

DESIGN OF AN AUTOMATED SYSTEM FOR TESTING EGR VALVE LEAKAGE

PROJEKTOVANJE AUTOMATIZIRANOG SISTEMA ZA ISPITIVANJE PROPUSNOSTI AGR VENTILA

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ABSTRACT

Increasing production capacity and increasing the number of orders has resulted in the need for faster, easier and simpler testing and control of products before delivery. The use of automated measurement and control systems achieves great savings and advantages, which allows for the reduction of complaints and the delivery of poor-quality products to the end customer. The automotive industry requires high precision and product quality. In order to meet all requirements, it is necessary to raise the measurement and control systems to a higher level and thus facilitate the fulfillment of the above. The paper presents the process of automating the measurement system for testing EGR (Exhaust Gas Recirculation) valve leakage. The automation of the system and the method of control open up the possibilities of application to other similar parts. By analyzing the operation of the system, monitoring and controlling output parameters, data indicating the quality of the product. Improving product quality results in increased competitiveness on the market.

Keywords: automation; measured system; measurement; programming; product control; mechatronic.

REZIME

Povećavanje kapaciteta proizvodnje i povećavanje broja narudžbi rezultiralo je potrebom za bržim, lakšim i jednostavnijim ispitivanjem i kontrolom proizvoda prije same isporuke. Primjenom automatiziranih sistema za mjerenje i kontrolu ostvaraju se velike uštede i prednosti što omogućava smanjenje reklamacije i isporuke nekvalitetnih proizvoda krajnjem kupcu. U automobilske industriji zahtijeva se velika preciznost, kvalitet proizvoda, te tačnu i pravovremenu isporuku. Da bi se svi zahtjevi ispunili neophodno je sisteme mjerenja i kontrole podizati na veći nivo i tako olakšavati ispunjavanje navedenog. U radu je prikazan proces automatizacija mjernog sistema za ispitivanje propusnosti AGR ventila. Automatizacijom sistema i načinom kontrolisanja, otvaraju se mogućnosti primjene i na druge slične dijelove. Analizom rada sistema, praćenjem i kontrolisanjem izlaznih parametara prikupljeni su podaci koji ukazuju na kvalitet odnosno valjanost proizvoda.

Ključne riječi: automatika; mjereni sistem; automatizacija; mjerenje; programiranje; kontrola proizvoda.

1. INTRODUCTION

The complexity of manufacturing products for the automotive industry results in an increasing number of measurements and product controls before delivery. Specific customer requirements, standard requirements, monitoring and control result in increased product manufacturing and delivery times. In order to optimize the above, it is necessary to design a device for automatic product measurement. Nowadays, when companies are trying to reduce production costs as much as possible, every part of the production system is analyzed with the aim of eliminating unnecessary costs [1,2]. One of the areas that offers significant opportunities for cost reduction is the measurement and control of the EGR valve. The basic construction characteristics of the EGR valve relate to its connection to the exhaust gases on the one hand and the connection to the electronics on the other. Since the EGR valve is manufactured as a casting, its air permeability and leakage control is necessary, as circulation of exhaust gases of different pressures, it is necessary to control the permeability of the casting structure itself. When forming and manufacturing the product, there is a possibility that certain measurements on the openings to which the car exhaust systems are connected are not within the appropriate tolerances, which leads to inadequate air circulation, and thus reduces the overall functionality of the device [3,4,5].

2. APPLICATION AND MANUFACTURING METHOD OF EGR VALVE

Due to increasingly strict legal regulations regarding the release of harmful gases into the environment, there has been a need for devices that enable the reduction of harmful gas emissions while also not reducing the overall functional and usable characteristics of the vehicle [6].

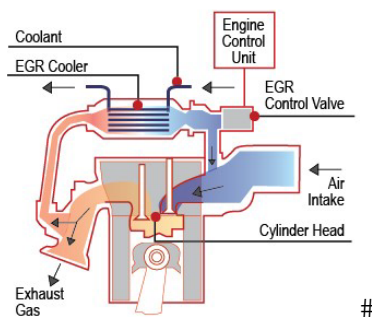


Figure 1. Example of installing an EGR valve in a vehicle engine [6].

The EGR valve is a device that allows the control of exhaust gases that are returned to the intake manifold. It is used in diesel and gasoline engines. The principle of operation consists of separating a part of the exhaust gases from the engine and redirecting them back into the engine cylinders, i.e. the goal is to introduce a smaller or larger amount of exhaust gases into the fresh air and fuel mixture, which is used to regulate combustion. In other words, an excessive amount of oxygen creates a hot flame and accelerated combustion of the mixture, as a reaction to the increase in temperature in the combustion chamber, an unwanted chemical reaction occurs between oxygen and nitrogen from the intake air, during which toxic nitrogen

oxide is created. The consequence of this is an increase in environmental pollution, and less oxygen remains in the mixture in the engine for fuel combustion, which reduces engine power. Namely, when an appropriate amount of burned exhaust gases, which do not contain oxygen, is added to the burned mixture, the combustion temperature decreases and the engine operating parameters are brought back to normal.

2.1. Manufacturing the aluminium housing of the EGR valve

The manufacturing process of the aluminium EGR valve housing consists of high pressure casting of aluminium in metal molds. The construction of metal molds for die-casting procedures represents a significant construction challenge and requires a combination of knowledge and acquired experience in shaping and making them. A large number of criteria must be met during the process of constructing and shaping metal molds. Molds must be designed and constructed so that they can fulfill four basic functions:

- must be able to hold the melt in the shape of the future casting,
- must be designed to allow a path for the melt to reach the mold cavity,
- should be able to dissipate heat during casting,
- the ability to separate the formed casting from the mold at the end of the process.

The mold for the casting of the AGR valve housing consists of a total of four molds, two of which are located on the moving side and two on the non-moving side, and four slides that directly affect the formation of the valve housing engraving. In addition to the molds, there are also inlet chambers for the supply and removal of melt, as well as four pairs of aerators that enable the removal of dirt and unwanted particles inside the housing [7].

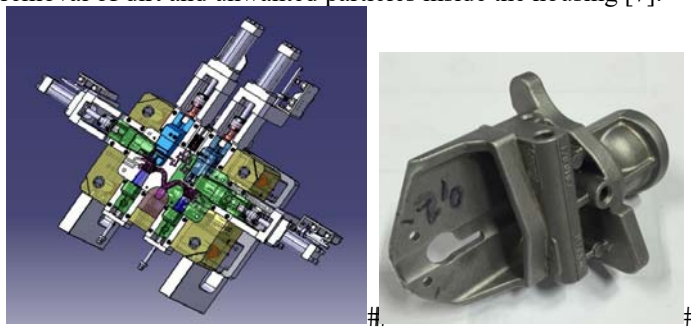


Figure 2. EGR valve casting mold and EGR valve.

3. DESIGN OF AN AUTOMATED SYSTEM FOR MEASURING EGR VALVE LEAKAGE

The size, shape and other physical characteristics of the automated testing device, since the beginning of the idea for the construction, have changed according to the upgrades and the use of the necessary components. Thus, in the very beginnings, a miniature construction was thought of, which would consist of a stand where the EGR valve is placed and the supply of the necessary pressure for testing. However, by adding the necessary components, sensors, pneumatic cylinders and other things, the size increased and was constantly upgraded.

3.1. The supporting structure of the measuring device

As other devices with similar purpose, the supporting structure of the measuring device represents the basis of support for all necessary components. In this regard, the structure is designed to meet the requirements of strength and stability. In addition to these requirements, it is necessary to ensure easy handling and access from an ergonomic point of view, since the operator is directly involved in testing EGR throughout the working time. The supporting

frame is made of steel profiles connected by welded joints. The lower part of the supporting structure is open on all sides and allows the placement of carrying pallets with products directly next to the device. The upper part of the supporting structure is covered with plexiglass panels that prevent the entry of unwanted substances, emulsions and dust. The supporting structure also includes a power supply and control cabine. The power supply and control cabinet is placed on the front of the permeability measuring device with the possibility of moving it depending on the operator's needs.



Figure 3. Measuring device and components.

The basic and most important elements for measuring EGR valve leaks are: Pressure transducers are instruments that convert measured pressure into an electrical signal that is proportional to the measured pressure. The nature of the measurement method and the corresponding instruments affect the performance of the pressure transducer. Depending on the model, the output signal can be: Current, Voltage and Frequency. The pressure gauge (sitran) is a differential pressure gauge inside the device for measuring permeability. Its main role is to measure the pressure difference between the product being tested (the EGR valve) and the preparation chamber as an external element. The pressure gauge is directly connected to the valve body, one pipeline, and the preparation chamber to the other.



Figure 4. D8A-02A pressure transducer and pressure gauge.

4. MEASUREMENT, VALIDATION AND VERIFICATION OF THE OBTAINED RESULTS

The product measurement and control procedure begins with checking the correctness of the device for measuring. Correctness is checked by using of calibration etalon. One of the basic conditions for the correctness of the obtained results is the procedure for placing and clamping the product. When placing the product at the control point, it is very important to determine the appropriate orientation of the product in accordance with the testing procedure. The product clamping device is designed to allow quick and easy positioning and orientation

based on a pin on the top that allows for precise fit. The basic permeability (leakage) limits are defined by the customer and based on them programmed into tolerance limits.

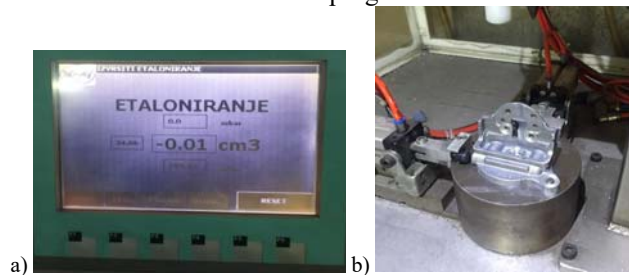


Figure 5. Calibration of the permeability measuring device a), setting up the product for testing b).

Table 1. Measurement parameters.

Charging time [s]	3
Stabilization time [s]	5
Testing time [s]	5
Allowed leakage [cm ³ /min]	0.7
Volume [cm ³]	33
Minimum pressure [mbar]	3400
Maximum pressure [mbar]	3600
Minimum standard flow [cm ³ /min]	0
Maximum standard flow [cm ³ /min]	1,05

The measurement and control process was observed on the basis of products included in different batches or parts of the product delivery by the casting process. The measurement and control procedure, as well as the setting of measurement parameters, is the same for all tested products.

4.1. Statistical data analysis

Analyses and tests were carried out on a precisely defined number of samples, based on which the results obtained serve to establish process stability and form a control chart according to customer requirements. Since the complete measurement process consists of reading the results on the control monitor and classifying good and bad pieces, the entire measurement process, as well as statistical data were carried out. The measurement results of the selected products are shown in the figure 6. Based on the results of the measurement and statistical verification and reproducibility of the results, the histogram of the nominal values of the obtained data such as the mean value of the deviation and the maximum deviation from the nominal values, it can be concluded that the results correspond to the required desired values when testing the leakage of the EGR valve.

5. CONCLUSION

In the first part of the paper, a brief description and role of EGR valve in vehicles is given. The aim of the work was the construction of an automated device for measuring leakage EGR valve. When defining the basic elements of the measuring device, special care must be taken into account during selecting components. The design and stability of the supporting structure greatly affects the results of measurements and permeability testing. The selection of basic pneumatic elements as well as measuring devices is of particular importance for the accuracy of control of the entire testing process. It is very important for measurement and control time to be as short as possible, the organization of the work space and the expertise of the operator

are necessary. Also, great importance should be attached to the maximum use of simple components when making the device, as well as the use of already existing components. Taking into account everything present in this work, the use of such a device for automatic testing of EGR valve leakage is extremely important in industrial processes related to the production of parts for the automotive industry.

	1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17
DATUM/SAT	9.4.2018	10.4.2018	12.4.2018	16.4.2018	17.4.2018	18.4.2018	19.4.2018	20.4.2018	23.4.2018	24.4.2018	25.4.2018	26.4.2018	27.4.2018	30.4.2018	3.5.2018	4.5.2018
VRJEDNOSTI	0,9000	0,3200	0,2500	1,0500	0,4900	0,1600	0,2400	1,4400	-0,6700	1,0800	1,5800	-0,6500	0,7700	1,5800	1,4800	-0,8000
	1,8000	1,8700	2,7900	0,4200	0,7100	0,1000	0,7500	-0,8200	0,8200	1,0800	0,1300	0,8800	-0,5800	1,7000	1,5200	1,6900
	0,2900	0,6300	0,2200	1,1600	1,7500	1,1200	1,1600	0,8600	-0,8000	1,6900	1,2900	1,6800	1,0700	0,9600	0,5000	1,1500
SRED. X =	0,9967	0,9400	1,0867	0,8767	0,9833	0,4600	0,7167	0,4933	-0,2167	1,2833	1,0000	0,6367	0,4200	1,4133	1,1667	0,6800
R =	1,5100	1,5500	2,5700	0,7400	1,2600	1,0200	0,9200	2,2600	1,6200	0,6100	1,4500	2,3300	1,6500	0,7400	1,0200	2,4900

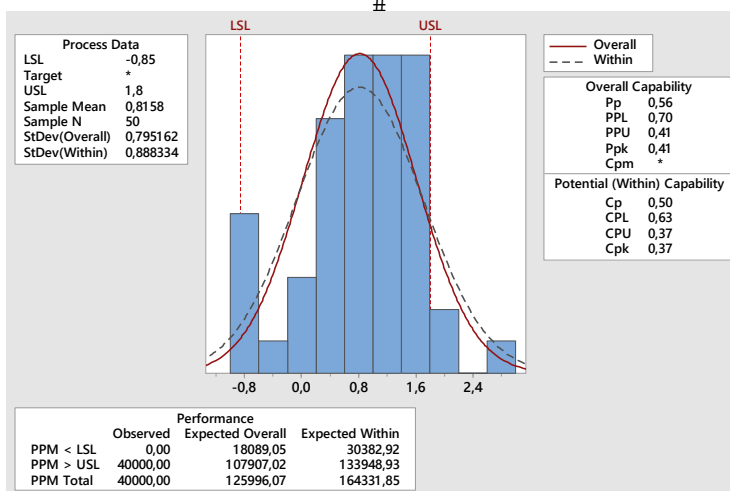


Figure 6. Table of measured values and graph of deviation from the nominal value.

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