

Feasibility study into the use of on machine-gauging on high explosives

George Goddard



Introduction

Explosive machining involves the manufacture of components to tight tolerances using CNC (computer numerical control) lathes and milling machines. On machine gauging uses a probing system to measure components by using the machine to probe the component. Measuring the component on the machine removes the need for CMM inspection, saving time moving the component to the quality cell, and improving safety by reducing the amount of time spent handing and moving explosives. Before on machine gauging can be used on explosives it must be deemed safe for use and be reliable.

Background

A systems engineering approach was used to help implement on machine gauging. Ensuring all stakeholders are engaged from the beginning of the project increases the change of the project succeeding and avoiding costly rework at the end. A list of requirements was created, these included:

- Cheap
- Easy to use
- Accurate
- Reliable
- Safe
- Remote operation
- Interpretable results

A quad of aims detailing the stakeholders, deliverables and measures of success was made. This tool is useful to have a quick look at and keep the project on track.

Purpose & Scope	Stakeholders & Benefits
Why / Current State – Currently when the first component is machine it is sent for inspection. This can take up to 5 hours. During this time the MAM is not operational. On-machine gauging will enable the accurate measuring of components on the machine. Any errors can be corrected immediately meaning the component does not need to be removed from the machine. The component will still go for first off inspection however during this time the MAM can start on the next component. Once inspected the results can be analysed and any corrections made to the tool or work offset if required. The use of ball bar testing on the machines will detect any issue with the machines before they become a problem.	Stakeholders • Project manager • ESH • Explosive safety • Technical authority • Facility management • Facility engineering • Budget holder • Machinists (User) • Manufacturing engineer • SQEP ME • Quality engineers • Quality inspectors • Supply chain • External suppliers • External training supplier Benefits • Reduce machine downtime waiting for components to be inspected • Reduce number of explosive moves required by at least six per batch • Increase CMM availability • Increase MAM availability save over 7 hours per batch • Reduce the handling of explosives by at least six moves per batch
Deliverables	Measures of Success
• Purchase required hardware • Implement ball bar testing • Test probe force	• Reduction in the time taken to machine components • Increase in the availability of CMM machines • Reduction in the number of explosive moves required



Machine verification

Measuring a component on the machine can be inaccurate as you are using the same linear encoders and control system to make the component and measure it. If there is a kinematic error within the machine it will measure the component correct. To compensate for this, ballbar testing has been introduced. A ballbar test uses an independent measuring device to verify that the machine is running accurately. The results from the testing can be monitored with issues picked up before the machine is out of specification.



Method and conclusion

Force testing was carried out to verify that the machine didn't apply too much force. A stand was 3D printed to hold a force meter as seen above, this could not be used as the original testing machine (left) had a fault. Testing was carried out on a high accuracy lathe (far left), with the results shown below. 0.16 – 0.22 newtons is the range of force the machine can apply. The results show that forces applied in the X axis are within the allowable range at all speeds. The force applied in the Z axis was too high, which could damage or insult the explosive. More research is needed before the probe can be used on explosives. The probe force could be reduced by:

- Swinging the machine head
- Using a dog leg probe
- Changing the Renishaw cycles
- Designing an ultra low force probe
- Reducing the weight of the machine head

Feed rate (mm per minute)	Force applied in X axis (N)	Force applied in Z axis (N)
5	0.054	2.710
10	0.072	3.010
30	0.143	4.090