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Development of a Test System to Make Circularity Measurements of Rubber Bushing After Stress Relief

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Abstract: Rubber metal bushings are one of the most important parts of the suspension system. These parts are specially designed to minimize the vibrations and noises that vehicles are exposed to while driving. In this study, it is aimed to measure the circularity of rubber metal bushings after stress relief. A modular design is provided according to the tolerance values of the bushings in the inventory. Simultaneously with deep learning and image processing algorithms, laser circularity measurements are verified with reference to bush circularity and deformation points are determined. The detected deformation is transferred to the HMI screen. With this study, it was ensured that the circularity errors in the rubber metal bushings were taken under control and the problems that may be encountered after the production were eliminated, a more sensitive solution was provided, and a quality production and accurate results were obtained.

Keywords: bushing; circularity; deep learning; image processing; quality control

1 INTRODUCTION

The wishbone, which is one of the most important components of vehicle suspension parts, has important components within itself. Wishbone bush is one of these parts. The bushing, which enables the swing to work better, is one of the most important parts that absorb the effects such as vibration, shock and impact from the road and the moving parts of the vehicle, preventing their transmission to the vehicle body and providing the driving comfort requirement. The bushings, which can have various geometries according to the place and task used, are basically single-layer bushings consisting of inner bushing, outer bushing and rubber material filling between the bushings [1]. Fig. 1 shows various metal rubber bushing parts.

Figure 1 Bushings [1]

The rubber metal bushings shown in Fig. 1 generally consist of a metal outer bushing, a metal inner bushing and a rubber material filling between the bushings. Rubber parts are produced in special molds in rubber presses with a method called vulcanization method. In rubber bushings, diameter process is applied by giving a plastic shape to the outer metal along the radius from the outside to the center. This diameter process can be done with symmetrically closing jaws, or it can be done by passing it through a conical mold. In Fig. 2, there is a visual representation of the diameter process [2].

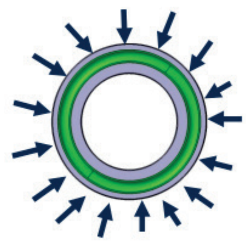

Figure 2 Diameter Processes [2]

When the production for rubber bushings is examined, the part coming out of the mold is left to the cooling process. During cooling, the rubber material in the regions close to the inner and outer bushings cools later and is pulled towards the edges. As a result of this shrinkage, internal stresses occur in the rubber material. For this reason, the produced bushings are produced slightly larger than the slot to be mounted, and the outer bushing is plastically deformed by the diameter process and the diameter value is reduced and mounted in the slot. After the diameter process, the outer bush may deteriorate due to errors such as circularity, rubber material behavior, insufficient pressure, mold error. The cases where this deterioration is ignored should only be within the tolerance values. In cases where the bushings are outside the tolerance values, the tight fit of the bushing surface cannot be ensured and the bushings come out of the body. For this reason, 100% control of the bushings is required after the diameter process.

1.1 Measuring

The measurements made before the measurement standards were created varied depending on the abilities of the person making the measurement, and there was no certain limit to these variations. In order to eliminate these differences, international measurement standards have been established. In order to ensure the conformity of the productions and to be within the tolerance limits, the measurements must be correct. The position of the part to be measured is one of the factors affecting the measurement.

Accordingly, the sensitivity of the measuring instrument and the environmental impact should be taken into account according to the limits of the parts to be measured. Circularity is the condition that all elements in the plane perpendicular to the axis of the part are equidistant from the axis of rotation. The condition that the elements in the plane perpendicular to the part axis are in two concentric circles within the tolerance distance is called the circularity tolerance [3].

2 MATERIAL AND METHOD

Within the scope of this study, firstly, the tolerance values of the bushings in the inventory were determined. Diameter, tolerance and product code values of the determined bushings are recorded. In order to provide modular design according to the bush variety in the recorded table, bushing positioning apparatuses in accordance with the bushing inner diameters were designed and produced. At the same time, the apparatus has been designed for the laser sensor in such a way that the height adjustment can be made without error according to the bushing inventory. Apparatuses made are exemplified in Fig. 3.

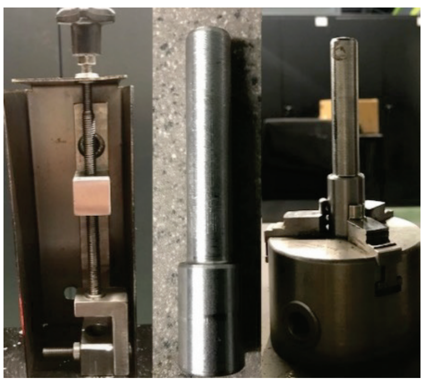

Figure 3 Apparatus [3]

2.1 Test System Preparation

Secondly, the preliminary design of the system, material selections, the laser sensor to be used, servo motor and motor driver, image processing interface, industrial type camera and PLC and HMI as controller were determined. Sensor sensitivity is selected according to bushing tolerance values. With deep learning and image processing algorithms, laser circularity measurements are verified with reference to the circularity of the bush, and the points where the circularity is corrupted or deformed are detected. The detected deformation is transferred to the screen as a faulty area. Tolerance values and bush diameter value specified in the calibration page must be entered. Afterwards, calibration should be done in order to use the test device and to obtain healthy measurements. The bushing inner diameter apparatus, which is selected according to the bushings to be tested, is fixed to the chuck. The bushing to be referenced is placed and at least 10 measurements are made by changing the direction. Measurements are made with the data collection button. After the data collection process is completed, the calibrate button is pressed. The recipe number field on the main screen is filled. The calibrated recipe number for the bushing to be measured from the registered recipes is activated, the bushings are placed on the apparatus in order and the test process is started.

Figure 4 Machine Interface

If a bushing is not placed on the bushing inner diameter apparatus, the error screen displays a missing part warning and the green light does not appear. During the placement of the bush on the apparatus and the measurement, data is taken from both sensors. If there is a measurement that is not within the tolerance values, the red light representing that sensor lights up, and the inspection is repeated with the image processing algorithm. The lower and upper bases of the tolerance values are located next to the light that represents each sensor. If the measurement result is incorrect, the red warning lamp lights up and audible warning is given. The machine interface is shown in Fig. 4.

2.2 Measurement and Verification

The measurement system is as follows; A bushing, which is determined for calibration and has the correct dimensions, is taken and the bush is properly positioned in the measuring slot. Sampling data is collected from 10 different points randomly on the bush. The bushing tolerance value is entered and the calibration process is completed. These calibration data will be used in the verification of the bushing data to be measured, and the surface diameter values will be checked and compared with the results of image processing and deep learning algorithms. As a result of these comparisons, the instant diameter value of the bush and the surface points with diameter errors are detected and reflected on the screen. The verification made by image processing and deep learning method is shown in Fig. 5.

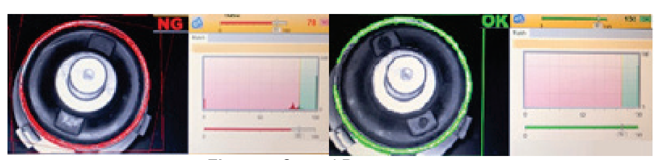

Figure 5 Control Process

3 RESEARCH RESULT AND DISCUSSION

With this study, circularity errors in rubber metal bushings are controlled, eliminating the problems that may be encountered after production and ensuring a quality production, and also obtaining accurate results by taking the margin of error from the operator and offering a more precise solution. With 6 different recipe recording systems, bushing measurements in different tolerance ranges and different diameters have been accelerated. The distance values of the instantaneous laser values were measured for the accept bushing and reject bushings.

These measured values are shown in Fig. 6. For cases where the value difference between the center distance and the target distance values exceeds the tolerance range, the deformation zone was determined by comparing the values with deep learning and image processing algorithms.

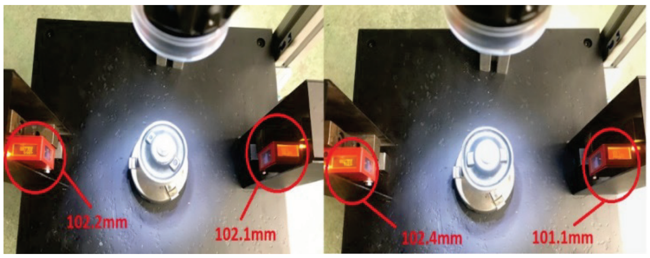

Figure 6 Measuring Process

3.1 System Measurement and Compliance Check

Measurement trials were carried out on a total of 450 bushings. As a result of these trials, there are 395 accepted and 55 rejected bushings after manual measurement. There are 406 accepted and 44 rejected bushings in the trials with system measurement.

When manually measured and rejected bushes are re-measured precisely, it is determined that they comply with the acceptance criteria and it has been determined that the system measurement works more stable than the manual measurement.

Table 1 Manual and System Measurements

	⌀20,5-25,5	⌀25,5-30,5	⌀30,5-35,5	⌀35,5-40,5	⌀40,5-45,5
Manuel Reject	27	15	9	1	3
Manual Accept	123	85	91	39	57
System Reject	22	12	9	0	1
System Accept	128	88	91	40	59

As can be seen in Tab. 1, the number of bushings with deformation detected has been reduced. In addition, deformation detection has been performed clearly for bushings where no deformation could be detected.

4 CONCLUSION

In this study, diameter measurements and bushing ovality approval processes were carried out after the diameter process in rubber metal bushes. With the automatic control system, the operator's initiative has been removed in control. The system seen in Fig. 7 can be controlled and monitored via HMI screen and SCADA.

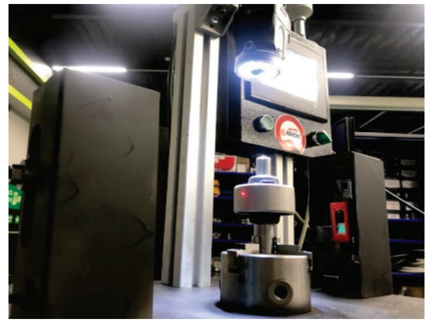

Figure 7 Test System

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Notice

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