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Industry can do it



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GRINDING | ULTRA PRECISION

HIGH PRECISION MACHINES

# Cranfield Precision Engineering Partnership

—

Ultra-precision technologies: process development, precision machine design & process technology improvement

Renowned legacy names:
Bryant, Cincinnati, Cranfield Precision, Daisho, Gardner, Giustina and Landis

# CRANFIELD PRECISION ENGINEERING PARTNERSHIP

## GRINDING | ULTRA PRECISION

> Fives and its dedicated Grinding | Ultra Precision teams - over 700 people globally - offer a complete range of grinding and specialist ultra-precision machines, plus a comprehensive range of systems, grinding accessories and service/support programs.

Located in Bedford, UK, Cranfield Precision® teams have over 50 years of experience in precision machine design and manufacture of world-leading ultra-precision machine tools.

The business area encompasses ultra-precision machine tools, precision measuring systems and custom designed special purpose machines.

The strong links to university research groups and trade associations give Cranfield Precision® the capacity to undertake projects ranging from R&D and process consultancy to complete machine design and manufacture.

Aerospace | Bearings | Computing/Semiconductor Manufacturing | Defense

Energy | Medical | Optics | Astronomy | Transmission

## OVER 50 YEARS OF SPECIAL-PURPOSE PROJECTS

### 1970s

- Large scale metrology
- Ultra-precision grinding for primary development of computer hard disk read write heads

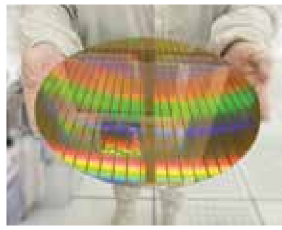
### 1980s

- Diamond turning, aerospace and defense
- World's first CNC orbital cam grinder

### 1990s

- Optical metrology for space telescopes
- Precision grinding and metrology for satellite optics

### 2000s

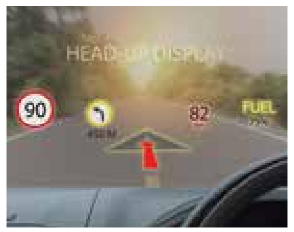


- Micromachining and hard turning
- Silicon wafer manufacture and measurement

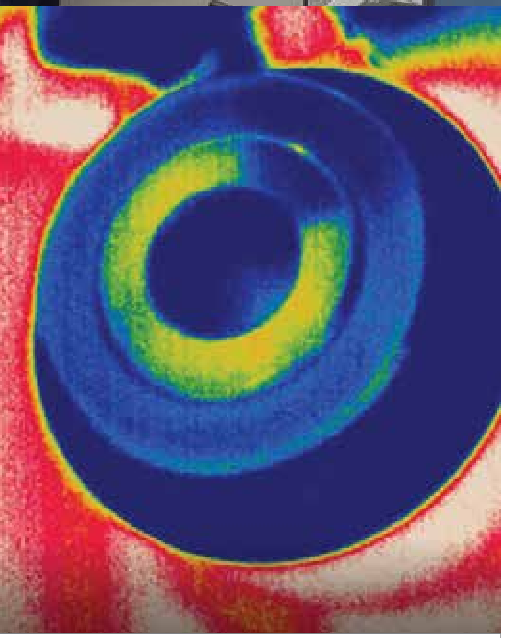
### 2010s

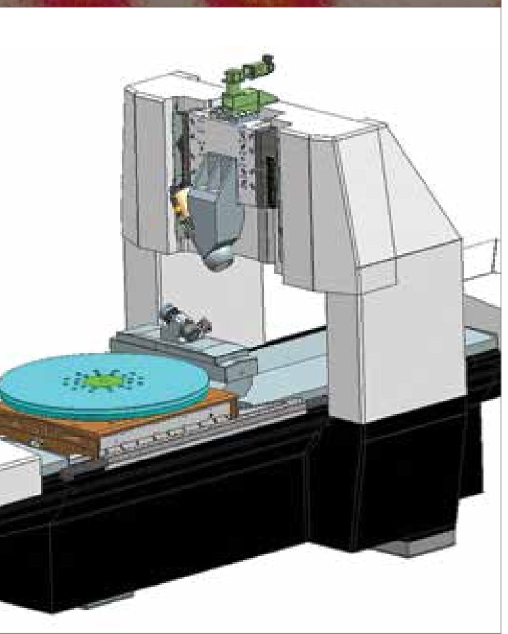
- Diamond turning for brightness enhancement film microreplication used in advanced displays
- High precision boring and orbital grinding for large engine cranks

### 2020s




- Ultra-precision grinding for optics, freeforms, head-up displays, optical molds and precision bearings
- Large optic manufacture for EUV semiconductor lithography





## MACHINING PROCESS DEVELOPMENT

Gain access to our facilities, resources and ultra-precision development machines and collaborate with us to improve your machining processes and develop new, market leading products.

— Develop a new product
— Improve your component specification
— Solve a complex toolpath problem
— Try new processes
— Reduce your R&D overhead
— Free up your machinery for production

## PROCESS TECHNOLOGY IMPROVEMENT

With over 50 years experience in ultra-precision machine and process development, let Cranfield Precision work with you to employ proven analysis and design techniques to enhance your capabilities.

— Solve production problems
— Update old production equipment
— Enhance your software capabilities
— Make high quality parts
— Improve your machine capability
— Develop a new manufacturing process

## PRECISION DESIGN

Develop a specification with Cranfield Precision and collaborate to produce an ultra-precision design to your requirements. Our assembly facilities can even manufacture prototype, production and batch machines for you.

— Design complex components
— Upgrade existing machines or sub-assemblies
— Solve work holding problems
— Develop new software solutions
— Improve your machine capability
— Create bespoke machines

CASE STUDY

# PROCESS DEVELOPMENT FOR OPTICAL MOLDS

### THE PROBLEM

Manufacture high precision optical molds used in vehicle head-up displays (HUD) and camera lenses, for automotive and mobile applications. Molds, which often require complex and freeform geometry, are made from materials that are difficult to grind (stavax and tungsten carbide), thus require many hours of post-grinding corrective polishing.



### THE SOLUTION

Cranfield Precision engineers developed a solution that takes the mold surface design and generates the necessary grinding operations for the freeform and complex geometries. Tooling is carefully designed, selected and then tested in our ultra-precision machining lab. The complex and freeform molds are ground using unique grinding machinery that has class-leading stiffness, damping and thermal stability.

### THE RESULT

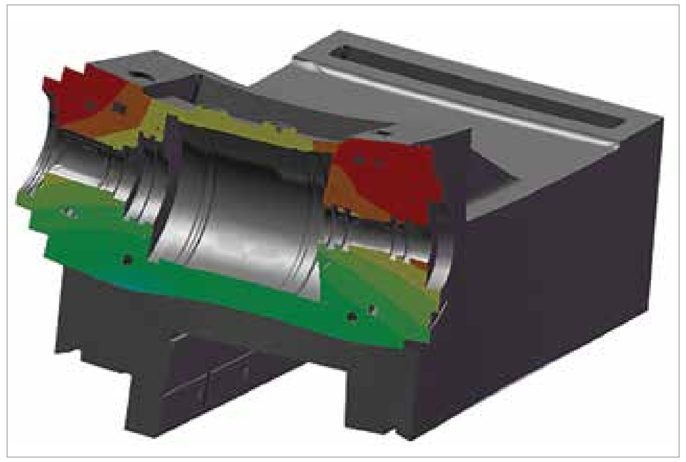
— Low form error
— High quality surface finish; near polish quality
— Minimal SSD
— Minimal post-polishing required

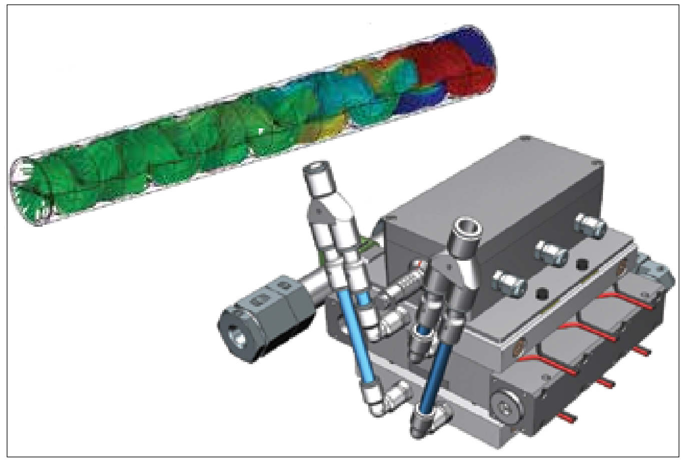
# PROCESS TECHNOLOGY FOR IMPROVED THERMAL CONTROL

CASE STUDY

### THE PROBLEM

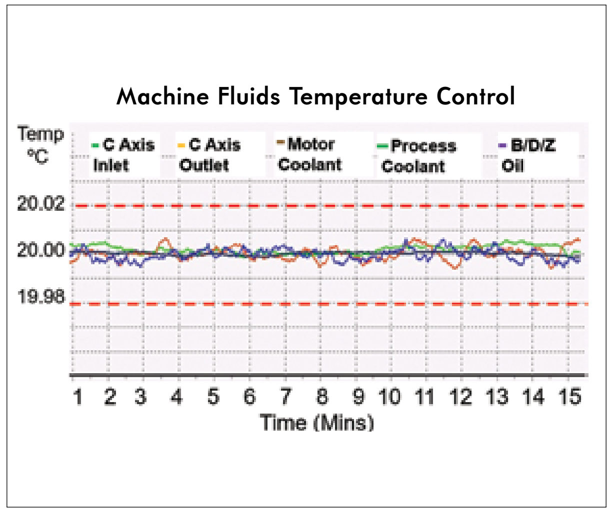
When taking the next step toward greater production accuracy on a machine where stiffness, damping and abbe errors have been reduced to a minimum, it is often thermal effects that remain dominant and prevent the desired improvement in product specification. When using standard chiller systems for temperature control, the on/off control of the system can often be seen imprinted in the surface of precision optics. Some fluid chillers claim ±0.1 °C control, but in order to achieve sub-micron form error across the surface of an optic, it can be necessary to go further, with a target of ±0.01 °C.





### THE SOLUTION

A small thermal control unit was designed that could be retrofitted to existing fluid control circuits on the machine. Taking the standard temperature control capability of a normal chiller system, say ±0.1 °C, fluid temperature deviation is corrected further and smoothed to reduce hysteresis and overall fluctuations. CFD was used to ensure optimal fluid flows and thorough mixing of fluids to guarantee uniform temperatures of all circuits.




### THE RESULT

- Multiple circuits controlled to better than ±0.01 °C, including motor cooling, hydrostatic oil and process cutting fluid
- Sub-micron form errors across ground component surfaces – no corrective form polishing required
- Scalable solution for larger machines and fluid volumes

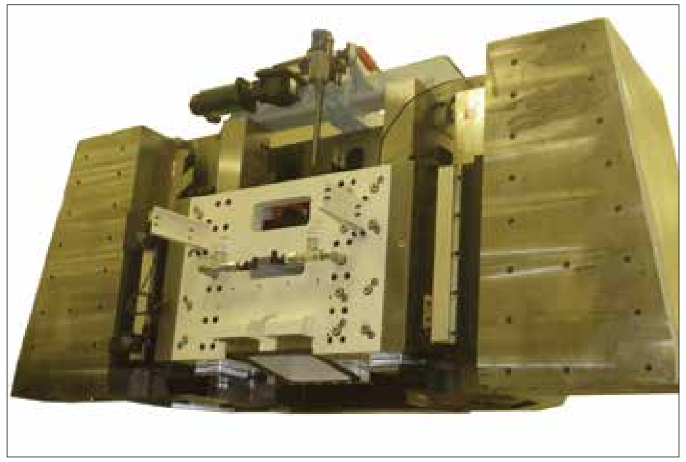


# PRECISION DESIGN FOR VERTICAL COUNTERFORCE

CASE STUDY

### THE PROBLEM

On many large machine tools, the performance of the vertical axis is often the limiting factor in the accuracy of the machine. Traditional ball screw methods have inherent backlash and a limited life. For large axes, a counterforce mechanism will be required. Pneumatic and hydraulic methods are used, but these are expensive, complex and all introduce hysteresis to the axis. Therefore, a new counterforce design was needed to allow higher speeds and accuracies, better dynamic performance, reduced mass and cost – particularly important where linear motors are desired.



### THE SOLUTION

Using CAD, FEA and test rigs, a new counterforce mechanism was designed. A slave axis uses a traditional ball screw to support the mass of the carriage but is mechanically decoupled from the carriage itself, through a spring system. For the master axis, linear motors and high resolution linear encoders are used to drive and position the axis, for high accuracy positioning. A position demand is sent to the master axis, simultaneously 'followed' by the slave axis to provide a counterforce to the carriage mass.


### THE RESULT

- A patented, high accuracy, high speed, counterforce solution for large axis mass
- Successfully implemented as an upgrade to existing customer machines, 25 years after the original machine was installed. As well as new, large optics grinders with freeform capability and sub-micron positioning accuracy