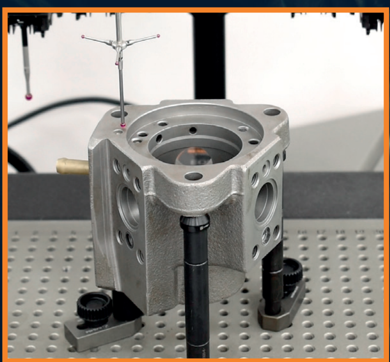
Case brief

Pump housing: process control for multiple part variants

All inspection on one device

High accuracy automated shop floor gauging

In-line control of critical features



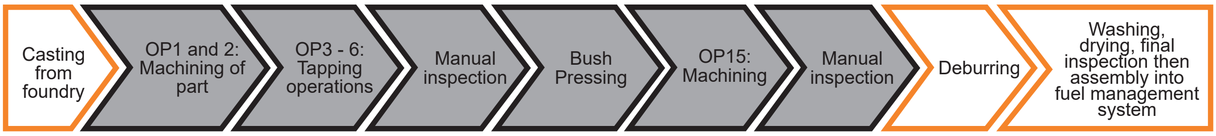
Overview

Manufacturers of fuel pump housings use CNC machining, involving several operations to create a housing ready for assembly into the fuel management system.

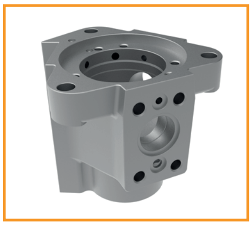
Typically a combination of various forms of gauging are used alongside the machine to monitor pump housing quality, and allow engineers to correct the process. However, producers are now looking to reduce regular costly maintenance, high capital investment and improve production cycle times.

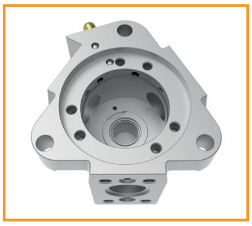
This case brief examines a typical pump housing manufacturing process with actual benefits that Renishaw technology has delivered to manufacturers who produce high quality parts on high yield processes and are aiming for zero scrap.

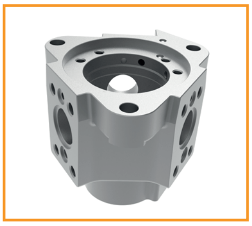
Typical pump housing manufacturing process - *without the Equator™ gauge*



Pump housing machining







*Other manufacturers' processes may differ.

Challenges

1 Inspect different part variants on one device

Current methods of inspection involve gauges which have a high purchase cost and can only be used for one variant of parts. Many similar gauges have to be purchased to inspect all part variants. New gauges often have to be purchased for new parts as previous gauges are difficult and costly to rework for re-use. Moving parts between gauges means that inspection cycle times are too long.

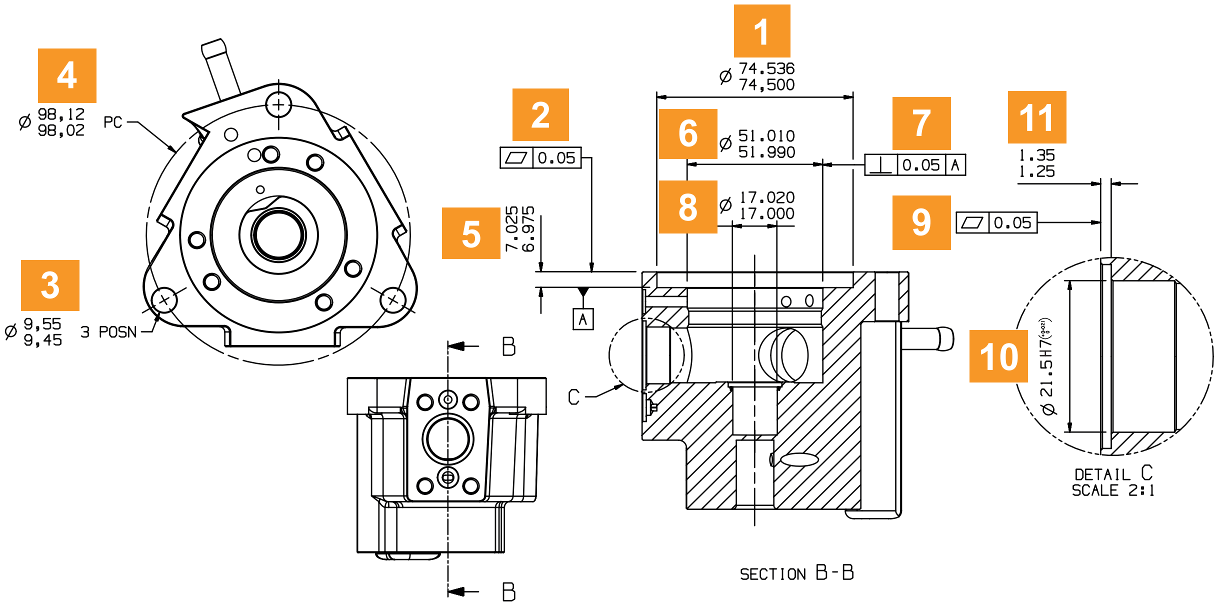
2 Improve reliability of inspection results

Parts are inspected by multiple different operators with varying levels of experience and technique. As a result there is inconsistency in how the manual bench and hand gauges are used. This has a negative impact on the reliability of inspection results.

3 Improve process control

Current gauges provide simple pass/fail results and it is difficult to accurately record inspection data. Machine offset updates are applied, but not recorded. There is no consistent approach between operators for how inspection results are used to correct the process.

Inspection requirements for pump housing



#	Inspection	Tolerance	Why is this feature critical to part function?	Active tool offsetting action
1	Flange joint bore diameter	36 µm (0.0014”)	Ensures correct fit of the flange joint. Incorrect fitment can cause misalignment between flange joint centre bore and camshaft.	
2	Mating face flatness	50 µm (0.0020”)	Ensures correct fitment of pump to fuel system	
3	Bolt through hole diameter	100 µm (0.0039”)	Ensures correct fitment of pump to fuel system	
4	PCD of bolt through holes	100 µm (0.0039”)	Ensures correct fitment of pump to fuel system	
5	Depth of flange joint face	±25 µm (±0.0010”)	Ensures correct fit of the flange joint preventing misalignment between flange joint and camshaft.	
6	Central bore diameter	±10 µm (0.0004”)	Allows for correct fit of the internal supply pump and plunger.	
7	Central bore perpendicularity	50 µm (0.0020”)	Ensures that the cam shaft, cam lobe and internal supply pump are central within the fuel pump housing.	
8	Bushing bore	20 µm (0.0008”)	Ensures cam shaft is held centrally within pump to prevent uneven wear and maximise efficency.	
9	Suction valve bore face flatness	50 µm (0.0020”)	Ensures best fit of seals, preventing leaks and loss of pressure	
10	Suction valve bore seal diameter	21 µm (0.0008”)	Ensures correct fit of suction valve seal, making sure no fuel leaks.	
11	Suction valve seal bore depth	±50 µm (±0.0020”)	Ensures correct fit of suction valve seal, making sure no fuel leaks.	

Key:

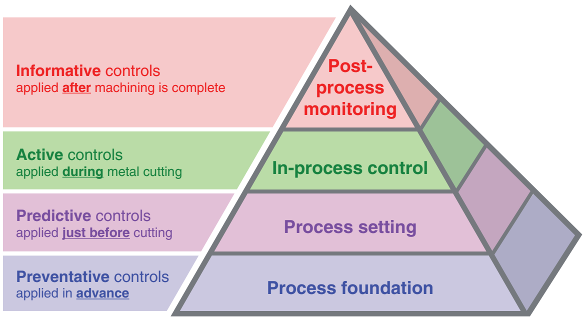
Automatic update of machine offsets through inspection of indicated features.

Please note: In addition to the feedback of geometric features, the monitoring of form can be indicative of the health of the tools.

Process considerations

Renishaw engineers considered key elements within the pump housing manufacturing process using Renishaw's ***Productive Process Pyramid™***. This framework is used to identify and control the variations that can occur at key stages of the machining process.

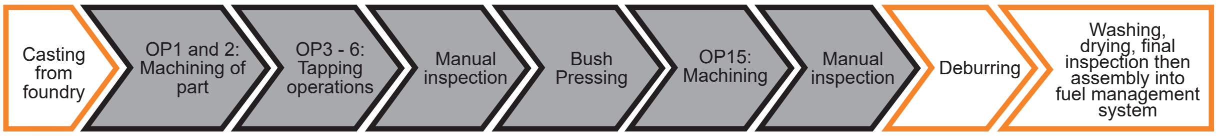
For this process, methods to control variation include machine maintainance and calibration, tool breakage detection and shop-floor gauging for inspection and automatic feedback.



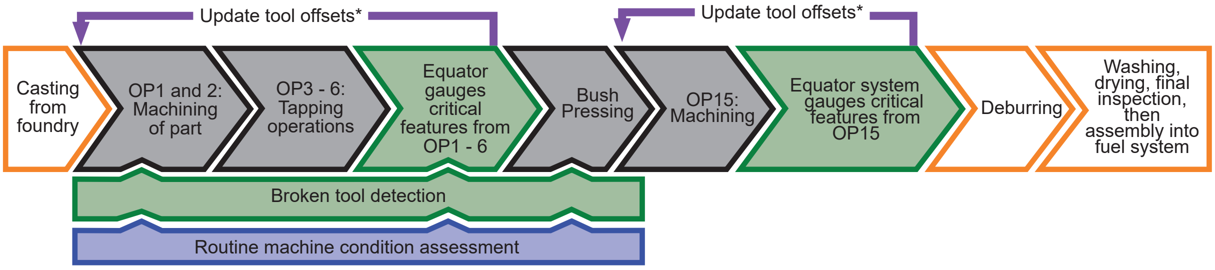
Productive Process Pyramid

Manufacturing process - opportunities for improvement

Original process



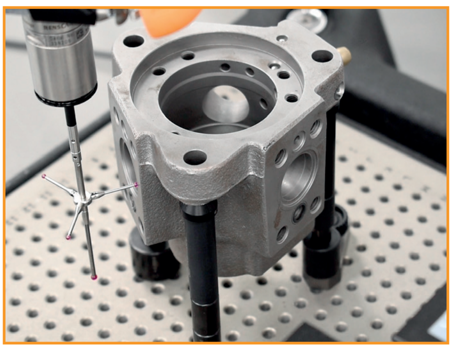
Identified areas for improvement



* Offset updates are automatically applied using IPC (intelligent process control) software which uses dimensional data to feedback offset updates to CNC controllers. Updates could alternatively be applied manually based on the inspection data displayed in Process Monitor.

Typical results

A key action for pump housing manufacturers has been to install the Equator™ gauging system, consolidating inspection activities taken at three stages onto one device, reducing capital and ongoing costs. This has also streamlined inspection, with critical features now inspected within the machining cycle time. Automatic tool offset feedback has enabled the features to be produced closer to nominal, improving yields and quality.



RENISHAW apply innovation™

1 All inspection on **one device**

Equator gauging systems are inspecting all dimensions including the position and geometric form features without the need for other inspection devices.

Savings in inspection cycle time have been made as there is no longer a need to move parts between gauges. As the Equator gauge operates automatically, operator time has also been freed up to carry out other tasks.

Products are changing on the line very often. The Equator gauges have been programmed to run multiple part programs and are reprogrammed easily when part designs change.

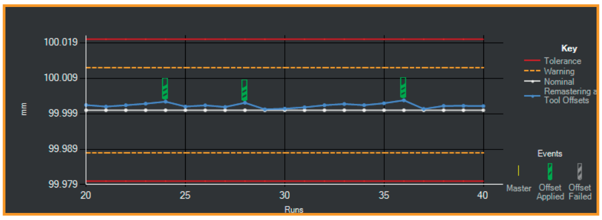
Repurposing the Equator gauges delivers huge cost savings and ROI compared with the previous gauging method.

#	Inspection Total time: 3 mins 5 secs	Tolerance	Gauge R&R % of tol*	Gauge R&R range*
1	Flange joint bore diameter	36 µm (0.0014”)	5.8%	1.2 µm 47 µin
2	Mating face flatness	50 µm (0.0020”)	4.9%	2.8 µm 110 µin
3	Bolt through hole diameter	100 µm (0.0039”)	1.6%	1.1 µm 43 µin
4	PCD of bolt through holes	100 µm (0.0039”)	2.1%	1.2 µm 47 µin
5	Depth of flange joint face	±25 µm (±0.0010”)	5.5%	2.2 µm 87 µin
6	Central bore diameter	±10 µm (0.0004”)	9.5%	1.0 µm 39 µin
7	Central bore perpendicularity	50 µm (0.0020”)	1.3%	1.0 µm 39 µin
8	Bushing bore	20 µm (0.0008”)	5.3%	0.8 µm 31 µin
9	Suction valve bore face flatness	50 µm (0.0020”)	3.2%	2.1 µm 83 µin
10	Suction valve bore diameter	21 µm (0.0008”)	10.9%	1.8 µm 71 µin
11	Suction valve bore depth	±50 µm (±0.0020”)	1.3%	0.8 µm 31 µin

* Type 1 Gauge Repeatability and Reproducibility - loading and unloading the same part 30 times.

2 **Reliable** inspection results

Equator gauging systems operate automatically and are designed to run pre-programmed inspection routines with a repeatability of ±2 µm. As part of the program set-up, Renishaw engineers conducted GR&R studies to ensure repeatable results are achieved between operators. The deployment of Equator gauges has eliminated previous issues with unreliable, inconsistent results between operators.



Example of Process Monitor screen showing drift due to tool wear, corrected by IPC

3 **Traceable** process control

Process Monitor is part of the software package which runs on Equator gauging systems. Process Monitor includes an instant status monitor bar graph of the last measured part and historical results for the selected feature. Previously operators were only receiving pass/fail data. Now the inspection results from the Equator gauge are exported as .CSV files and stored for traceability. These results are also being used to update machine offsets, bringing drifting processes back in-line before scrap parts are produced.

Renishaw plc

New Mills, Wotton-under-Edge
Gloucestershire, GL12 8JR
United Kingdom

T +44 (0) 1453 524524
F +44 (0) 1453 524901
E uk@renishaw.com

www.renishaw.com

RENISHAW
apply innovation™

About Renishaw

Renishaw is an established world leader in engineering technologies, with a strong history of innovation in product development and manufacturing. Since its formation in 1973, the company has supplied leading-edge products that increase process productivity, improve product quality and deliver cost-effective automation solutions.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

Products include:

- Additive manufacturing and vacuum casting technologies for design, prototyping, and production applications
- Dental CAD/CAM scanning systems and supply of dental structures
- Encoder systems for high-accuracy linear, angle and rotary position feedback
- Fixturing for CMMs (co-ordinate measuring machines) and gauging systems
- Gauging systems for comparative measurement of machined parts
- High-speed laser measurement and surveying systems for use in extreme environments
- Laser and ballbar systems for performance measurement and calibration of machines
- Medical devices for neurosurgical applications
- Probe systems and software for job set-up, tool setting and inspection on CNC machine tools
- Raman spectroscopy systems for non-destructive material analysis
- Sensor systems and software for measurement on CMMs
- Styli for CMM and machine tool probe applications

For worldwide contact details, visit www.renishaw.com/contact

H-5504-8910-01

Part no.: H-5504-8910-01
Issued: 06.2019