Opportunities to improve product quality with the support of industrial robots

Erika Hrušková[1,*], Miriam Matúšová[2]
Slovak University of Technology, Slovakia[1]
Slovak University of Technology, Slovakia[2]
erika.hruskova@stuba.sk, miriam.matusova@stuba.sk

Abstract: *In the industry, the concept of "production quality" means a very important and inseparable role, which has a large share in the final quality of the product. Various factors affect product quality. Above all, state-of-the-art technologies are used in every industry, which helps to adapt quickly and efficiently to changes in market conditions, which has a significant impact on the competitiveness of manufacturers to become market leaders. The manufacturers 'efforts are made to produce a flawless product that will excessively meet customers' requirements for the perfect product. An integral part of the production process is the quality control of products at certain stages of production. Measurement requirements are defined by satisfactory accuracy, variability, total cost and speed. An important factor in product inspection is currently the creation of a three-dimensional virtual model of a real product, where you can easily compare the created 3D model with the original CAD model and display dimensional deviations.*
Keywords*: QUALITY OF THE PRODUCT, PRODUCTION PROCESS, VIRTUAL MODEL, 3D MODEL, DIMENSIONAL DEVIATIONS.*

1. Introduction

The role of materials management is to extend technologies so that they can respond flexibly to new economic conditions, the determining factor of which is no longer the supply side but the demand side. If the company does not ensure efficient and effective control of the material flow of input materials, the production process will not be able to produce products at the required price, at a time when these products are required for distribution to customers. In a production environment, a lack of the right materials and low-quality semi-finished products at the time they are needed can lead to a slowdown or even cessation of production, which can then lead to depletion of stocks (finished products). For these reasons, due attention must be paid to material flow management in the manufacturing plant. The goal of material movement management is to solve material problems from a company-wide point of view, by coordinating the performance of various material functions, providing a communication network and managing material flow.
Four basic activities in the field of material flow management:

- anticipation of material requirements,
- identifying the resources and obtaining materials,
- transport and introduction of material into the working space of the machine,
- material condition monitoring. [1]

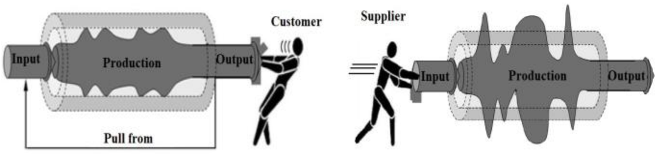

Fig. 1 *Pull system a Push system of controlling in the manufacturing process* [2]

With a focus on the goals of Industry 4.0, it is possible to create an automatic and flexible adaptation of the production process designed to track the position of materials and products. The output is to simplify and streamline communication between the material, the machines and the product itself.

2. Description of product and its assembly workplace

Bearings as mechanical components are among the most extensive products in the automotive and industrial sectors.

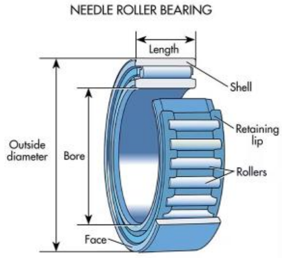

Fig. 2 *Bearing as a product of analyse [3]*

They are found in common industrial production facilities. The assembly process is fully automated and human personnel are needed at the exit of line Fig.3, when checking the inner diameter of bearings (HK) on the measuring mandrel, when packing the finished bearings into a box and then placing the full boxes on a pallet.

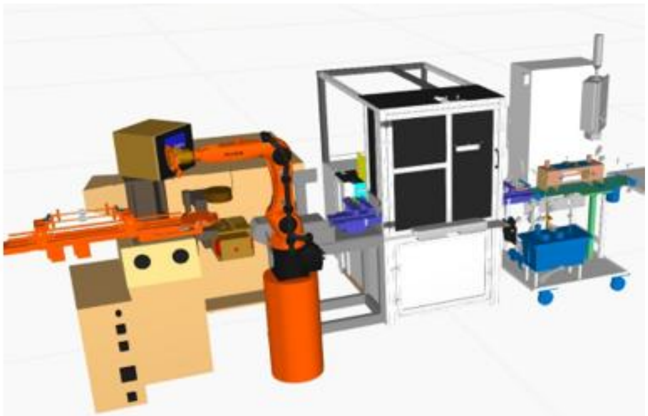

Fig.3 *Workplace of assembly line*

3. Product assembly with usage of industrial robot

Automatic control of the inner diameter of bearings can be performed manually or using a robotic workplace. A robotic workplace using a conventional robot or a collaborative robot must take into account:

- placing the robot in a confined space of an existing workplace,
- reach of the industrial robot to all parts of the workplace,
- robot load more than 0.5 kg.

The KUKA LBR isyy collaborative robot was used to design the robotic workplace to compare the measurement of the inner diameter of bearings, human vs. collaborative robot. Fig.4

Collaborative robot	KUKA LBR isyy
Number of controlled axies	6
Reliability of robot positioning	±0,015mm
Weight controlling	18,8kg
Max. carrying capacity	3kg
Max. distance from rotary axies	600mm
Max. operation speed	1000mm/s
Max. operation noisy	Not up 67dB
Safety level	IP40
Operation range of temperature	+5°C - +45°C
Assembly	Floor
Controlling	KR robot cotroller
Process of programming and simulation	KUKA Sim Pro 3.1
Manual controlling panel	KUKA SmartPAD
Manual programming	Manual directing

Fig. 4 *Parameters of robota [4]*

Industrial robot programming is possible in several ways. In the classic way in offline mode, with manual KUKA smartPAd control or manual programming, so-called learning. When programming manually, the robot is manually guided to the desired position, which is saved. Quick and easy programming of the collaborative robot allows quick changes in the program and reduces the time needed to change the program and its implementation in the workplace.

All movements of the KUKA LBR isyy collaborative robot should be sensed by speed sensors as well as torque sensors directly in the joints of the collaborative robot. The aim is to measure the required values in real time and the possibility of using these values in the automated process of measuring the inner diameter HK on the roller bearing NK.

Sensor representation of the environment is an important part of an intelligent robotic perception system. The display here covers the metric model and its semantic interpretation, which allows to represent the environment. Machine learning is used at various levels in process. Choosing a method of work of robots often comes down to getting the latest prepared information from an online repository and fine-tuning it to the current problem. Usage collaborative robots has greatly improved performance in a variety of tasks such as follows: object detection, recognition, semantic segmentation, etc. development is possible this direction for availability of experiments on publicly available data sets, as well as their comparison with other methods using standard criteria. Perception is a very important part of a complex, embodied, active, and goal-driven intelligent robotic system. fig.5

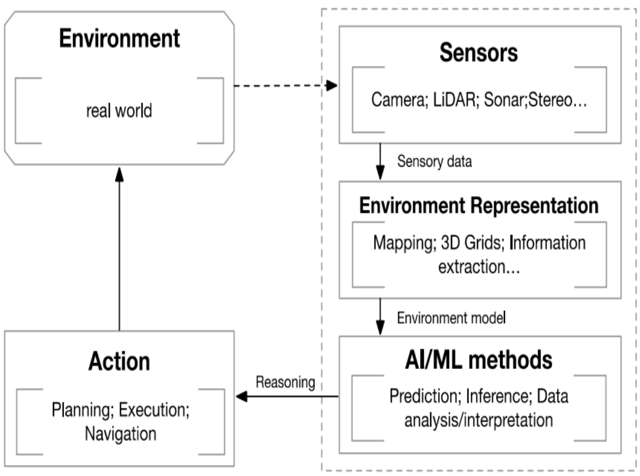

Fig. 5 *Parameters of robot* ***[5]***

3. Methods of measuring the inner diameter of the bearing

The possibilities of measuring the inner diameter of the bearing must be analyzed based on the choice of method and the possibility of using the end effector. When choosing the method of measuring the average, the following methods were analyzed these possibilities:

a) The inner diameter is measured from the image obtained using the 2D optical projection method.

b) Hole diameters are measured by bending the optical axes of two sensor heads 90° using a prism.

c) During insertion, the pressure force of the roller bearing on the measuring mandrel is automatically measured. After reaching the pressing force of 50N, the control system of the collaboration robot reads the position of the roller bearing on the measuring mandrel according to the coordinate system of the collaboration robot. [6]

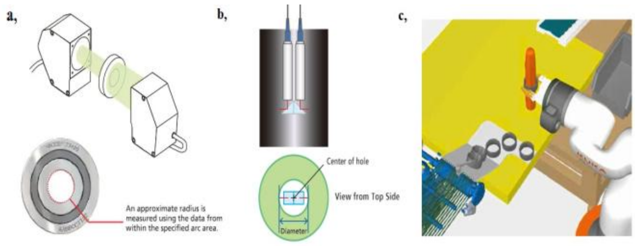

Fig.5 *Diameter measurement options* ***[6]***

When designing the automation of the inner diameter control, it is necessary to determine the trajectory of the robot's work cycles. Compared to the activity of measuring the inner diameter of a bearing by a human, the trajectory of the robot is given by the algorithm fig.6, but the trajectory of human labor is irregular. Different trajectories and man-made times arise due to imperfections in determining the pressing force of the roller bearing on the gauging mandrel.

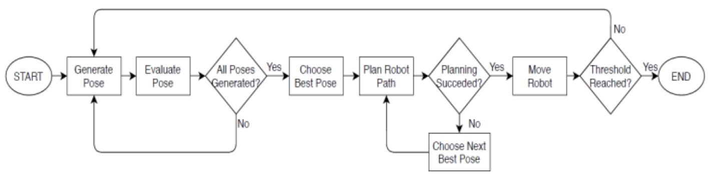

Fig.6 *The manipulator's movement to the pose [7]*

If the operator exceeds the specified value of the pressing force, the bearing will jam on the mandrel and it is necessary to use more force to pull the bearing out of the measuring mandrel. When using the robot to measure the inner diameter of the bearing, the speed and force of sliding the bearing onto the measuring mandrel must be clearly defined. When planning the trajectory of the robot, it is necessary to ensure the boundaries of safety zones. According to the ISO / TS 15066 specification, it is necessary to define three zones in which specific safety conditions apply. Fig.6

Fig. 6 *Safety zones of robot [4]*

The simulation model can be used to verify the availability of a collaborative robot and a possible collision with other objects. Subsequently, it is possible to compare the measurement time of the inner diameter HK at the NK bearing by a human factor, i.e. this operation is performed manually, with the time of the same measurement and in an automated simulated process. Fig.7

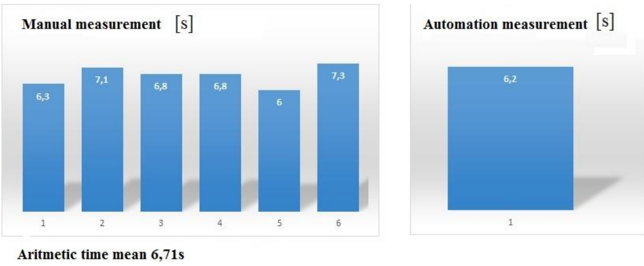

Fig. 7 *Comparison of times of manual and automatic measurement of the inner diameter of the bearing*

The time difference of manual measurement compared to automated measurement is 0,51s. The time difference of the measurement was compared on the number of 4500 pieces of measured roller bearings in one working day and the time saving in ideal conditions is 17 minutes.

When looking at time savings, only a small time difference can be seen. Therefore, there is a need to compare manual and automated measurements based on several criteria such as:

- Accuracy of the pressing force of the roller bearing on the measuring mandrel.
- Quality of evaluation of good and bad inner diameter HK.
- The real time measured during the working day.
- Human factor error.

The accuracy of the pressing force on the measuring mandrel is very important for the correct reading of the value of the inner diameter HK on the roller bearing NK, which must be within the tolerance range of the value of the inner diameter HK. The change in the pressing force therefore has a direct effect on the learning quality of the good or bad inner average of the HK, especially at the tolerance limits. The comparison was based on measurement operation time and did not take into account, for example, the rotation of operator changes, the time taken for operator breaks and many other aspects that enter into the manual measurement process. A more extensive analysis with regard to all aspects entering the measurement process would be needed to determine the exact times of the manual measurement.

With the automated measurement process, there are no common aspects enter into that to extend the measurement time. Fig.8

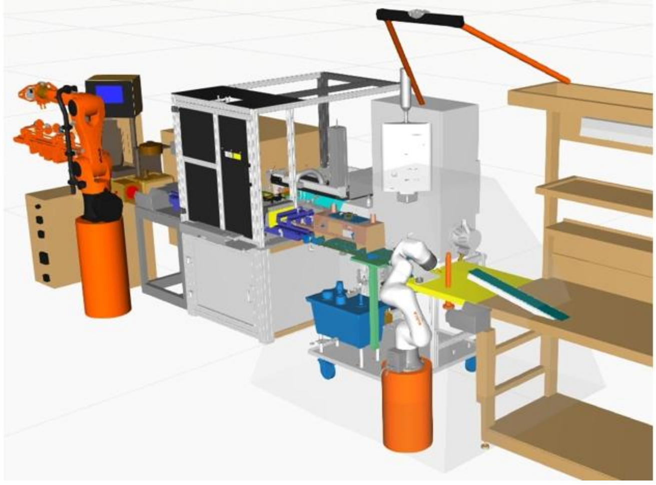

Fig. 8 *Robot workplace and simulation of measuring process*

Unforeseen aspects that enter into the automated process, such as slowing down or stopping the collaborative robot when the workspace is disturbed, or the failure, cannot be taken into account when comparing time in the manual and automated measurement process. In this process, the human factor is removed, thus eliminating the error rate during the measurement process. In conclusion we can state that mismatched roller bearing pieces do not continue into the package, but end up in a box for mismatched roller bearings.

3. Conclusion

The constant effort to streamline and improve the production system leads to efforts to reduce time, eliminate downtime, unnecessary costs for maintenance, operation and the technological, handling, transport and other functions. For all these areas, the solution is automation itself, which, if set correctly on the basis of detailed professional analyzes, provides a full-fledged substitute for the human factor.

As a substitute for the human factor, the use of a collaborative robot, which with its properties comes closest to the characteristics and movements of man.

The aim of the research was to simulate the automatic measurement of the pitch circle (HK) on roller bearings using a collaborative technique in comparison with manual measurement. A description of the method of measuring the inner diameter of roller bearings on the measuring mandrel on both sides, which is performed in cooperation with the human factor on the basis of the ISO 1132-2 standard, was characterized. The analysis took into account the following criteria: increased measurement quality, reduced line service, overall safety, increased degree of automation, complexity of equipment used and use of the latest technologies.

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