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CONTRIBUTION TO REDUCE DEFECTS IN PRODUCTION OF PLAIN BEARINGS

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Abstract:
DAIDO METAL KOTOR AD (DMK) is a Japanese company dealing with production of plain bearings for vehicle engines. There are four highly productive automatized machining lines in DMK for bearings production. During production, some measures can deviate from the required ones. For this purpose, I have made a resolving concept, designed, had it made and tested a device-machine for checking bearings production and reached excellent results. The device is installed on the line consisting of: machine construction, electro-pneumatics, optical sensors, other sensors, PLC operation. After treatment, the bearing comes into device, it is checked, and if defected, it is rejected, the line is stopped and the operator searches the cause. This ensures quality of production, eliminates defected bearings, reduces costs, making customers more satisfied. Some of many high rating customers are: Honda, Volvo, Mercedes,..

Keywords:
Plain bearing, sensors, electro-pneumatics, PLC operating

1. INTRODUCTION

DAIDO METAL KOTOR AD (DMK) located in Kotor, Montenegro is one of the affiliated companies of DAIDO METAL Ltd. Co, which is the head company located in Nagoya – Japan, dealing with the production of plain bearings for vehicles engines. There are four automatized highly productive machining lines and two lines of presses in DMK, for OEM (Orginal Engine Manufacturing) mass production of plain (slide) bearings.

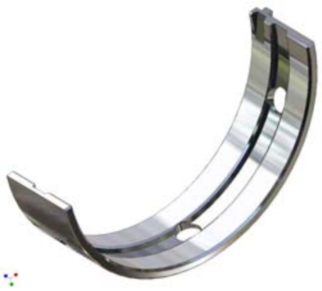


Figure 1 Typical example of plain bearing

DMK supplies top world companies with its products, such as: Volvo, Honda, Mercedes, Ford, etc. Figure 1 shows typical example of plain bearing. Products, that are made for the famous customers on the machining lines herein noted, are connrod and main bearings.

This production, as much as any other, is followed by appearance of defected products, which has to be identified, located, controlled, reduced or, if possible, to be completely eliminated.

2. DEVELOPMENT OF DEVICE FOR CHECKING PLAIN BEARINGS

Plain bearing, as a mechanical element, appears simple, on the first sight. However, this is a very important, precise product for vehicles engines, which has specific characteristics of materials made of. Figure 2 shows location of plain elements-bearings.

Materials used for making plain bearings for vehicles engines of bimetal strip, are mostly alloys of aluminium, bronze and tin. Figure 3 shows bimetal strip- material for production of plain bearings.

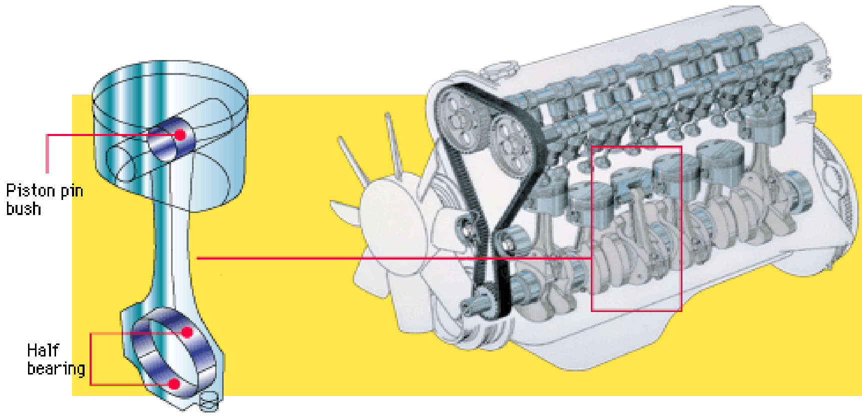


Figure 2. Plain elements as parts of vehicles engines

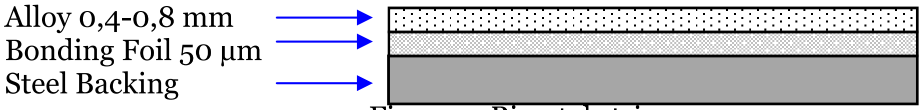


Figure 3 Bimetal strip

Elements characteristic for plain bearings are: wall thickness, height of half bearing, including its height crush, nick, oil groove, lubrication holes, free spread, relief, etc.

Technology of manufacturing plain bearings from bimetal strip involves the operations on the pressing machines and the machining lines.

There are four operations carried out on the pressing machines: stamping the blanks, cutting the blanks off the bimetal strip which is coiled, then operations of bending and forming.

There are 11 operations carried out on the machining lines: face and chamfering, corner chamfering, piercing the lubrication holes, nick milling, nicking, grooving, counter sinking, back side brushing, height crush finishing, auto checking and wall thickness finishing.

On the operations carried out on the lines of presses and the machining lines, from different reasons there comes to production of defected bearings. A list defining the causes of defected (rejected) bearings was made, according to the records and analysis of defected bearings.

The reject causes are: indents on back steel, set - up pieces, thickness, length, height crush, corrosion of back steel, indents on inner surface, mechanical damages of back steel on bm – strip, roundness, inside chamfering, position of nick, damage of inner surface, position of lubrication holes, position of oil grooves, outside chamfering, countersinking, free spread, bad blue contact, twisting, bad nick shape, bad stamp, etc.

Control of some elements (dimensions) of each bearing is carried out during the machining process. Former control refers to the elements of bearings that are checked on Autochecker machine: height, nick protrudence (if the bearing has nick, according to drawing), detection of lubrication holes, but not the position (if the bearing has any, according to drawing), and wall thickness which is controlled on the boring machine.

According to the analysis of plain bearings, proposals for improving production process and reducing reject, aiming to cut down expenses, upgrade satisfaction of customers and employees, in conformity with ISO standards, the Device for checking plain elements which is installed into the machining line Y-01 has been developed.

According to my conception and project, the Device for checking plain bearings working *in-line* and controlling certain elements of each bearing being machined on the line Y-01, has been developed within the company DAIDO METAL KOTOR AD.

The elements that have to be checked are the following: length of plain bearings (Figure 4a), position of lubrication holes in respect to the angle and length of bearings (Figure 4a) and free spread of plain bearings (Figure 4b).

The elements noted have not been so far controlled on every bearing made, having as a consequence considerable amount of rejected-bad bearings. Figure 4 shows the elements of plain bearings which have to be controlled.

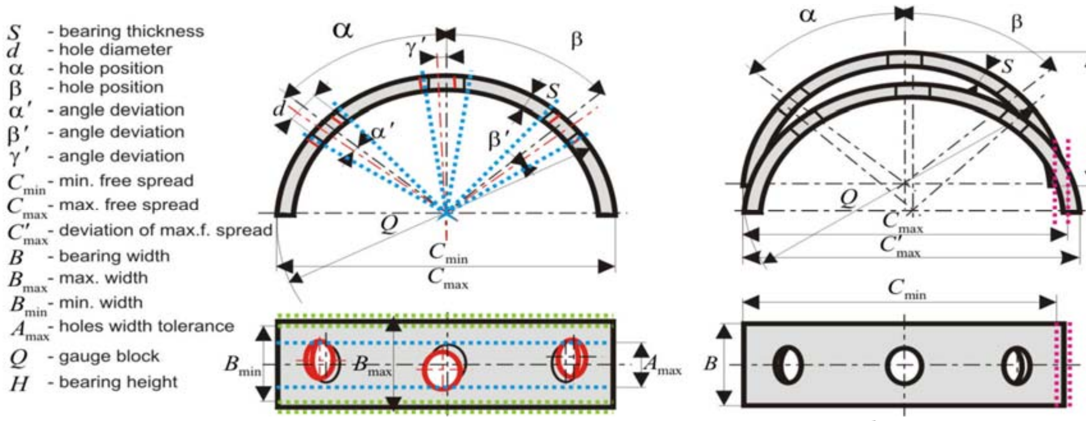


Figure 4 Elements of plain bearing which is checked

Deviation of position of lubrication holes, length and free spread of bearings from the dimensions required by the drawing, can be caused by the following: bad set up of machines and tools, mishap of tool, change delay, etc.

Projected and made device (Figure 7) for checking three elements of plain bearings (holes, width and free spread), will be installed on the most suitable location in the line Y-01 and it will be working in-line. When projecting, the following parameters were used: velocity (cycle) of Y-01 operation, 1.8 sec. , diameter of bearing which can be reached on the line, and which is 30-80 mm, length of bearing which is to be checked, 13-30 mm, number of holes for checking, 0-3, positiong is after Autochecker machine.

Construction

Construction is made of steel costisting of: control assembly (Figure 7), conveyor belt, support and stand, energetic-driving box, operating-commanding box, pneumatics and electropneumatics, and technique of sensors.

Figure 5 Device for checking plain bearings

Driving

Driving is microcontrolling-PLC MITSUBISHI Fxon-60MR , shown in Figure 6.

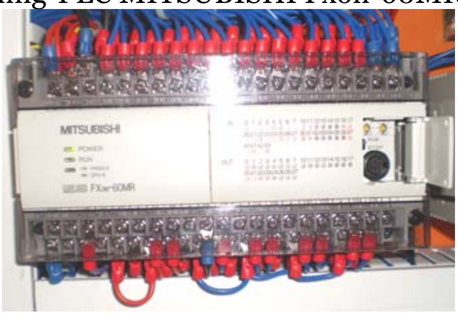


Figure 6. PLC of device for checking plain bearings

Description of operation

Before activating the Device for checking bearings to automatic operation, the option for checking plain bearings, ie., bearing with a hole, number of holes, is chosen by switches. Of course, before starting automatic operation, the Device for checking bearings is set up manually.

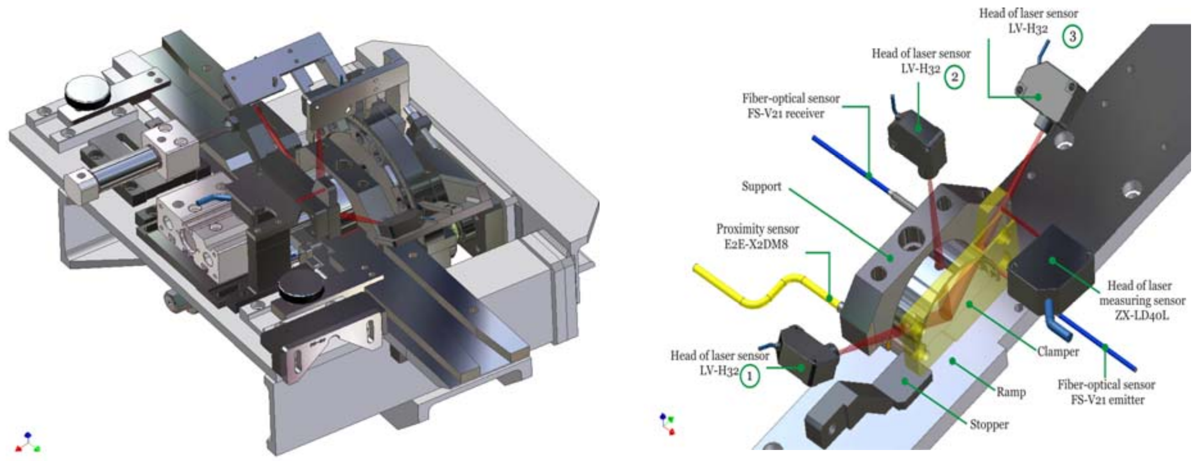
After having been checked in autochecker machine in the line Y-01, plain bearings (one by one) are driven by a conveyor belt to the separator (assembly activated by a pneumatic cylinder) which stops them making „magazine“ (row of 2-8 bearings). Receiving the command from PLC (Programabil Logic Controler), the separator passes one by one bearing into Device for checking where the check is carried out in the control assembly (Figure 7a). When the bearing is let through by the separator, the conveyor belt takes it to the entry of the Device for checking, goes down the ramp between the guides (one guide is fixed, and the other one is movable depending on the lentgh of the plain bearing being machined) and gets stopped by a stopper to the checking position.

When the bearing is stopped, its presence is detected by an inductive proximity sensor, and according to the program, PLC provides an instruction ie. an outgoing signal which activates a pneumatic valve 5/2 of a clamper. The clamper is a plate linked to the pneumatic cylinder and clamps the bearing to the plate which makes it fixed and ready for control.

In the same time, checking is performed, ie., comparing the values with input tolerances on amplifiers for lubrication holes, width and free spread.

After checking, which lasts for 0.4 ms, the bearing is released by the clamper and the stopper, anf if any of checked values is not good ie., is not in conformity with the input tolerances, a lamp switches on through PLC, giving a signal to the pneumatic valve of the pusher, that after the bearing goes under the second inductive proximity sensor, it is detected and pushed to the box for bad-rejected bearings. However, if the bearing is good, it goes freely down the ramp to the conveyor which is horisontal. The conveyor then takes it towards the machine for the final treatment (wall thickness finishing).

The Device contains the following electro-pneumatic and pneumatic elements:
Electro-pneumatic valve, type SMC SY7120-1MZ-02, SMC VS3115-021DBL, noise bumper SMC ANA 1-02, clamping switch NISCON BN-121B-10, pneumatic cylinder KOGANEI DA 20x15-12, pneumatic cylinder SMC MGPM-20-20-Z7BW, pneumatic cylinder KOGANEI DA 20x50-12, pneumatic cylinder SMC CM2RK-A20-25, bumping irretrievable valve SMC AS 2201 F 1/8.



a) b)

Figure 7. Control assembly
Figure 7a – Control assembly of device for checking plain bearings
Figure 7b – Sensor control of plain bearings elements

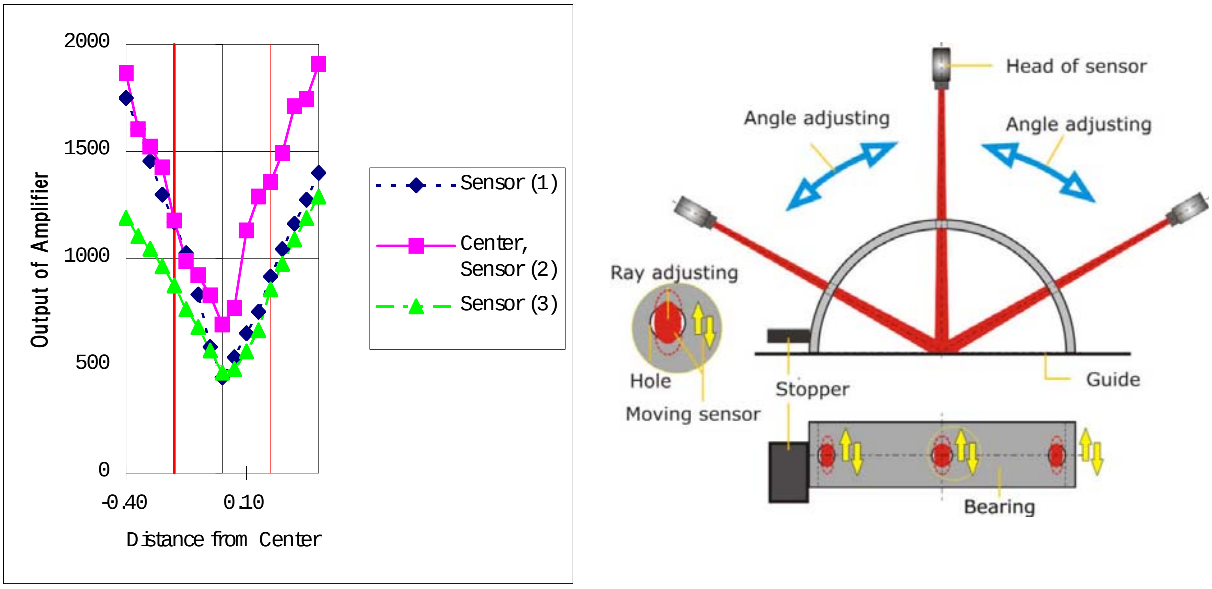
The following checks are done by selecting the sensors shown in Figure 7b: checking position of lubrication holes in relation to the angle and width KEYENCE LV-H32, checking the plain bearing width OMRON ZX-LD40L and checking free spread of plain bearing KEYENCE FS-V21.

2.1 Testing device for checking plain bearings

Testing the head of the laser optical sensors LV-H32 (1), (2), (3) and amplifiers LV-21A. Sensitivity and sensing the amplifier to the change of positions of the holes for lubricating bearings. Sensing the amplifier LV-21 A

Table 1 Sensing the amplifier for different holes out of position

Distance from hole centre	Sensing the amplifier			Note
	Sensor (1)	Centre, sensor (2)	Sensor (3)	
0,40	1400	1908	1290	Forward
-	-	-	-	
0,05	540	768	485	
0,00	446	692	469	Centre
-0,05	588	828	572	Backward
-	-	-	-	
-0,40	1750	1865	1190	



a) b)

Figure 8 Testing sensitivity of laser optical sensor LV-H32 and amplifier LV-21A

Figure 8a shows a diagram of results reached by testing sensitivity of sensing the amplifier KEYENCE LV-21A, to the changes of positions of holes related to width. Figure 8b shows set up of the control assembly for this testing and laser light beam previously adjusted, holes deviation rating 0.0 do ±0.4 mm by step of 0.05 mm in direction of bearing axis, on the diagram, sensing the amplifier is shown (with enough accuracy) by linear dependence.

2.2 Testing device for checking – Position of holes for lubricating plain bearings

Testing Device for checking plain bearings, regarding the position of holes for lubrication, was done using forty plain bearings with three holes, prepared in advance. Also, all measuring pieces were measured, marked, and all required measures were entered into the diagram (Figure 10).

After setting Device for checking plain bearings, all measuring pieces-bearings are let through device where sensing the amplifier is done and data are entered into the table 2 and diagram in figure. These data are taken for all measuring pieces for different adjustments (size of laser beam) of head of laser sensor LV-H32.

After having these data, the diagrams for every sensor (1,2,3) were made, which resulted with a final analysis.

Table 2 Sensing the amplifier for beam adjusted as in Figure 9

r/b	Head 1, amplifier 1	Head 2, amplifier 2	Head 3, amplifier 3
No.1	163	177	147
No.2	197	181	156
-	-	-	-
No.40	787	442	739

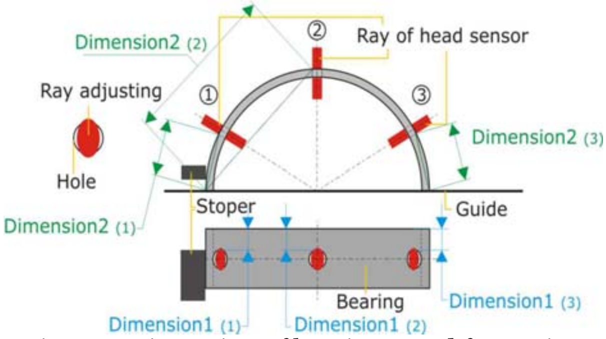


Figure 9 Dimension of bearings used for testing

Figure 10 shows the diagram of testing the device for the hole 1, all 40 bearings, for adjusted beam of laser light of senor head LV-H32, as in Figure 9. Also, this diagram presents sensing the amplifier and measured Dimension 1 and Dimension 2, as well as rejected pieces marked with x, for 40 measuring pieces.

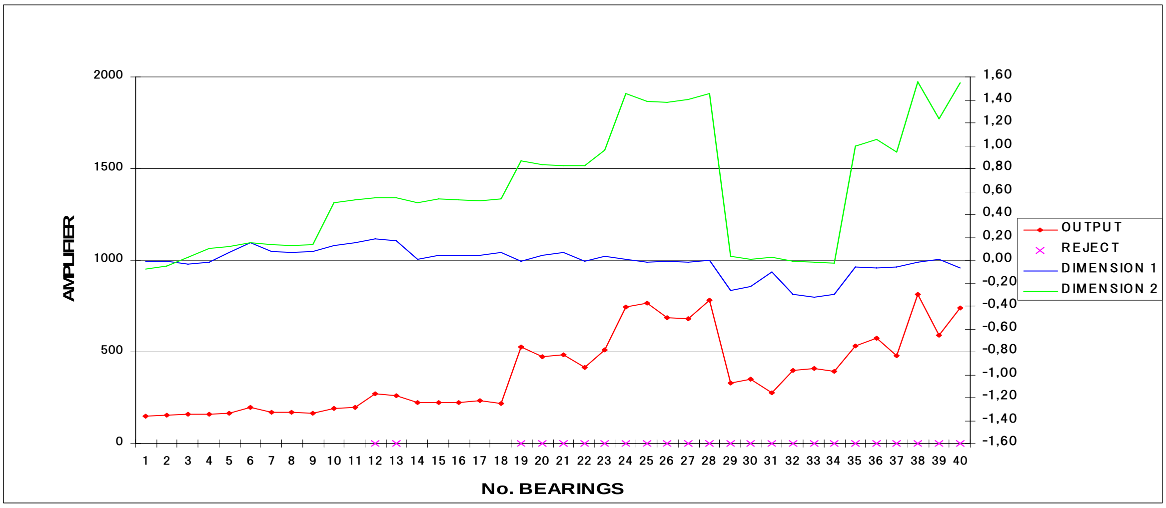


Figure 10 Diagram of results got by testing device regarding the position of holes for lubricating bearings

Figure 10 shows that changes of Dimension 1, Dimension 2 cause changes in sensing the amplifier. If you input the sensing limit corresponding the values of amplifier sensing good pieces or if it is greater enough, the rejected bearings (x) will be detected (value of sensing the amplifier exceeds the limits) and device for checking will eliminate them, according to the program defined in PLC.

2.3 Testing device for checking – Width of plain bearings

For testing the device regarding width of bearings, 10 measuring pieces were prepared.

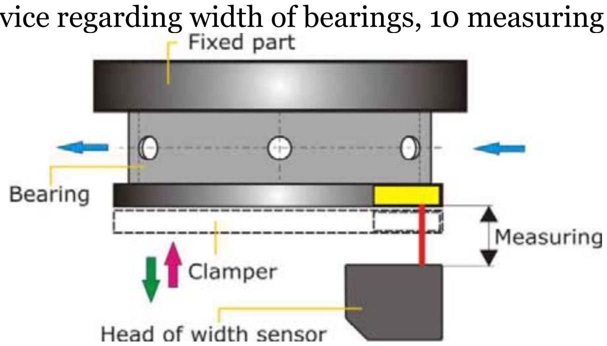


Figure 11 Layout of checking width of bearings in device

Table 3 Dimensions and results of testing with measuring pieces for checking width of bearings

Measuring pieces	Mark	Measured values	Sensing the amplifier	Bottom value, by drawing	Peak value by drawing	Bottom value of amplifier	Peak value of amplifier
No.1	1	19,00	19,03	19,10	19,60	19,15	19,55
-	-	-	-	-	-	-	-
No.10	10	19,70	19,689	19,10	19,60	19,15	19,55

Figure 12 shows the diagram of results got by testing for 10 bearings prepared in advance whose dimensions were measured and shown in table 3.

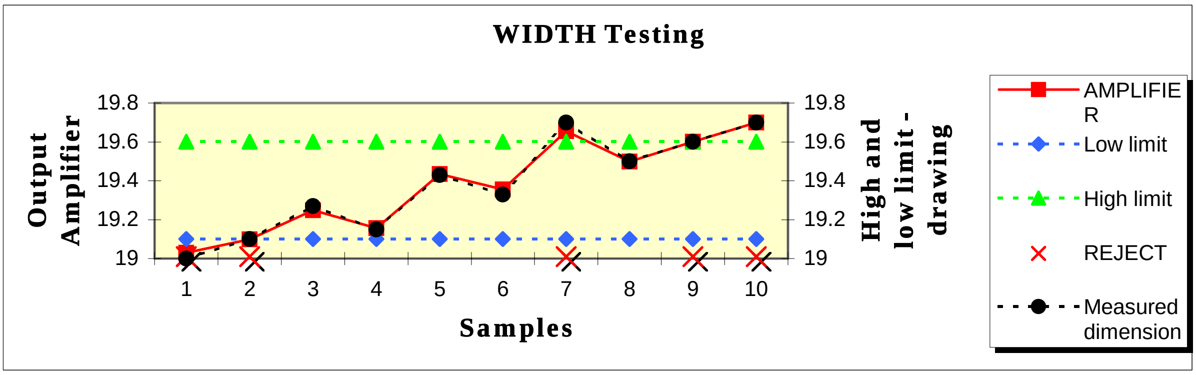


Figure 12 Diagram of results got by testing device regarding bearing width

Highly precise optical OMRON laser sensor ZX-LD40L and amplifier OMRON ZX-LDA 11-N, were previously adjusted to the device and the bearings drawing, sensing the width values of measuring pieces (Figure 11) which were later on entered into the diagram. Bottom and peak values set on the amplifier, correspond to the tolerance field being a little bit more narrow in respect to the tolerance field defined by the drawing, because of those bearings whose values are on the limit of tolerance field – for sake of assurance. The amplifier detects those bearings whose width is out of tolerance field and according to PLC program, the elements of device eject them as defected.

2.4 Testing device for checking – Free spread of plain bearings

For testing the device in respect to the bearing free spread, 10 measuring pieces were prepared.

Firstly, the Control assembly of device (figure 7a) is set for a certain product ie., measuring pieces, according to Figure 13, as well as the position of a fiber optical sensor KEYENCE FS-V21 (emitter and receiver). Measuring pieces are let through device and the amplifier reads the values for every part. Values got are shown in Table 4 and on diagram. Diagram also shows that dimensions which were previously measured (given in Table 4) follow the values read on the amplifier. If you set peak value of the amplifier sensing, in accordance with the initial value on the amplifier and the bearing drawing, measuring parts exceeding the limit set on the amplifier, are ejected from device. Dependence of values of sensing the amplifier and changes of free spread dimensions is linear.

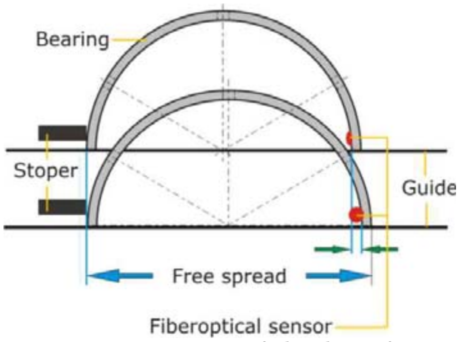


Figure 13 Layout of checking free spread in the device for checking

Table 4 Dimensions and results of testing with measuring pieces for checking free spread of bearing

Measuring pieces	Mark	Measured values	The amplifier sensing	Bottom value by drawing	Peak value by drawing	Peak value of amplifier
No.1	1	71,00	445	69,5	71	430
-	-	-	-	-	-	-
No.10	10	70,75	367	69,5	71	430

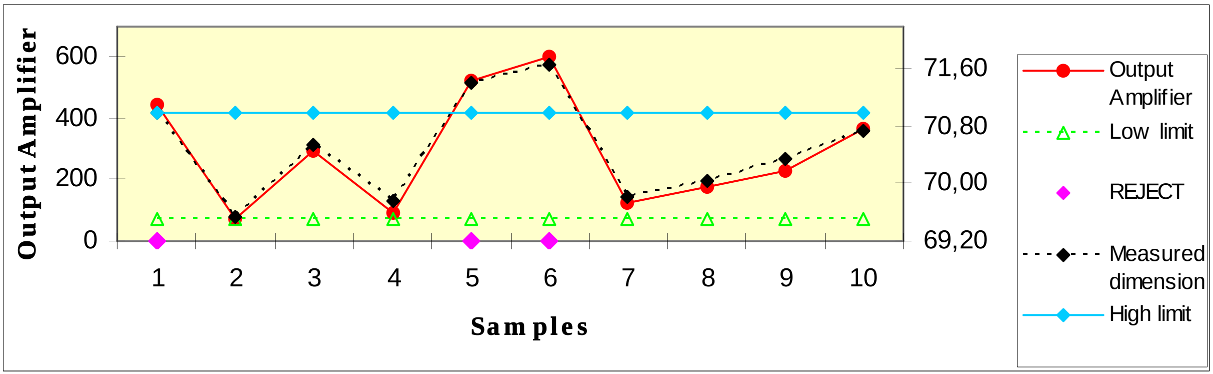


Figure 14 Diagram of results got by testing device in respect to free spread of bearings

3. ANALYSIS

Using the most modern laser technique and constructive design of the device – adjusted to the selected sensors, PLC driving, has contributed to control of products elements in this type of industry. Testing results, previously described, confirm possibility of checking the elements of bearings with selected sensors (wide range of adjustments) and assurance that a rejected bearing, caused by these three elements being controlled, will be detected.

After individual testing, testing of operation stability of Device for checking was also performed, including coexistence of results got by individual testing. All measuring parts were mixed and let through device, which exactly selected and ejected all defected parts into the reject box. Process of testing was repeated for 10 times.

4. CONCLUSION

This paper describes the device which was projected with intention to work in-line and to check three parameters of each bearing during the production process. In case of detecting defected parts, it stops the process of bearings production on the machining line Y-01. The device for checking incorporates: electro-pneumatics, the most modern sensor technique and its application in industry, including complete driving by PLC.

Reduction of rejects, based on three elements noted in total reject amount, is also reflected in cutting down production costs, price of manufacturing, final price of product. This also results in providing profit for the company, therefore affecting the employees`salaries and their satisfaction , as well.

This project is important, not only for reducing defects in production, but also to assure that the final customer will get well controlled and high quality product.

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