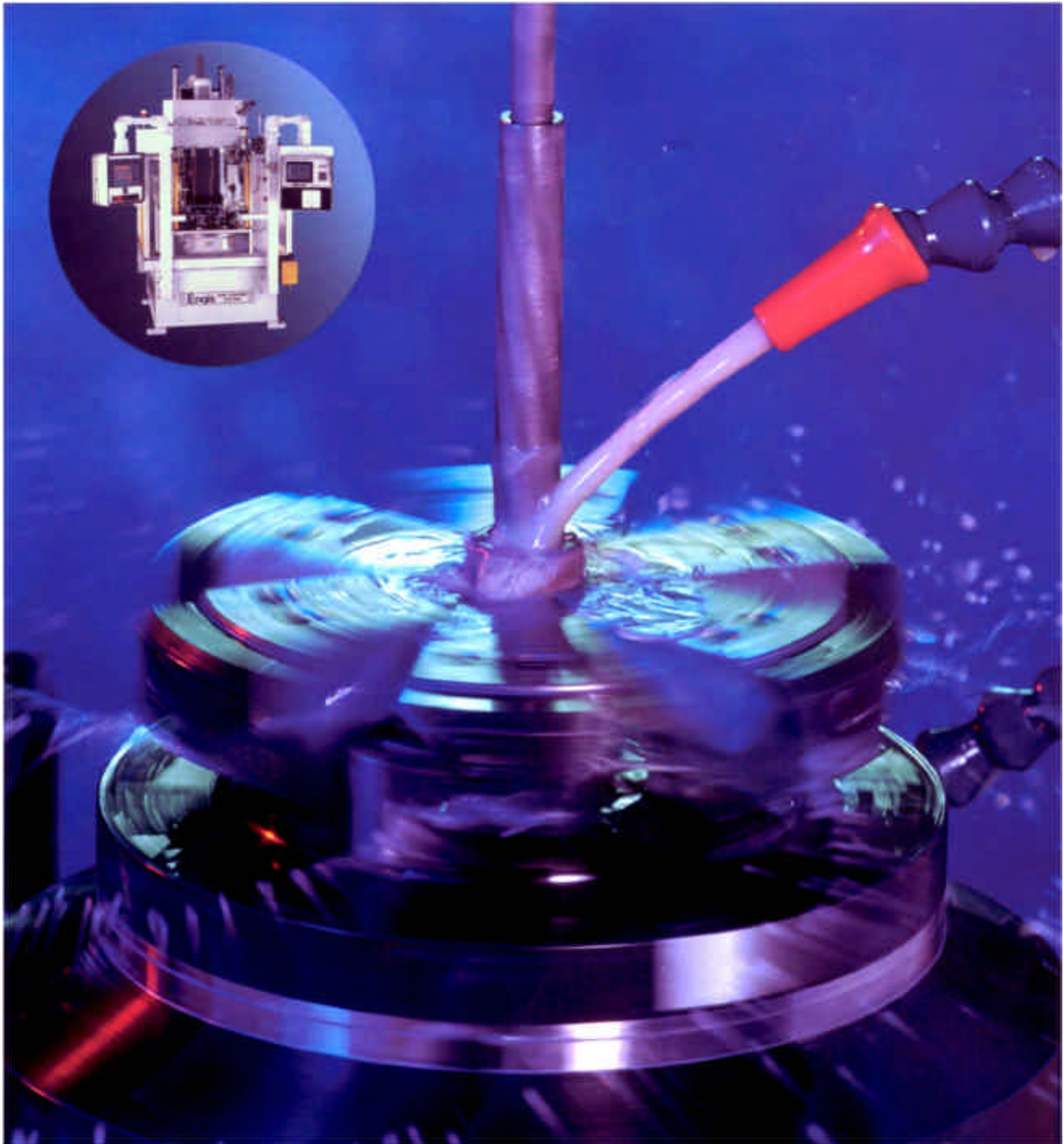


SINGLE-PASS

Engis Single-Pass Superabrasive Bore Finishing Systems



Leaders In Superabrasive Finishing Systems



Engis – Pioneering New Advances in Bore Finishing



From machine and tool design to automated support systems, Engis provides end-to-end bore finishing expertise.

Single-Pass Superabrasive Technology Cuts Costs, Improves Productivity



A rapidly evolving machining technology is surpassing conventional honing as the preferred process for finishing the inside diameter of a part. Utilizing

single-pass superabrasive bore finishing technology developed by Engis, extremely tight tolerances can be held reliably and consistently in a production environment, at a lower overall cost per finished piece.

The single-pass process is the most cost-effective choice for virtually any bore finishing application and workpiece material.

Diamond-plated and superabrasive finishing tools are capable of achieving – in standard, blind and semi-blind bores – *bore geometries to within 0.000020"*.

Here is a summary of the compelling and cost-effective benefits:

- Lower labor costs through automated finishing
- Lower cost per hole through long tool life
- Predictable, consistent results
- Improved bore quality
- Fewer rejects
- Less frequent part inspection
- Higher production rates
- SPC values >2.0 Cpk



Connecting Rod

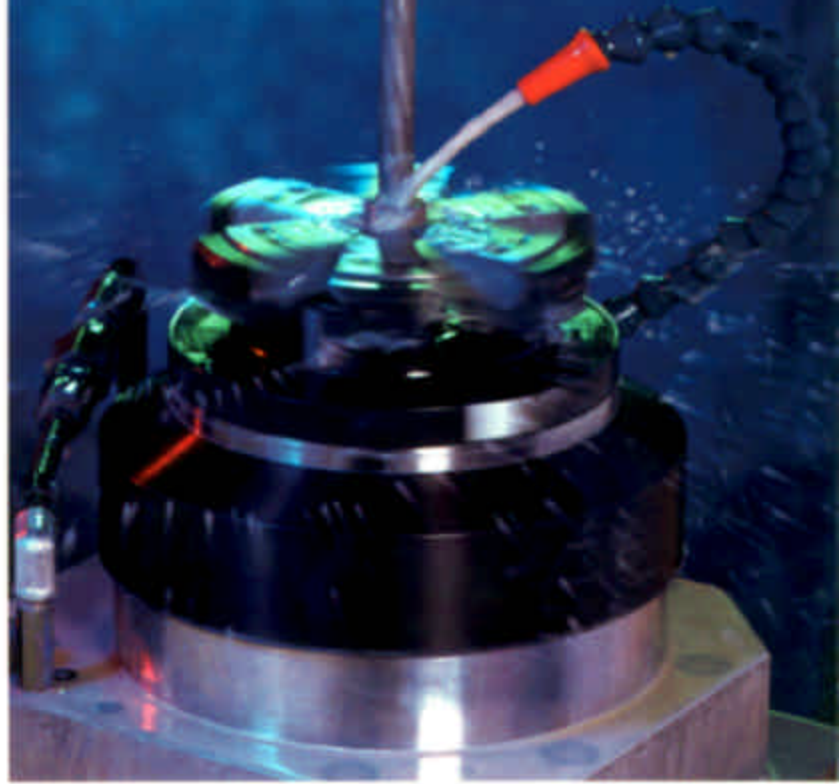
Length of Bore: 25mm **Material:** Bronze
Machine: Two Spindle Transfer System
Stock Removal: .037mm **Float Method:** Part

Feature	Required	Achieved
Size:	.004mm	.002mm
Roundness:	.005mm	<.002mm
Straightness:	.005mm	<.001mm
Finish:	.5Ra	<.40Ra

Production Rate: 360 Parts Per Hour **Special Note:** Water based coolant

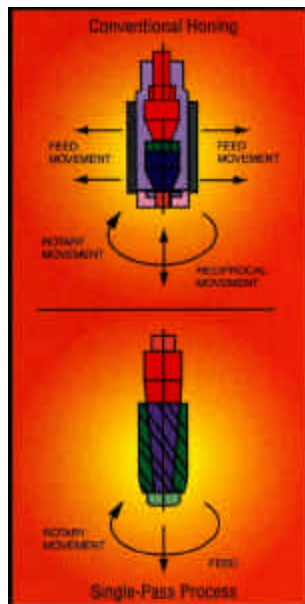
Shortest Cycle Times in the Industry

Engis Bore Finishing Systems feature controls that dramatically reduce cycle times. The Engis system utilizes a combination of software, in-process sensors and sophisticated engineering to achieve the most efficient cycle time – *for your application*. The fastest cycle time for any given operation is dependent on the material and the part configuration. Engis bore finishing systems give you maximum flexibility, including optional torque-based feed compensation to maintain shortest cycle times.



Whether it's a process that requires rotating fixtures (above), blind and semi-blind bore Finishing, bore-to-datum concentricity applications – even OD finishing – Engis designs Solutions tailored to each customer's application.

Single-Pass vs. Conventional Honing



Single-pass bore finishing is performed with pre-set barrel-shaped tools that pass once through the bore, while the tool, the part, or both, rotate. Conventional honing utilizes a hone that reciprocates, expands and contracts during each cycle. Single-pass bore finishing tools, because they don't have to expand and contract during each cycle, combined with the slow-wearing diamond coating, ensure the maximum control of bore size.



Rocker Arm Bushing

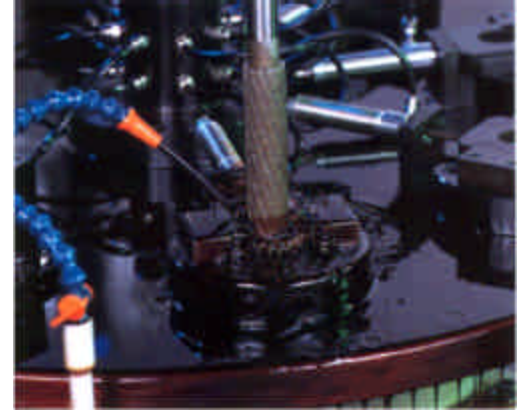
Length of Bore: 1.50" **Material:** Hardened Steel **Machine:** Four Spindle
Stock Removal: .002" **Float Method:** Tool

Feature	Required	Achieved
Size:	.0005"	.0002"
Straightness:	.0002"	.0001"
Finish:	20 Ra. in.	8 Ra. in.

Production Rate: 278 Parts Per Hour (13 sec. CYCLE TIME)

End-to-End System Design

- The Tooling & Fixtures
- The Machines & Controls
- The Automation & Process Development



Engis Single-Pass Bore Finishing Systems are just that – a complete system. From tool and fixture design, through machine design, engineering and manufacturing, to process development,



metrology, final run-offs, automation packages and in-field support...

Engis does it all.

Our end-to-end system approach assures each customer that they are getting the most value and performance at every stage of the

finishing operation. The key is two-fold: a commanding knowledge of single-pass bore finishing technology, and the capability to engineer and integrate that technology into the customer's specific application. Matching the right tool, machine, process and automation – and then backing it up after it is deployed and running.

Technology Leadership

- R&D Leadership, with 25+ years developing single-pass bore finishing
- Superior expertise in diamond tooling and machining
- Blind bore finishing
- Patented OD finishing capability
- Bore-to-datum concentricity capability
- Precision seating capabilities

Performance & Precision

- Size control within one micron
- Bore geometry to better than one-half micron
- Surface finishes to meet almost any specification, including crosshatch and sine curve patterns



This Engis solution combines multiple machining operations – bushing Assembly, pad brushing, bore finishing, seat polishing and part washing – Into one end-to-end automated system.



Brake Cylinder

Length of Bore: 31.75mm
Material: Cast Iron
Machine: Six Spindle
Stock Removal: .0027" **Float Method:** Part

Feature	Required	Achieved
Size:	.0005"	.0002"
Roundness:	.0005"	.0002"
Finish:	135 Rz	100 Rz

Production Rate: 514 Parts Per Hour
Special Note: Two Parts Per Index, Two Passes and Final Brush

Engis Tooling & Fixtures —

The Key to Low-Cost, High-Precision Finishing



Among the most critical features in any system design is the workholding fixture. Engis specializes in custom fixture design capability. Each application is carefully reviewed for simplicity, ease of use, versatility and fastest changeover. Options include fixed or floating solutions designed with your application in mind.

Engis bore finishing tools are the key to optimizing your single-pass finishing operations. Both diamond and cubic boron nitride

systems. Tool type, design and size are driven by each customer's application. Engis provides both standard and custom tooling packages, including:

- *Standard diamond & CBN plated tools*
- *Custom diamond plated tools*
- *Spring-load tooling*
- *Coolant-through-tool designs*
- *Self-adjusting tooling*
- *Specialized tooling for bore-to-datum concentricity*
- *O.D. finishing tools*
- *Seat finishing tools*



Engis bore finishing tools utilize plated diamonds, which cut cooler, maintain size and achieve extremely long tool life. Because of this, the overall cost per finished piece is reduced.



(CBN) tooling packages are manufactured by Engis under ISO 9002 certified quality

ISO 9002 Certified Quality Systems Govern Production of Engis Bore Finishing Tools



Pump Body

Length of Bore: 35mm
Material: Hardened Steel Insert
Stock Removal: .120" **Machine:** Eight Spindle
Float Method: Part

Feature	Required	Achieved
Size:	.015mm	.002mm
Roundness:	.0005mm	.0002mm
Straightness:	.0003mm	.00015mm
Finish:	.6 Rz.	.4 Rz.

Production Rate: 120 Parts Per Hour

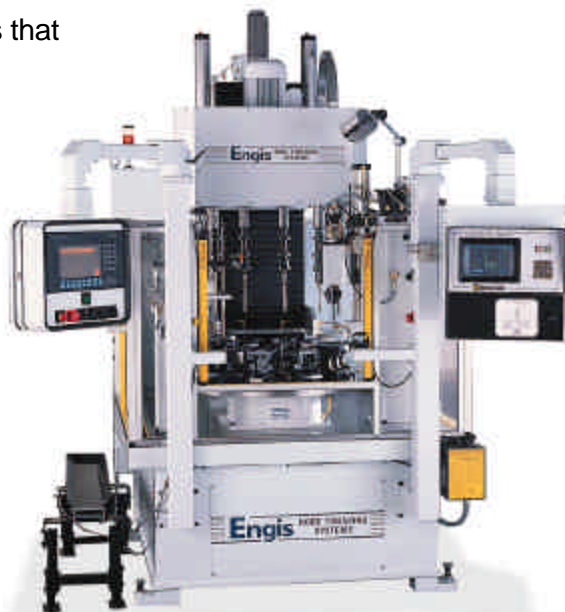


Performance Series

This series is a standard line of machines that include 4, 6 and 8 spindle models. These systems are for parts with bore sizes that range from .060" to 4".

Standard features include:

- Servo fed column design
- 25" Stroke
- Hydraulic index table
- Allen-Bradley controls
- Class 7 duplex spindle bearings
- 1.375" ASA spindles
- Automatic Lube System
- Pneumatic counter balance on heads
- Optional automation, gauging, brushing and guarding packages available



SPM Series

This series is a standard line of machines designed to meet the needs of job shops for small to medium size parts. Available in 2, 4 and 6 spindle models. These systems are primarily for parts with bores of 1" or smaller.

Standard features include:

- Servo fed column design
- 25" Stroke
- Hydraulic index table
- Allen-Bradley controls
- Class 7 duplex spindle bearings
- 1.375" ASA spindles
- Automatic Lube System
- Pneumatic counter balance on heads
- Optional automation, gauging, brushing and guarding packages available



Valve Sleeve

Length of Bore/Clearance: 1.20"

Material: 12L14 Steel **Machine:** Four Spindle with Automation

Stock Removal: .0026" / .0036" **Float Method:** Part

Feature	Required	Achieved
Size:	.0001"	.0001"
Roundness:	.0001"	.00005"
Taper:	.0001"	.00004"
Finish:	16 Ra. in.	12 Ra. in.

Production Rate: 240 Parts Per Hour

Special Note: Size and Geometry NOT affected by interruptions and undercuts in Bore

Specialty Series

This line incorporates all the special, custom designed machines and can include various features from the other series of machines. These machines can also incorporate other manufacturing processes as well. The following are some examples from the Specialty Series:

- *In-line transfer system*
- *Concentricity established model*
- *3-Axis, multi-spindle system*
- *Automated pressing, polishing, and bore finishing model*
- *Multi-column system for large parts including bore finishing, gauging, brushing, face de-burring and marking*



Horizon Series

This line features a range of horizontal machines with both manual and slide-assisted part feeding. The basic model is the 5000-2, which utilizes two spindles for a rough and finish operation. Various features and options include:

- *Dual clutch mechanism for spindle engagement*
- *Torque bars*
- *Variable spindle speed control*
- *Work light*
- *Internal and external coolant system options*
- *Precision spindles with ER collet tool holding*
- *Powered slide system*
- *Custom part fixture*



Power Steering Body

Length of Bore/Clearance: 40mm/8mm
Material: Cast Iron **Machine:** Six Spindle
Stock Removal: .050 mm max. **Float Method:** Tool

<u>Feature</u>	<u>Required</u>	<u>Achieved</u>
Size:	.012mm	.002mm
Roundness:	.005mm	.001mm
Straightness:	.005mm	.002mm
Finish:	1.6 Rz.	1.4 Rz.

Production Rate: 157 Parts Per Hour

Special Note: Special fixtures used that allow a family of parts to be run without any changeover.

Superior Machine Design & Controls to Boost Productivity & Safety



Machine Design & Constructions

- Precision spindles with class 7 bearings
- Rugged, compact machine base
- Servo-fed column
- Pneumatic counter balance design for extended ball screw life
- Hydraulic, mechanical, and pneumatic indexing configurations
- Automatic lubrication system
- Interlocked coolant system
- Isolation transformer
- Torque sensors monitor spindle load and can be pre-set to alarm at any pre-determined value
- Extensive machine manuals

Flexible Machine Design

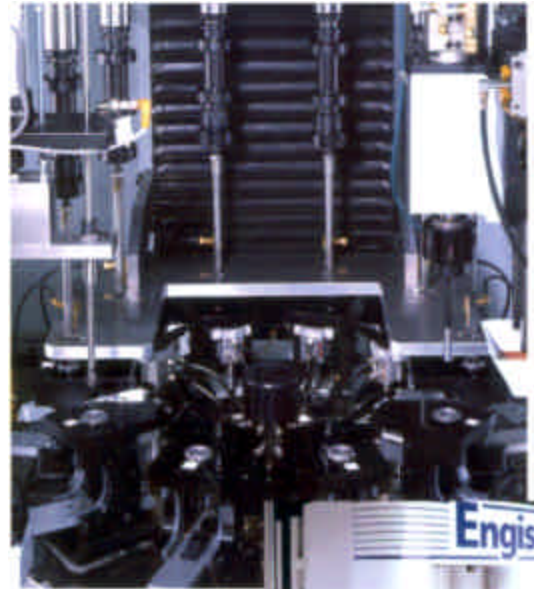
- Standard and custom multi-spindle designs
- Specialized column/spindle operation capabilities
 - De-burring
 - Cross-hatch finishing single-pass
 - Sine curve finishing
 - Gauging

Optional Features & Enhancements

- Spring-loaded tooling interlocked with machine controls protects machine and tooling from potential crashes
- Shadow gauge detects misloaded components – interlocked with machine controller
- Full-perimeter guarding with light curtain for added operator safety
- Wide variety of automation & gauging packages
- Torque-based feed compensation

Service

- 24/7 service support
- Preventive maintenance program
- Extended warranty options



Turbocharger Body

Length of Bore/Clearance: 100 mm / 2.5 mm
Material: Cast Iron **Machine:** Eight Spindle
Stock Removal: .127 mm max. **Float Method:** Tool

Feature	Required	Achieved
Size:	.013mm	.005mm
Roundness:	.005mm	.003mm
Straightness:	.005mm	.003mm
Finish:	.8Ra. mm	.4Ra. mm

Production Rate: 180 Parts Per Hour

Customized Automation Systems

Engineered to Optimize Productivity

Engis provides complete, customized automation packages, including both in-bound and out-bound product flow. From pick-and-place units and robotics, to in-process gauging and sensor systems to conveyor systems linking automated machining cells, Engis is capable of helping you design, engineer, test and deploy the right solution.



Through Integrated Controls and automation systems, Engis Bore finishing Systems bring new cost-saving efficiencies to operations the world over.



In this application, bowl feeders drop bushings into place, where they are automatically inserted into castings. Pick-and-place units transfer the castings into and out of the station.

Among the specific automation systems and capabilities currently in use by Engis customers in the field are:

- Pick and place units
- Robotics
- Bowl feeders
- Conveyors
- Discharge chutes
- In-process sensor monitoring
- In-process tool adjustment systems



Transmission Gear

Length of Bore: 1.00" Avg
Material: Hardened Steel **Machine:** Four Spindle
Stock Removal: .003" max. **Float Method:** Tool and Part

Feature	Required	Achieved
Size:	.0004"	.0002"
Roundness:	.0004"	.0001"
Taper:	.0004"	.0001"
Finish:	64 Ra. In.	32 Ra. In.

Production Rate: 360 Parts Per Hour

Engis Bore Finishing Process Development Laboratories

The Engis Bore Finishing Process Development Labs provide valuable process breakthroughs and technical support for our customers. Within these laboratories, Engis system engineers work side-by-side with customers to test, refine and improve bore finishing processes and technologies.



Production scale machines and state-of-the-art Metrology combine to provide customers with valuable insights and improvements in their specific bore finishing operations.

For example, tooling packages are tested and refined to optimize the process. Tool holders, stationary or rotary fixturing packages and other factors leading to greater precision and capability are identified and tested. Prototype parts are run at various cycle rates. Each process is studied, step by step, including stock removal rates, bore geometry requirements and surface finish.



- *New Machine Run-Offs*
- *Customer Part Testing and Run-Offs*
- *New Process Research & Development*
- *Machine Development*
- *New Tooling Development*
- *New Fixture Development*
- *Metrology – Testing and Analysis*



Gun Barrel

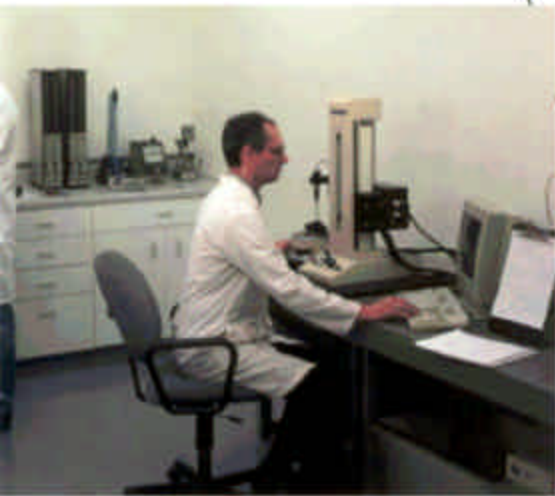
Length of Bore: 165 mm
Material: Stainless Steel **Machine:** Six Spindle
Stock Removal: .10 mm **Float Method:** Tool

<u>Feature</u>	<u>Required</u>	<u>Achieved</u>
Size:	.025 mm	.005 mm
Roundness:	.012 mm	.005 mm
Taper:	.012 mm	.005 mm
Finish:	.3 Ra. mm	.25 Ra. mm

Production Rate: 50 Parts Per Hour

Special Note: Peck Style Motion

Helping customers harness the precision & reliability of the single-pass process, Engis operates labs in the U.S., Japan and the United Kingdom.



The core mission of the Engis Process Development Labs is to ensure that each Engis bore finishing system exceeds the performance standards demanded by today's sophisticated materials, components and customer requirements.

Prototypes and first-run samples, as well as spot checks of customer production runs, undergo thorough inspection.

Material removal, surface finish and bore geometry are all rigorously measured and documented in each facility's metrology lab. These labs utilize state-of-the-art devices capable of making extremely precise, sub-micron measurements.

Each part is checked for bore roundness, straightness, concentricity and surface finish. A full complement of instrumentation, including a computerized Talyrond system, is constantly being upgraded and expanded.



Prototypes and test-bed parts undergo rigorous inspection, utilizing the lab's computerized Talyrond system (above) and other devices to measure bore quality.



Compressor Part

Length of Bore: 2.00"
Material: Powdered Metal **Machine:** Four Spindle
Stock Removal: .002" / .0025" **Float Method:** Tool and Part

<u>Feature</u>	<u>Required</u>	<u>Achieved</u>
Size:	.0005"	.0002"
Roundness:	.0002"	.0001"
Finish:	10 Ra. in.	2-5 Ra. in.

Production Rate: 180 Parts Per Hour
Special Note: Machine Equipped with Tool protection and part sensors

Global Customers & Applications

Engis Single-Pass Bore Finishing Systems are bringing increased productivity, higher levels of precision and cost-saving reliability to customers worldwide. Engis bore finishing systems are in operation throughout North America and the United Kingdom, as well as in Europe, Asia and South America.



Engis Single-Pass Bore Finishing Technology and Systems have been adopted by many of the worlds leading manufacturers in various industries, including:

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- Hydraulic
 - Pneumatic
 - Ceramic
 - Compressor
 - Gear
 - Aerospace
 - PMPA
 - Powdered metal
 - Plastic
 - Firearms
 - Automotive ...
 - Connecting rods
 - Rocker arms
 - Tappet bores
 - Cam & Crank bores
 - Fuel systems
 - Steering systems
 - Brake systems
 - Turbo chargers
 - Transmission components



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