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QUALITY CONTROL IN THE PRODUCTION OF VACUUM PUMPS FOR THE AUTOMOTIVE INDUSTRY

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Abstract
The company "Hanon Systems Plovdiv Ltd" produces components for the automotive industry. It is a leader in the production of vacuum pumps, chassis pumps, servo pumps, transmission pumps, etc. This paper focuses on vacuum pumps and the production of their aluminum housings, manufactured for the company Daimler, a world leader in the automotive industry. The aim is to trace the quality throughout the entire process, i.e. from the production of the casing to the complete assembly of the pump and to continuously improve the processes of quality management and compliance with standards in order to meet the requirements of users (high quality, low cost and high-efficiency product capacity) in the production of vacuum pumps for engines that are not able to produce enough pressure for the brake systems of cars.

Keywords*: quality control, vacuum pumps, automotive industry, pump housing, ISO BDS EN ISO 9001:2015*

1. INTRODUCTION

To achieve the development goals, the parts used in the automotive industry are tested according to certain quality management standards. The ISO 9000 series are international standards for quality assurance and management, established in 1987 and revised in 2015. The current standard is called BDS EN ISO 9001:2015, which combines five standards.

The ISO 9001:20015 standards consistently emphasize the need for continuous improvement of the quality management system [1].

There are six guidelines for ensuring different functions:
• Production Part Approval Process (PPAP);
• Advanced Product Quality Planning (APQP);
• Failure Mode and Effects Analysis (FMEA);
• Measurement Systems Analysis (MSA);
• Fundamental Statistical Process Control (SPC);
• Quality System Assessment (QSA).

The company producing vacuum pumps for the automotive industry, the subject of this study, uses MSA, PPAP, APQP, FMEA, SPC.

Total quality management is the effort to stimulate the production of competitive products on the market and initiates a new organizational method for continuous improvement of the quality of all processes in an organization (production, service, etc.), which is called Total Quality Management (TQM) and has been implemented in "Hanon Systems Plovdiv Ltd". ISO 9000 is a basic element in the TQM system. ISO focuses on the production process of the company (design and production of the product). TQM extends quality management to all departments and includes all employees in quality improvement teams (QIT). There is a model that makes TQM measurable with the European Quality Award (EQA). TQM is a complex system oriented towards continuous quality improvement, minimizing production losses and just-in-time delivery, based on the principle -

improvement has no limits and is called quality improvement. The four correspondences in TQM are: correspondence of the standard, of the application, of the value and of the hidden needs [2, 3].

At the company "Hanon Systems Plovdiv Ltd" for quality control of manufactured parts (vacuum pumps, chassis pumps, servo pumps, transmission pumps) for cars, process improvement is carried out using control plans, which is a procedure, repeating the main phases of collection - control and analysis. The collected data are used to calculate control limits, which are the basis for interpreting statistical control data. When a process is statistically controlled, conclusions can be drawn about its capability. In order to implement improvements in the control and capabilities of the process, common causes of variations must be identified and the process changed accordingly, after which the cycle begins again [4].

2. EXPERIMENTAL (PROCESS CONTROL TOOLS)

At the company "Hanon Systems Plovdiv Ltd", control plans (Figure 1 and Figure 2 are being developed for collecting and interpreting more data, used to perform efficiency control of manufactured vacuum pumps.

HANON SYSTEMS

Control Plan

Page 4 of 11

☐Prototype ☐Pre-launch ☒Production Plan No.: 5014449	Key Contact/Phone Thomas Nottke-Franz	Date (Orig.) Apr 30, 2024	Date (Rev.) Jun 1, 2024
Part Number/Latest Change Level 5014449 / D	Core Team Stefan Kestermann; Norbert Toepfer	Customer Engineering Approval/Date (If Req'd)	
Part Name/Description LF19V Pump	Supplier/Plant Approval/Date	Customer Quality Approval/Date (If Req'd)	
Supplier/Plant HCW (Serie) / 3000 — Supplier Code ----------	Other Approval/Date (If Req'd)	Other Approval/Date (If Req'd)	

Part/Process No.	Part- / Process Name Operation Description	Machine, Device, Tools for Production	Prod. Resources		Characteristics			Methods				Response Plan
			No	Description	No.	Product/Process	spec. char. class.	Product / Process/ Specification/ Tolerance	Test Equipment	Sample	Control Method	
			6003488	Kamera	10	Stopfen per Kamera				100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts
5014449 N-50008752-03-20	LF19V Pump Z2/1 Flachformf. u. Ventilh. verschraub.	Montage DAG M276 Move	8720023	Elektroschrauber EM35-10J	10	Verschraubung nach SC300501		3,0 /3,5 Nm	Elektroschrauber EM35-10J	100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts
			6014657	Sensor misc.	20	Abfrage Ventilhalter vorhanden			Sensor misc.	100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts
			6014657	Sensor misc.	30	Abfrage Flachformfeder (Anzahl, Position)			Sensor misc.	100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts
			6005278	M270 mit NV ohne Ventilhalter N.i.O								
			6005279	M270 mit NV Bohrung FFF zu groß								
5014449 N-50008752-03-30	LF19V Pump Z2/2 Düse einpressen	Montage DAG M276 Move										

Figure 1. Control plan for vacuum pump housing

Control Plan

Page 5 of 11

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Part/Process No.	Part- / Process Name Operation Description	Machine, Device, Tools for Production	Prod. Resources		Characteristics			Methods				Response Plan
			No	Description	No.	Product/Process	spec. char. class.	Product / Process/ Specification/ Tolerance	Test Equipment	Sample	Control Method	
			6014099 6005280	NC-Fügemodul NCFT 2157A3 Fa.Kistler M270 mit NV Bohrung Sieb zu groß N.i.O	10	Einpressen Düse		600 N	NC-Fügemodul NCFT 2157A3 Fa. Kistler	100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts
5014449 N-50008752-03-50	LF19V Pump Z3/2 Durchflußprüfung FFF	Montage DAG M276 Move	6003130 6005281 6005282 1630294-PSP-004--	flow rate gage Flow M270 mit NV ohne FFF N.i.O M270 mit NV FFF Dicht i.O.	10	Durchflussprüfung FFF siehe PSP			flow rate gage Flow	100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts
5014449 N-50008752-03-60	LF19V Pump Z3/3 Durchflußprüfung Düse	Montage DAG M276 Move	6009496 6005283	Durchflussmesser PF2A510-01-2 SMC M270 mit NV Ölbohrung zu N.i.O	10	Durchflussprüfung Düse siehe PSP			Durchflussmesser PF2A510-01-2 SMC	100% inspection	Instruction	FPC-BHP-06-P-0005 Control of nok parts

Figure 1.b Control plan for vacuum pump housing

After collecting extensive data from the control plans, control limits are calculated based on that data. The process is then analyzed to implement improvementsThe main indices that describe the ability and potential of the process, used in the control charts are:

- Cp or process capability index: Measures the potential capability of the process under the assumption of perfect centering.

- Cpk or process capacity index: Reflects the actual capability given the process mean.

The requirements for the control of the aluminum housing, which will subsequently be assembled into a vacuum pump, are specified in advance with the customer. The customer's design department, together with that of the company, determines the important dimensions for the functionality, the informative dimensions, the dimensions that will be monitored and which dimensions will participate in the evaluation of the indices Cp and Cpk. The dimensions that must be included for the analysis of Cp and Cpk are circled on the drawing of the part. Customer requirements are visualized precisely through a control chart and a drawing of the part.

In the company manufacturing a housing for an automotive vacuum pump, a target Cpk 1.33 corresponding to the Motorola definition of 4σ, which corresponds to the Motorola definition that the sigma level is measured in units of defects per million opportunities for defect (Defects per million opportunities – DMPO) [5].

The control chart depicts the entire process of creating the part. It starts from the arrival of the blank at the factory, through machining, washing, packaging.

The drawing of the part indicates the dimensions that are important to the customer. The control chart is the basis for process audits and audits on the customer side.

In order to implement comprehensive company quality control, the necessary control documents must be developed: Control plan (control chart); Detail drawing; Analysis of dimensions important to the customer; Self-control plan for housing production; Selection of measuring instruments for quality control [6].

3. RESULTS AND DISCUSSION

Based on the prepared control charts and a drawing of the detail of an aluminum housing for an automotive vacuum pump, it can be concluded that the benefits of using control charts for implementing quality control in the production of automotive parts are:

- used by operators for ongoing process control;
- the process is executed consistently and predictably;
- products have higher quality, lower cost and higher effective capacity; distinguishing random from common causes of variation;
- making a decision for local intervention or intervention on the system

The implementation in the company "Hanon Systems Plovdiv Ltd" of 4σ (DPMO) = 6.210 (99.98% yield; 0.02% defect rate) fully satisfies the customers and the manufacturer of aluminum housings for automotive vacuum pumps.

4. CONCLUSION

Based on a number of analyzes and protocols conducted at "Hanon Systems Plovdiv Ltd", it has been determined that the process stability indicator Cp with the lowest indicator is 1.96, which is above 1.33 or sigma 4, which are the customer requirements regarding the quality standard in the production of aluminum housing for vacuum pumps in the automotive industry.

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