DESIGN CONCEPT OF A DEVICE FOR ALIGNING RUBBER HOSES

Pavel SRB[1], Petr KULHAVÝ[1]

[1]Technical University of Liberec, Faculty of Mechanical Engineering, Department of the Design of Machine Elements and Mechanisms

Abstract
This article is focused on improving the production quality of reinforced rubber hoses used especially in the automotive industry. Some defects could occur during the hose production. One of the relatively frequently occurring problem is deviation of the perpendicularity and flatness of the end of the hose. This defect occurs during the vulcanization process when the hose is insufficiently pushed onto the shaped mandrel and leading to a refusing of the parts for subsequent processes. The way, how to correct this defect was sought in order to reduce the number of rejected hoses. Basic kinematic scheme and subsequently drafted design of a device based on orbital grinding have been created. This device grinds the unsatisfactory ends of the hoses so that the perpendicular tolerances could be easily met.

Key words: *Grinding, Manufacturing, Vulcanization.*

INTRODUCTION

The hoses are mainly used for the transport of liquids and gases. For low pressure transport it is possible to use simple hoses. The fiber reinforced hoses should be used for higher pressures of transported medium (*Brendan Rodgers, 2015*). The reinforced rubber hoses have wide variety of possible applications in automotive such as parts for the power steering, air conditioning systems, turbo charge, motor cooling circuit etc. Even though the most common used materials are the Nitrile and EPDM rubbers, the silicones and fluoroelastomers are more suitable to applications with high temperatures (*Anil K. Bhowmick, 1994*). Fig. 1 shows an example of reinforced rubber hose shape.

Fig. 1 Hose shape illustration.

The typical method of manufacturing reinforced hoses is shown in Fig. 2. The first step is to create a mixture of ingredients. Mixed ingredients fill an extruder where the mixture is pushed forward by the movement of the screw and heated by frictional heat. At the end of the screw there is a mixture with required properties that allows it to be pushed through the nozzle and according to the hole shape form a final profile of the created hose. After the extrusion the hoses passing through the cooling box where obtain dimensional stability. After cooling the adhesive backing layer is applied to the first layer of the hose. The next step is laying of the reinforcement layer. This layer can be made of some textile or metallic fibers and can be applied by various techniques such as winding, braiding, etc. The reinforcing fibers are impregnated with an adhesive rubber or latex prior to specific application. During application of the reinforcement it is necessary to keep the neutral angle of 54°44’. By keeping this angle the hose length does not change when the internal pressure is increased (*Demirkoparan, Pence, 2015*).

The outer layer of the hose is applied by a second extruder on the surface with the fibre reinforced layer. The number of reinforcement layers could be higher depending on the type of hose. Subsequently, the semifinished hose is cut to the required lengths. This way prepared semi-finished hoses are further pushed onto the complex shaped mandrels of the vulcanization device by operators.

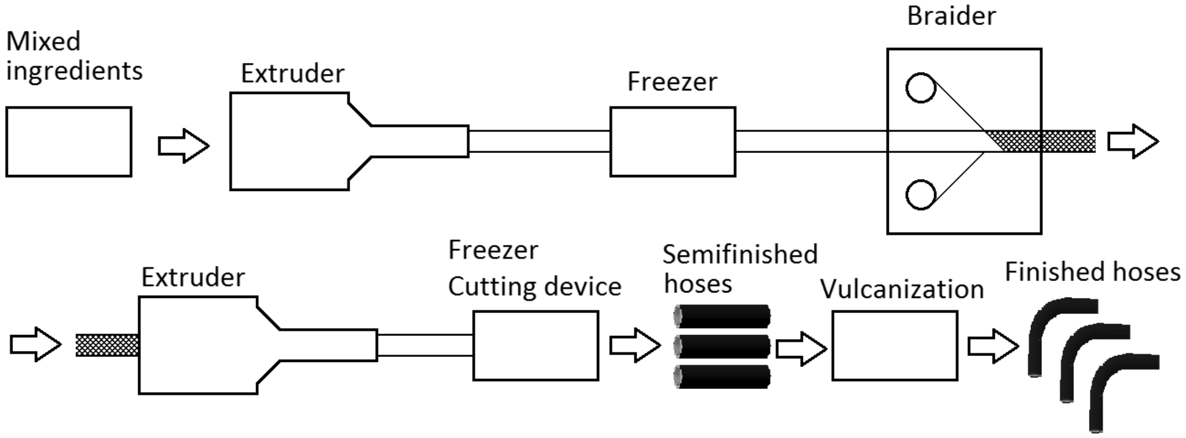

Fig. 2 Reinforced hose manufacturing line.

This is a very demanding physical work and also the place where the defects could occur. The blank hose of the exact length has to be evenly pushed on the mandrel. It is particularly important to properly tighten the ends of the hose to fit the mandrel ends. This correct placement depends mainly on the experiences and carefulness of the operator. Due to this fact occurs relatively large number of defects. When the operator does not press the hose on the mandrel properly, vulcanization can cause that the hose end deviate from the plane perpendicular to the actual axis in the end point as could be seen in the Fig.3. The maximum permissible deviation depends on the diameter of the hose. Usually for the standard diameters of hoses used in automotive is the tolerance about 1 mm in any of circumferential points. The aim of this article was to propose measures to prevent the occurrence of rejects parts or to design a device that the rejected hoses could simply repair.

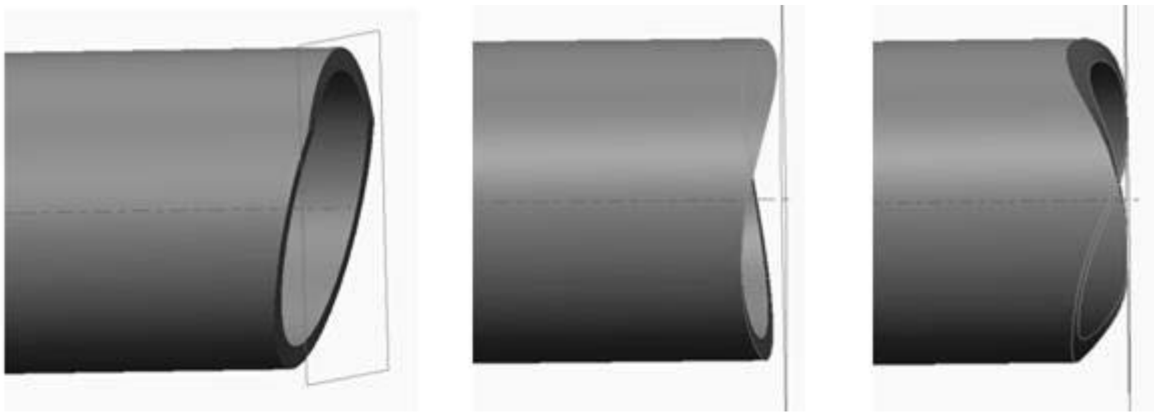

Fig. 3 Illustrations of the possible defects - oblique, concave, convex

MATERIALS AND METHODS

The first step in finding the corrective measures was to evaluate the current state. The problem is caused especially by the fact that unvulcanized rubber is very ductile. The mandrel is equipped at one end with a stop of a suitable shape (Fig. 4 left). Using of too high force can cause deformation in the stop area. On the other hand, with an insufficient force, the end of the hose will not be pushed to the stop. The other end of the mandrel is equipped with an undercut for the optical check of the sufficient hose push. First contact check was proposed, when several contact sensors were placed around the stop of the mandrel, and sufficient contact of the hose is checked with the entire front face of stop. Similarly, at the opposite end of the mandrel, the sensors are located in the radial direction to check the correct position of the hose, the design is shown in Fig. 4 right. Another option was using optical elements instead of contact in a similar configuration.

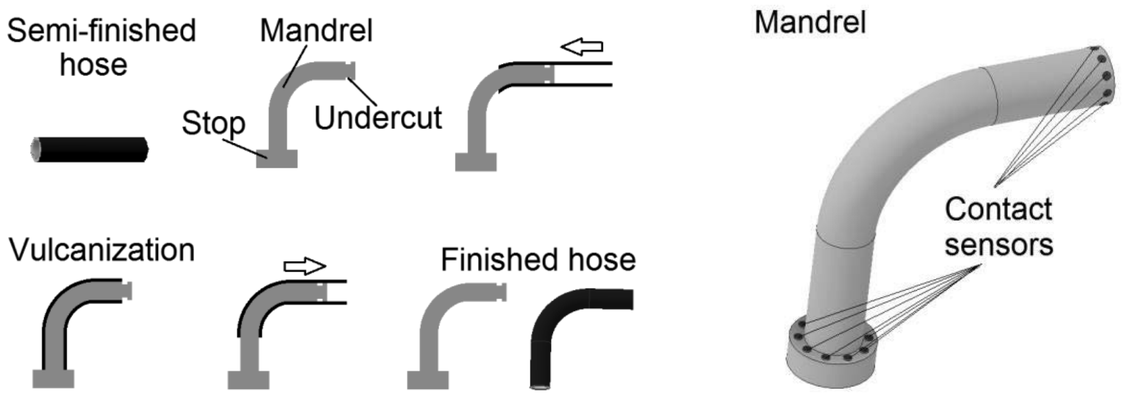

Fig. 4 Left - mandrel shape and hose placement, Right - locations of sensor on mandrel

Finally was decided that instead of preventing defects, faulty hoses will be repaired. Due to the relatively high complexity of the checking system and also because of the very variable range of hoses (lots of different mandrels shape and diameters). Each mandrel would have contain many active elements. In the vulcanization environment it is all burdened by high temperature and humidity, therefore it can be assumed that the electronic parts will lost their durability. The second considered option is to repair the already produced rejected parts. Usually the length of the hose has a considerably greater tolerance than the hose face from the plane. Here is the possibility to cut or grind the insufficient end of the hose to the required tolerance. Several experiments were performed with a grinding of hoses on conventional grinding machine Fig. 5. It has been proved that by grinding it is possible to achieve sufficient flatness of the end of the hose and also satisfactory surface quality.

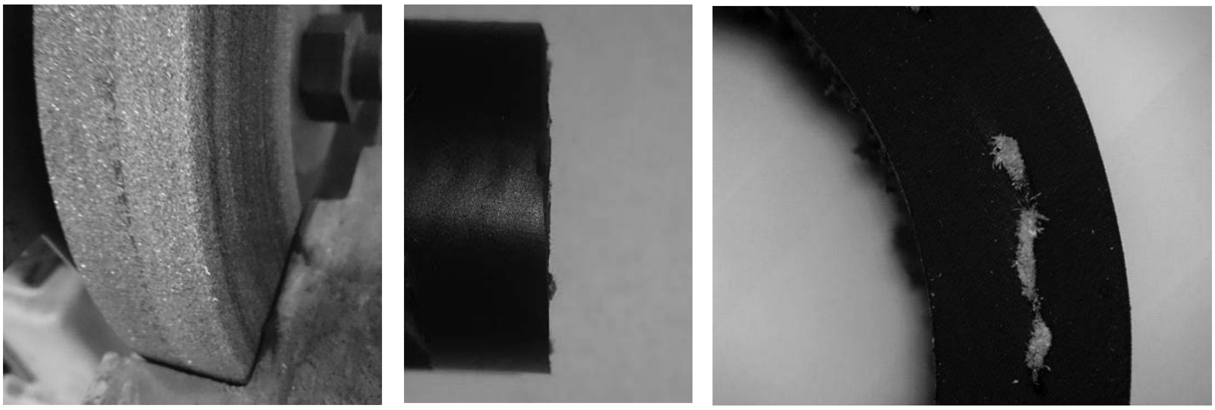

Fig. 5 Repairing of a rejected part: left – grinder, middle and right – the hose after grinding

RESULTS AND DISCUSSION

The conceptual design of a single purpose device for grinding the ends of hoses was developed (Fig. 6). The device consists of a rigid frame on which the hollow shaft is mounted by means of bearings. The fixed pin passings through the hollow shaft. The grinder is mounted on the hollow shaft slidably by means of grooving. The pneumatic drive enables the linear movement of the grinder. The stepper motor provides a rotary motion of the grinder around the pin. The principle of the device is that the hose is pushed onto pin and fixed. After that the grinder start rotation, the linear actuator sets the position of the grinder to the desired position and begins grind the hose face. The stepper motor performs a rotary movement of the grinder body around the circumference of the hose face. After circling the entire circumference, the grinder returns to the original position and the hose can be released and removed.

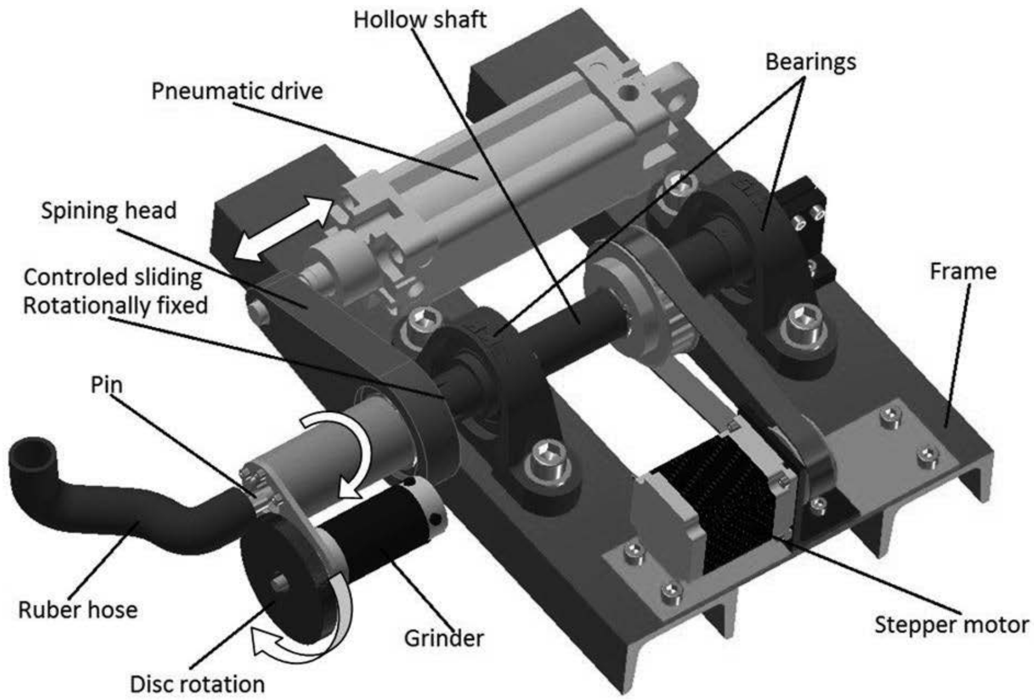

Fig.6 Design of device for aligning rubber hoses

CONCLUSIONS

The problem in the production of reinforced rubber hoses for automotive industry has been analyzed. At the beginning lot of efforts has been devoted to finding some possible mitigation measures. Later it was considered that the simplest way would be to repair the produced rejected parts subsequently after the manufacturing process. The concept of a one purpose device that could easily repair the refused parts with various diameters has been designed.

ACKNOWLEDGMENT

This publication was written at the Technical University of Liberec as part of the project "Innovation of products and equipment in engineering practice" with the support of the Specific University Research Grant, as provided by the Ministry of Education, Youth and Sports of the Czech Republic in the year 2017.

REFERENCES

1. Rodgers, B. (2015). Rubber Compounding, Chemistry and Applications, Second Edition, CRC Press 2015, ISBN: 978-1-4822-3549-4
2. Bhowmick, A. K. (1994). Rubber Products Manufacturing Technology, CRC Press, ISBN 9780824791124
3. Demirkoparan H., Pence T. J. (2015). Magic angles for fiber reinforcement in rubber-elastic tubes subject to pressure and swelling, International Journal of Non-Linear Mechanics, Volume 68, 87-95, ISSN 0020-7462.

Corresponding author:
Ing. Pavel Srb, Technical University of Liberec, Faculty of Mechanical Engineering, Department of Machine Elements and Mechanisms, Studentská 2, 461 17 Liberec 1, Czech Republic, phone: +420 48 535 3321, e-mail: pavel.srb@tul.cz