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Improving production of low pressure hoses

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Abstract
The paper presents the results of research carried out in one of the domestic companies producing rubber and plastics products for the automotive industry. The results of the evaluation of the quality control function during production of the low pressure hoses and the characteristics of the main machine taking part in this production process are presented. An analysis of the results of the evaluation of factors influencing the quality of production is presented and guidelines for improving this production process are presented. One of the proposed solutions for improvement is the modernization of the machine park and introduction of production nests.

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1. Introduction

According to (HYLA I. 204) extrusion, we define the process of shaping the article by extruding the intermediate with the nozzle of the device, which confers a characteristic, circular cross-sectional shape. The plastic material provided by the auger passes through the nozzle located in the head. The plastic state is obtained from solid raw material which is heated from the hopper in the cylinder. An important element in the plasticizing phase is the worm gear, whose friction with the material should be smaller than the material with the cylinder.

The extruder function also includes the removal of gases from the plasticizing system that come with the recycled material.

You can extract the layouts (STASIEK J. 2007):

a) screws:
- single screw in which the screw performs rotational movement;
- single screw with basic mixing function;
- single-screw with reciprocating dynamics;
- twin-screw, with co-operating cochlea;
- twin-screw, with screws running counter-rotating;
- twin-screws, whose snails do not mesh;
- multi-screw, with concurrent or counter-curvature characteristics;
- mixed.

b) without screws:
- gear pumps, used as a means of extrusion;
- piston, used in the manufacture of hoses.

Processing of polymers most often and extensively uses screw devices, and in particular single screw or twin screw. Extrusion efficiency is the ability to extrude products of the highest quality with the highest efficiency by qualitative, quantitative and operational criteria.

2. Quality control

The analyzed company is a manufacturer of low pressure hoses used in the automotive industry. The characteristics and intended use of this type of product require the manufacturer to perform a series of tests that ensure a very high level of quality and minimize the inconsistency. Therefore, many methods of quality control (WANG S., HUANG T., HOU T. 2017) of low pressure hoses are made on separate positions. Measurements occur in SPCs, laboratories, and metrology departments. The plant's laboratory is equipped with modern equipment necessary for testing products from the whole assortment, including hoses. These machines allow for accurate analysis of the strength of the plastic insert, ring picking, rubber resistance on the endurance device. Metrology, which is a metrological zone, is able to determine the properties of the hoses produced. Measurements were made by specialized measuring equipment and tools, which include:
- calipers,
- carbon paper,
- towers,
- rollers,
- magnets,

- laser,
- plates.
- weight.

In addition to the listed tools in Metrology, there is also a coordinate measuring machine used to obtain accurate measurement results of 3D objects. In addition to creating 3D lumps, the measuring device is used to validate dimensions and other objects by pointing and matching the desired dimensions. Metrology also cooperates with the Prototype department to create innovative design details. It performs an analysis of future hoses, by setting assembly points, and then the finished prototype is sent to the customer for approval. The research area also performs systematic testing of current consumer products. This is achieved by using instructions that define all the properties of the elements, and then applied to the corresponding pieces of the specific piece of card. The number of products on which the research is conducted is determined by the customer.SPC stands are located in the Extrusion section. They are equipped with computers, instruments for measuring wall thickness, rubber diameter. In the rubber wall thickness test a mobile device with a sensor is used, where after contact with the surface of the hoses we get its dimension. The rubber diameter is tested by a tool composed of replaceable rollers corresponding to the diameter of the hoses and the laser. By omitting these tools at the SPC site on the faculty, dimensions are used, a key element for verifying the rubber profile. This is one of the most common inconsistencies on this type of hoses. Recently, the plant has SNAP software that can check whether the produced rubber is manufactured with fixed parameters. This is possible after having previously entered into the system details with the nominal values of each hoses. SNAP is used both at SPCs but also in the laboratory during testing. In addition to the above mentioned measurements, by analyzing the course of the process, the control is carried out at almost every stage of production by the operator. An employee handling the extruder is responsible for making the appropriate machine settings for the workpiece.

All information and parameters are included in the daily production schedule. Once the injection process has started, the employee is required to verify the random parameters of the rubber produced using the appropriate tools at the workstation. Another control takes place on autoclaves where the rubber is subjected to a vulcanisation process. A person working in this department after the completion of the process must perform a visual inspection to verify that the embossed rubber does not have any cracks, inclusions or other incompatibilities (BARTH A., HERPERS R. GREßNICH M. 2007, STROPPA L., RODRIGUES N., LEITAO P., PAONE N. 2012). Another control is performed at the operator's position of the washer, which after the cleaning process is obliged to check that the rubber does not have defects and randomly measure the diameter. After transportation to the production zone, depending on the hoses, the water and air control is confirmed by the label. When the hoses gets the final form it is subject to final inspection. It is made by a specialized group of people employed by an outside company specializing in repairing products and components and selections. Controllers must adhere to the site's occupational standards, including: 5S. Selections are made on the basis of a specific specification in which links are indicated which should be checked by controlling the hoses. They have rulers, dimensions and other necessary measuring tools.

3. Identify the problem of data collection and performance

In case of nonconformity, the controller must report the problem through the Andon system (BORKOWSKI S., KNOP K. 2013, MIELCZAREK K., KNOP K. 2016) and inform the supervisor. Andon is a light signal placed at each control station to indicate the location of the defect detection. Then, the product batch is blocked and subject to specific control to prevent customer complaints. There are situations in which reselection of a component and of a product after a final inspection occurs. For all blocked details, a selection report is provided to the quality technician. All detected incompatibilities are grouped, described and will be transported to the red zone. This is where the non-compliant parts are stored and then verified by a quality technician who confirms the defect by signing the card located in front of the zone. This card shows daily list of production gaps, quantity and type of missing. An anomaly has to be entered on the detected irregularities by the operator. After the selection, the inspectors are obliged to pack the finished product into the appropriate containers according to the palletization card, specifying the type and parameters of the container and the quantity to be put together with the packing method.

In addition to the information provided to quality managers, external quality auditors are required to fill in a selection report each time they provide information on the inspection site, detail, quantity and the absence. In addition to the number of incompatible products, the operator responsible for the process is also listed, where the defect is detected. Report information is sent to the quality department of the enterprise under review and to the management. From the existing situation, the consequences for the operator are drawn and meetings are held to determine the cause and corrective tasks. If the fault is entirely on the side of the machine, component, or a measurement tool are singled quality engineer and technicians to meet the situation. When a mismatch is detected at the customer, this results in a complaint. In this situation the company is charged with the selection costs at the customer. All defects found on individual details are included in the specification, in the selection instructions and the conservation measures. Production data are also collected on each person's work sheet, including the product, quantity and description of deficiencies. All cards are collected at the end of each change, as proof of the work done by the operator. All data is entered into the company's system database. The logistics department also collects data via the planners. Their task is to count the details, components, and semi-finished work to schedule a shipment to the customer. Audits are also conducted 10 minutes made by specified persons for company employees. They allow to gather information whether the operator complies with the standards of work, the position, whether or not it has adequate means of protection, or properly uses the machine or tool. Such data will

be used to determine whether a specific type of training should be carried out among employees.

4. FMEA analysis

The study used the FMEA method, that is, analysis of the effects and causes of defects, which allows for the identification of emerging problems, determine the risk of potential defects and, consequently, to identify the reasons for incompatibility (BORKOWSKI S., INGALDI M., JAGUSIAK-KOCIK M. 2014, PIĄTKOWSKI J., KAMIŃSKI P. 2017, CRISTEA G. CONSTANTINESCU D. M. 2017). COmpanies wanting to maintain the quality of our products at the highest level of risk value – LPR established at the level of 100. Optimal risk are those at which the defect can be easily identified and eliminated immediately.

Table 1. FMEA analysis of the incompatibility of low-pressure hoses

Element	Defect	Effect	Cause	Z	W	O	RPN	Preventive actions
Ring	Ring orientation	Incompatible cable, installation problem at the customer	Lack of employee skills	10	6	2	120	Staff training, preventive measures
	A detachable ring				4	3	120	
Rubber	Deformation		Bad vulcanization		1	5	50	Improvement of the vulcanization process
	Bad rubber profile		Worn forms		2	4	80	Purchase of new forms
	Inclusion		Bad mix of rubber		2	2	40	The use of better rubber mixtures
	No phase		Worn forms		1	4	40	Purchase of new forms
	No lubrication		Omission operations		1	5	50	Staff training, preventive measures
	No tampoprint				1	4	40	
Insert	Cracked insole		Inappropriate provider		7	2	140	Controlling the component delivery
	No seal		Omission operations		1	3	30	Staff training, preventive measures
	Incompatible element		Inattention of the employee		1	5	50	

The analysis is a method of systematic prevention of defects, which has been applied in enterprises producing products with a high degree of complexity. Each defect is attributed to the result, the cause. To calculate the RPN index, i.e. the risk priority number, the significance of the error for the customer Z, the probability of detecting O and the probability of occurrence of the error W. Their value is determined on a scale of 1-10. In Table 1 are shown inconsistencies that may occur during the production of low-pressure hoses. The number of 100 is the FMEA analysis threshold. Analyzing the data received in Table 1, it can be seen that as many as three non-compliances exceeded the risk priority number 100. These are the following discrepancies: ring orientation, peel ring and cracked liner. In order to avoid the disadvantages of the ring orientation and the peeled ring, trainings with employees should be carried out and emergency measures should be put in the workplace. This can be information for the operator in what position the ring should be correctly installed, which should be paid attention to before gluing the ring (quality of the glued surfaces). It is also necessary to work more carefully and with greater commitment. To avoid the problem of broken inserts, a component supply check should be made to avoid getting an undesirable element into the production area. Owing to this, certainty in producing compatible products will be increased. In addition to the above-mentioned activities, the employees of the company performing the final inspection of the cables before sending to the customer should pay particular attention to the defects of the insert, the presence of rings and their orientation.

Therefore, training and implementation of infographics is also recommended for these employees. In a pictorial way, present incorrectly placed rings. It is necessary to present possible control places where ring detachment occurs and provide examples of insert cracks. These graphics will allow in the future to increase the detection of discrepancies occurring during the manufacturing process, low pressure hoses. In the analysis, the problem of a bad rubber profile was high. After limiting the aforementioned problems, the company should also focus its attention on it. In part, it depends on the quality of the forms. Therefore, it is necessary to analyze the causes of wear of

these forms and defects arising during their operation. It will allow in the future to improve the selection of forms, material for forms and potential suppliers.

5. Summary and conclusion

Of all the factors affecting the level of quality and quantity of defective products are machines used. This is due in large part to an outdated engine park which causes numerous breakdowns of the production line, repairs and damage to the rubber surface. Corrective action will be the introduction of a program that suppresses the occurrence of downtime, shortages. Machinery under this system will undergo frequent inspections, inspections and repairs. These machines will include not only used machines but also those that work continuously and belong to the necessary for the production of low pressure hoses. The second more expensive way of improvement is to invest in a modern machine park. The most worn out and emergency machines will be replaced. This treatment will avoid downtime, stop production lines, produce shortages and waste. Due to modernity, energy consumption, components and tools will be reduced. Operators of new equipment will undergo training with proper and safe use. An example of a replacement machine is an extruder, which is a priority device in the rubber production. New technology in the form of sensors and light signals placed on the machine and equipment will allow the operator to react quickly, and the sudden changes in the technical parameters of the hoses will be avoided. Because of the high temperature inside the extruder and the pressing process, this machine is very wear-resistant and will therefore be subject to more frequent inspections. Another potential for improvement is the introduction of production nests. This treatment aims to set the machines and workstations next to each other so that they perform the production steps sequentially. This solution eliminates unnecessary transportation between workstations, which saves time. It will allow to increase the number of manufactured products. Improving will enable to gain production space to develop new machines. The production slot will also ensure the flow of details through all stages through the operator, so the responsibility for the hoses made will be shared by one person. In the event of a complaint, this will allow a quick verification of the operator, rather than checking the person responsible for the stage.

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改进低压软管的生产

關鍵詞
汽车
视觉控制
SPC
提高

摘要
本文介绍了在国内生产汽车橡胶和塑料产品的公司之一进行研究的结果。介绍了低压软管生产过程中质量控制功能的评估结果以及参与该生产过程的主要设备特点。提出了影响生产质量因素评估结果的分析，并提出了改进生产过程的指导原则。提出的改进方案之一是机械园的现代化和生产巢的引进。