During the internal analysis at the Forbo Malacky plant, differences were observed in the quality of the cut on the material punched with the profile part upwards and the standard placement of the material. When the joint was punched in the standard way, one tooth curved regularly in the same place. It was assumed that the PU material from the profile would flow through the gap in the tooth tip into the top PVC layer. In this case, the PU material was intended to act as a separator between the layers. After a period of use, abrasion of the PU material and the formation of a crack was expected to occur.

In Fig. 6, we can see a comparison of the quality of the joints after the profile side upwards and the profile side downwards were cut out. The chamfer can be seen on the tooth with the profile. The cut is not clean and when overlapping both sides of the joint, a minor unevenness could be seen at the profile welding point.

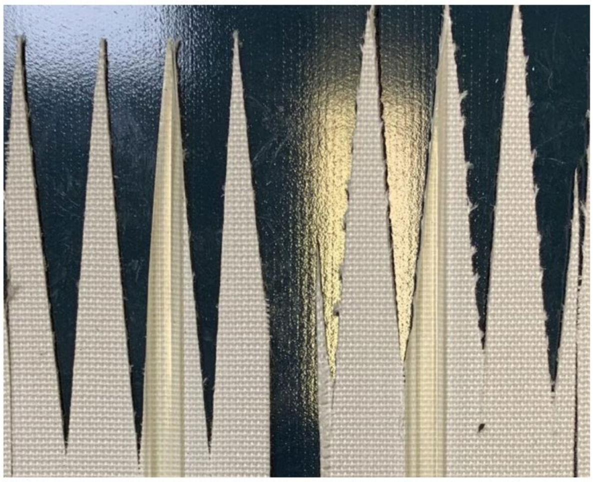

Fig. 6. Cutting out the teeth with the left side of the profile facing upwards. Right profile side downwards (Binčík, 2022)

3.6. Analysis of the possible causes of the problem in the pressing operation

The phenomenon of overflow occurred on approximately 10% of all belts delivered from BRE4 and LCY3 plants. The occurrence of PU material in the joint was also identified internally, when checking a replacement delivery of 250 belts and a new order of 426 belts.

Members of the Forbo Malacky team defined several possible causes of the overflow profile. Among the defined causes that needed to be verified are:

- Failure to follow the procedure for preparing the connections.
- Non-optimal setting of pressing parameters, which include temperature, pressure and heating time.
- Layout of the pressing surface.
- Depth of the profile groove on the press plates.

No deviations were detected during the inspection of the joint preparation process. Operators followed all instructions according to the procedures developed. The Forbo team had data on the set parameters on the presses from the period of production of the claimed CSC belts. These matched the parameters prescribed in the B-Rex programme. It is not possible to trace the layout of the presses. However, the current production uses the layout prescribed in the B-Rex database. Based on the information in the available documents, no change has been identified regarding the method of unloading the presses. The last change that concerned the pressing area was the increase of the heating time from 2 minutes to 6 minutes. Due to the change in the heating time, samples were sent to the Forbo Siegling Hannover plant for testing. The result of the test showed no significant difference in the strength or visual quality of the joints. The last defined possible cause was the homogeneity of the profile groove depth. A digital caliper was used to measure the depth. A total of 40 measurements were made on 4 plates, each plate having 2 grooves milled. These are fiberglass plates, the surface of which is covered with Teflon film. The Teflon film is glued to the 69 plates manually, as it wears off after certain pressing cycles (Fig. 7).

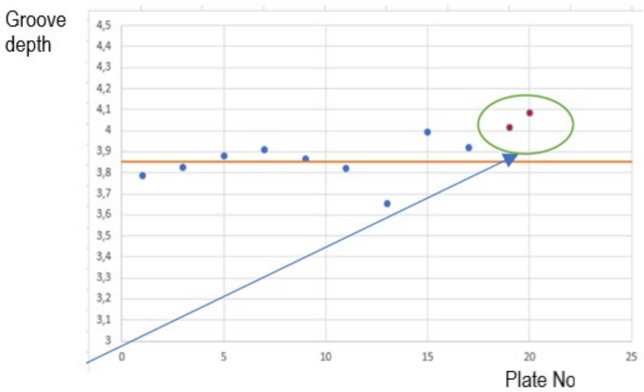

Fig. 7. Dot plot showing the arithmetic means of the individual measurements (Binčík, 2022)

3.7. Dynamic tests of CSC strips

Samples with overflowing PU material in the joint were first used for testing. The 1100 mm long specimens were placed on 2 rotary rollers of 50 mm diameter with a profile groove at 0.5 % spline. The belt rotation speed was set at 188.5 rpm. The sample placed in the test station reached 271 thousand revolutions per day. A total of 3 test stations were used to test the samples. The error could not be reproduced even after 4 days of continuous testing. All tested samples withstood approximately 1 million revolutions without obvious damage to the joint. The R&D team decided to modify the test station so that the sample would not rotate in line. On one of the cylinders they adjusted the offset by 8 mm. The belt on the test station with the offset ran diagonally. The test was successful, but the damage to the profile during testing was devastating. Due to profile damage, the test station was again optimized. An additional 40 mm diameter grooveless cylinder was installed on the station to apply pressure to the sample joint. The other testing parameters remained unchanged. During testing on the modified test stations, cracks appeared on all deployed specimens, except for the standard specimens produced in the Forbo Siegling Hannover production laboratory. A total of 8 samples were tested. The final testing time was set at 160 hours. If the sample lasts 160 hours without any sign of damage, the test result is evaluated as successful, meaning that the belt has lasted the specified service life in service. The results of the sample testing are shown in the Fig. 8.

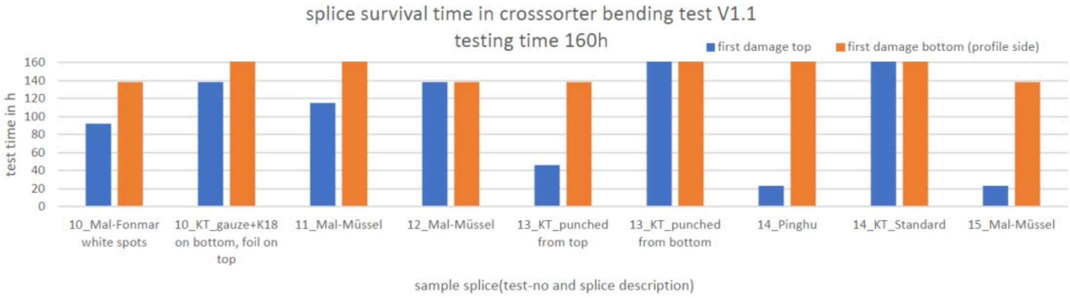

Fig. 8. Results of testing of individual samples at test stations (Binčík, 2022)

Only the specimen that was cut with the profile side up and the standard test specimen survived without damage.

3.8. Changing the side of the tooth joint cutting

The change in the die-cutting side of the joint introduced in 2020 has been identified as one of the most significant causes affecting the quality of the tooth joint design. The change in the manufacturing process had a significant impact on the efficiency and ergonomics of the work. The output increased from 80 pieces per shift to 250 pieces after the implemented change.

Recommendations to ensure efficient die-cutting of the tooth joint:

- The use of a non-slip material to ensure a lower coefficient of friction between the material and the table.
- Purchase and install an air system that would provide smooth and easy movement over the table surface and vacuum fixation of the web during the joint punching process. The company uses a similar system on the ZSG 3000.
- Installation of a conveyor belt made of S8-0 RTP A90 material, which includes replaceable and adaptable rollers in case of belt damage.

It was also suggested to the company to introduce control using AKU lamps into the existing control process.

4. DISCUSSION

In selecting the most appropriate alternative regarding the change in material position during the tooth extraction process, the team made decisions based on the speed of applying the changes and the purchase price. The use of materials with a low coefficient of surface friction was not successful. None of the material types tested achieved optimal handling results. The team decided to pursue the option of using a modular roller belt composed of S8-0 RTP A90 material, which is adaptable to the dimensions of the handling area (Fig. 9). The technical manager defined a test specimen on which the sliding properties were tested. The testing of the belt was evaluated as successful and the next steps in the modular belt implementation process were taken. Firstly, an internal purchase order was created in which the dimensions and technical requirements for the belts were defined. Production of the belts was completed within 24 hours of the order being established. Upon completion, the belts were installed on the handling area of the Rodder & Piller facility. The cost of producing the belts was EUR 798,66.

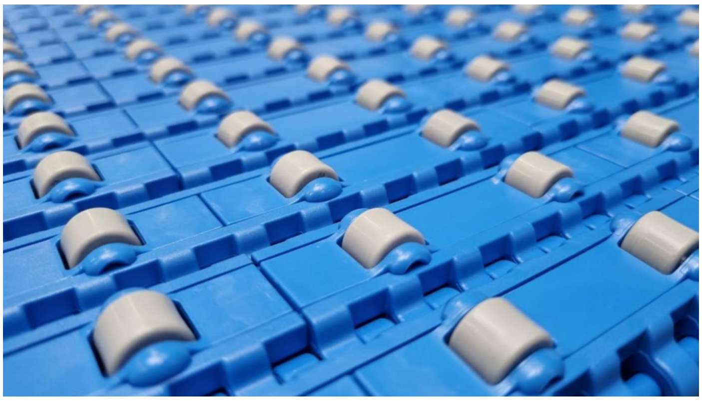

Fig. 9. Surface structure of modular conveyor belt S8-0 RTP A90 (Binčík, 2022)

The change of the connection type could not be achieved as it was not agreed by the customer. From the customer's side, new tests would have had to be carried out in R&D and the approval process would have been unnecessary and lengthy, according to the team. As there had been no similar problems in the past with joints of the same type, the customer did not see the need for a technological change in the joint. However, the point is part of the action plan in case the problem with opening of the joints recurs. The last suggestion was the implementation of a joint inspection point using work lighting, due to the detection of non-conforming parts during the CSC belt inspection process. A Brennenstuhl WL 500 A AKU work light was purchased for the quality control department, along with protective masks, with a dark filter to prevent possible eye damage (Fig. 10).

Fig. 10. LED work light Brennenstuhl WL 500 A (Binčík, 2022)

The process engineer in collaboration with the quality manager integrated this step into the existing SOP and issued a new revision of the document. The checkpoint was also added to the updated version of the checklist. Quality control personnel were trained on the safe use of the Brennenstuhl WL 500 A LED work light for inspection).

Fig. 11. The part of the SOP defining a link fault (Binčík, 2022)

Once the corrective measures were in place, a sample of four CSC belts was sent to R&D Forbo and Vanderlande to test the life of the belts using dynamic tests on test equipment. The results presented in report DOC01066721 show that the 3 belts survived the specified standard service life of 1,500,000 cycles without damage and joint opening. There was a cosmetic defect on one belt, but according to the customer's evaluation, this did not affect functionality. Based on the conclusions of the analysis carried out by the Vanderlande customer, we can assess that the measures and process improvements put in place are effective. The Forbo team, in collaboration with the Vanderlande team, have created a document DOC01064743 that describes when a belt containing a damaged joint needs to be replaced. The document defines that a crack in the joint from one side of the tooth without the tooth dislodging is not a problem for the functionality of the conveyor system. In the event that the tooth opens from both sides and tooth dislocation occurs, the belt must be replaced with a belt from the insurance stock. The insurance stock of belts under order number 16006175 was delivered at the expense of Forbo Siegling Ltd. to the BRE4 and LCY3 plants. The total amount for the insurance stock of belts was EUR 10 045. The original risk of returning and replacing the roughly 15,000 belts produced since the beginning of 2021, amounting to approximately one million Swiss francs, was eliminated after all measures were put in place and the insurance stock was shipped.

5. CONCLUSION

In this article we have introduced Forbo Siegling s.r.o. We found, that the company is part of the global Forbo Movement Systems matrix. Plant in Malacky is the largest plant in Europe. In addition to the plant in Malacky, there are production plants in Germany, China and the USA. Four product divisions are represented in the company, including Transilon, Transtex, Extremultus and Prolink. We found that the company has an integrated quality management system in place that integrates and manages safety, quality, energy and environmental standards. The Malacky plant is currently ISO 9001:2015 certified. The company has defined quality policy, which commits it to continuous improvement of quality and environmental performance, energy efficiency, as well as monitoring safety occupational health and safety. The IMS policy sets objectives applicable to the entire global matrix Forbo Movement Systems. The company has a system in place for monitoring and evaluating specific quality indicators, which include, for example, the incidence of external complaints, response time for processing complaints, evaluation of the timeliness of deliveries, the level of waste produced, energy consumption, productivity levels, and others. To monitor indicators, the company uses the QlikView tool, which is integrated with the database in the SAP system. In this article, we have focused on the process of planning, production and inspection of CSC belts. To document the processes, the company uses a standardised document called SOP. The document combines a description of each operation with a visual representation of the operation using pictures, diagrams or production drawings. We followed the G8D methodology to process the complaints problem and subsequent suggestions for process improvement measures. In a first step, we assembled a team of experts who worked together to solve the problem afterwards. In the second step, we researched and recorded all available information regarding the reclaimed belts. In the third step, the team defined the immediate measures to eliminate the risk associated with the potential breakage of the joints in the BRE4 and LCY3 logistics centres. The fourth step was an analysis aimed at discovering the cause of the problem of joints opening at the point of profile winding. The team created an Ishikawa diagram describing all possible causes of the problem. To verify the relevance of each cause, an action plan was defined and elaborated in the MSX Activity Charter document. Both documents were regularly updated and evaluated by the Forbo team and the Vanderlande team. Based on the possible causes listed in Ishikawa's diagram, the team analyzed the current joint punching and pressing operations and proposed appropriate measures for the said operations. Overall, three recommendations were proposed to improve and ensure quality related to the production and inspection process. Among the proposals defined were changing the die-cutting side of the gear joint on the Rodder & Piller machine, an alternative type joint on CSC belts, and implementation of joint inspection using work lighting. From the above suggestions, the proposals concerning the change of the party have been implemented joint punching and control by working lighting. On the Rodder device & Piller, roller conveyor belts from the Prolink division were installed, which ensured that production efficiency and output from the equipment were not reduced. Improvements quality and strength of joints was confirmed by the results of dynamic tests in the Forbo Hannover laboratories. The second proposal implemented was quality control of the joints using Brennenstuhl WL 500 A work lights. SOP document and checklist regarding the inspection of CSC belts for the customer were revised and the inspectors quality controllers were retrained. The implementation of an additional step in the inspection process did not fundamentally did not affect the effectiveness of the output. It was therefore not necessary to carry out any staffing or process optimisation steps.

Based on the above data, we can conclude that the solution presented in this study was effective, as the risk of returning and replacing approximately 15,000 belts was found to be reduced to zero during verification. The value of these belts is approximately one million Swiss francs.

Based on this, we can generalize the above problem-solving procedure for essentially any manufacturing organization to claim that the combination of methods from G8D, through the Ishikawa diagram (using e.g. the 5 Whys and the dot plot) with a link to the action plan is effective and provides a stable solution to the problem.

As a suggestion for the way forward, it would be useful to perform statistical control of the production process using the (X,R) diagram together with an assessment of the process capability using the Cpk index.

ACKNOWLEDGMENTS

The paper is part of a project within the Young Researchers Support Programme *„A set of competencies needed in the implementation of MIS in the context of Industry 4.0"*.

REFERENCES

Aikens, C.H., 2011. *Quality inspired management. The key to sustainability.* New Jersey: Pearson Education, Inc., publishing as Prentice Hall.

Andrássyová, Z., Hrubec, J., Kotus, M., 2014. *Assembly process capability of automotive seats*. Acta technologica agriculture. Nitra: SPU, 2011, 14(3), 74-78.

Binčík, R., 2022. *Zlepšovanie procesu výroby CSC pásov uplatnením vhodných metód manažérstva kvality*. Diploma thesis. Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava.

Boledovič, Ľ., 2017. *Zlepšovanie procesov*. IPA Slovakia.

BorkowskiI, S., Krynke, M., Ingaldi, M., 2012. *Quality of services from the scope of decorative concrete*. Chapter 5. [In:] Toyotarity. Quality of services assessment according to BOST method. ed. Borkowski S., Ingaldi M. University of Malibor, Słowenia 2012.p. 52-62.

Dziuba, S., Ingaldi, M., Kozina A., Hernes, M., 2021. *8D report as the product improvement tool*, Sistemas & Gestao, 16(2), 157-165, DOI: 10.20985/1980-5160.2021.v16n2.1709.

Dziuba, S., Jarossová, M., Golebiecka, N., 2014. *Applying the 5 Why method to verification of non-compliance causes established after application of the Ishikawa diagram in the process of improving the production of drive half-shafts.* Production engineering archives. ISSN 2353-5156, ISSN 2353-7779, 2(1), 16 -19.

Kumar, S.; Adaveesh, B. 2017. *Application of 8D Methodology for the Root Cause Analysis and Reduction of Valve Spring Rejection in a Valve Spring Manufacturing Company: A Case Study*". Indian Journal of Science and Technology, 10, 1-11, https://www.coursehero.com/file/55743756/106137-256659-1-PBpdf.

Udoagwu, K. 2024. What is an action plan? (Example and template). https://www.wrike.com/blog/what-is-an-action-plan-with-example/

https://www.whatissixsigma.net/8d-report/

https://www.ipaslovakia.sk/clanok/zlepsovanie-procesov