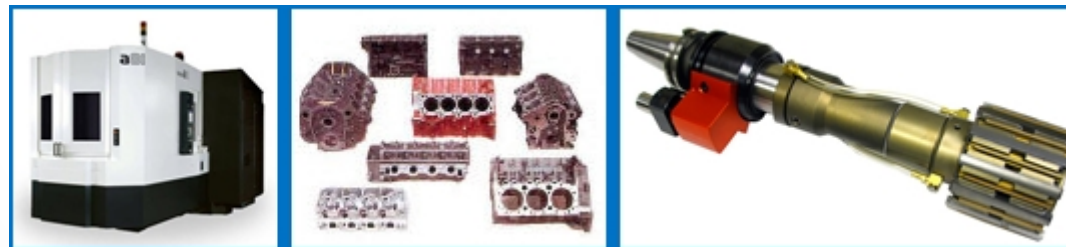


Perfection of Engine Block Honing on Agile/Flexible CNC Machining Centers

David Chobany
Vice President of Business Development
Bates Technologies, LLC



engineexpo2012

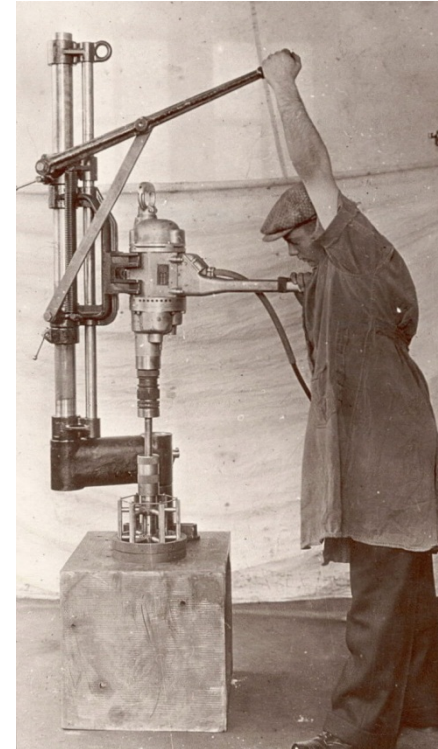
 **BATES**[®]
HONING SPECIALISTS
A DIVISION OF LAPMASTER INTERNATIONAL, LLC

Definitions

- Perfection:
 - The quality or condition of being perfect.
 - The act or process of perfecting:
 - Perfection of the invention took years.
 - A person or thing considered to be perfect.
 - An instance of excellence.
- Hone:
 - To perfect or make more intense or effective
 - A fine-grained stone for giving a keen edge to a cutting tool.
 - A tool with a rotating abrasive tip for enlarging holes to precise dimensions.
 - Verb as to “hone” in:
 - To move or advance toward a target or goal
 - To direct one's attention; focus

Honing in Metalworking

- Technology developed in the mid-1920's to challenge existing metalworking processes such as boring reaming, and grinding
- Promoted as a “working art form” to generate:
 - Bore Geometry
 - Stock Removal
 - Size Control
 - Surface Finishes
 - Surface Structuring



Perfect Bore Geometry

10 Common Errors in Bores



Out of Round



Bellmouth



Waviness



Undersize



Barrel



Taper



Boring Marks



Reamer Chatter



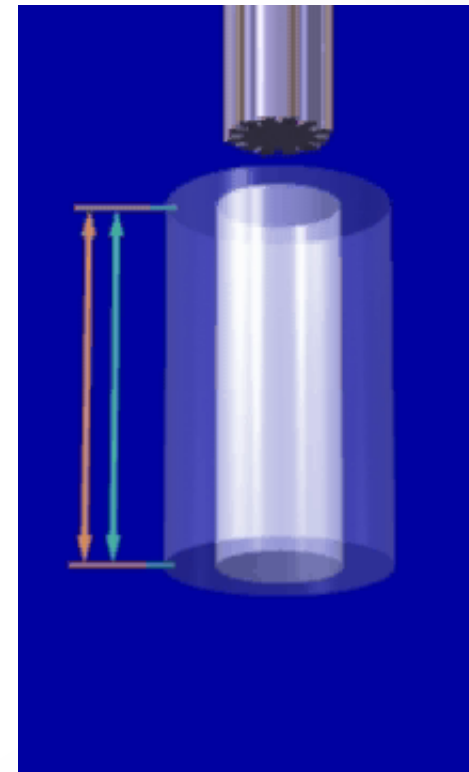
Rainbow



Misalignment

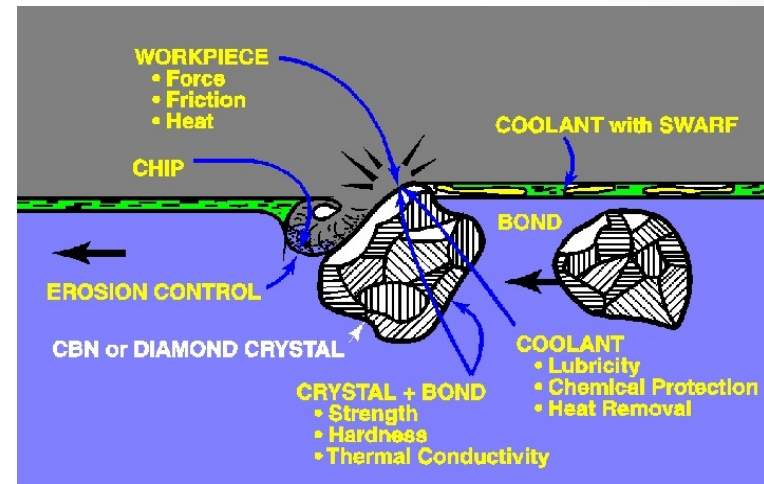
Perfect Bore Geometry

- Non-rigid tool design (follows centerline)
- Number and length of stones
- Stroke reversal areas



Stock Removal

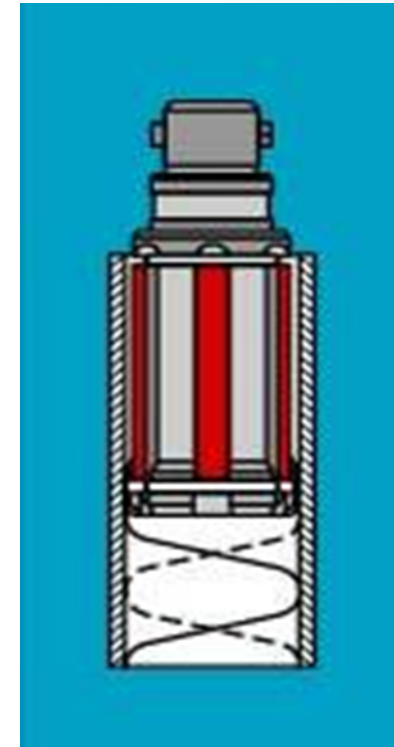
- Honing is a metal abrading process utilizing thousands of abrasive crystals sintered into the shape of stones.



Layered
abrasive in
sintered
metal bond

Stock Removal

- Cutting pressure (in-feed) is applied to all stones from the center of the tool to the wall of the part equally in all directions
- Minute metal chips are sheared off through the forces generated in combination with the reciprocation and rotational motions

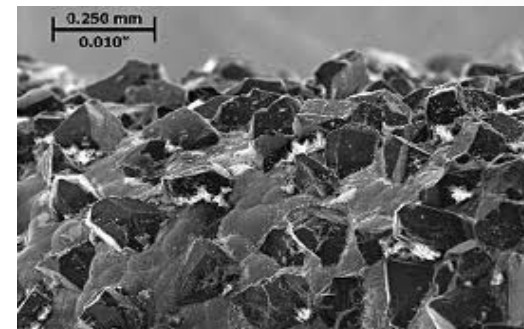
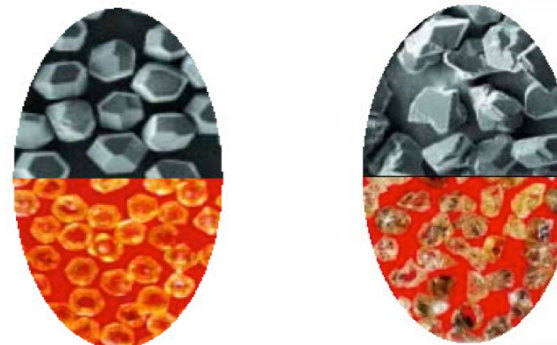


Surface Finish

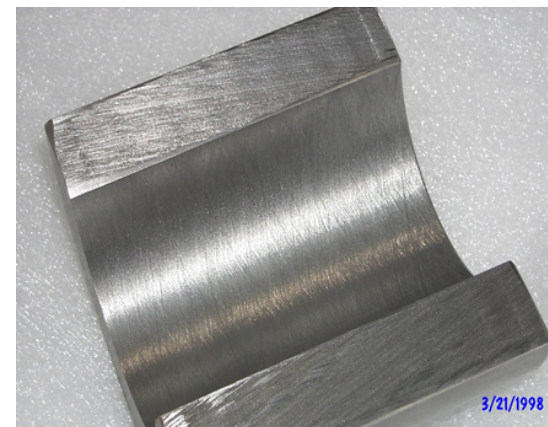
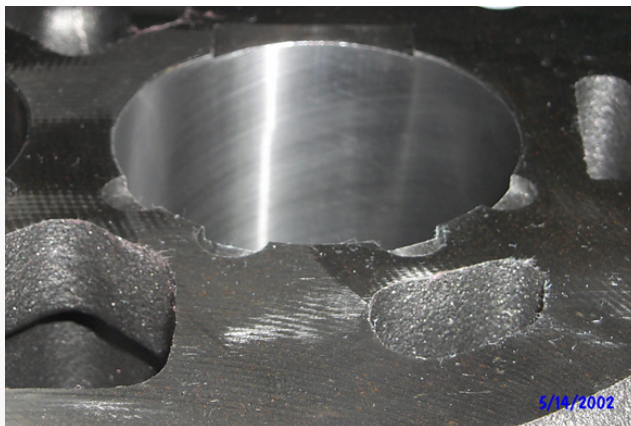
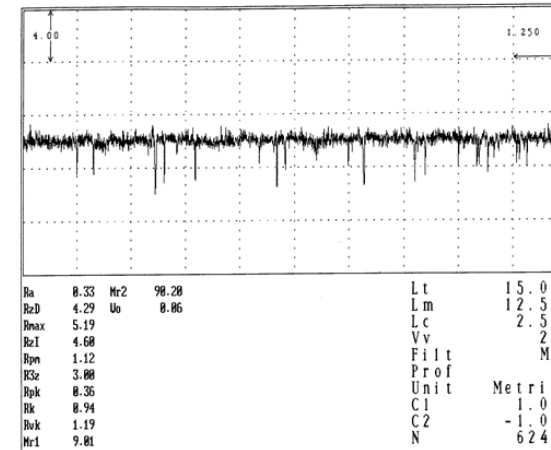
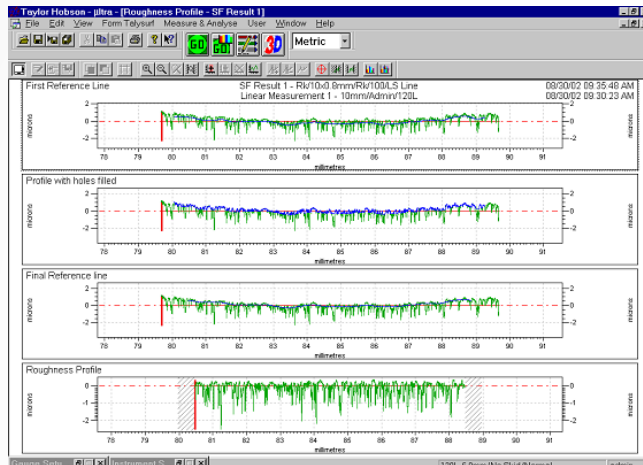
FEPA and Grit Sizes

Diamant/ diamond FEPA Standard		CBN FEPA-Standard		ASTM-E-11-70 (US Mesh)	
eng narrow	weit wide	eng narrow	weit wide	eng narrow	weit wide
D 426	D 427	B 426	B 427	40/ 45	40/50
D 356		B 356		45/ 50	
D 301		B 301		50/ 60	
D 251	D 252	B 251	B 252	60/ 70	
D 213		B 213		70/ 80	
D 181		B 181		80/100	
D 151		B 151		100/120	
D 126		B 126		120/140	
D 107		B 107		140/170	
D 91		B 91		170/200	
D 76		B 76		200/230	
D 64		B 64		230/270	
D 54		B 54		270/325	
D 46		B 46		325/400	
D 35				400/500	
D 30		B 30		400/600	
D 25				500/600	
D 20					
D 15		B 15			
D 10					
D 7					
D 3					
D 1					

Shape and Concentration



Surface Finish



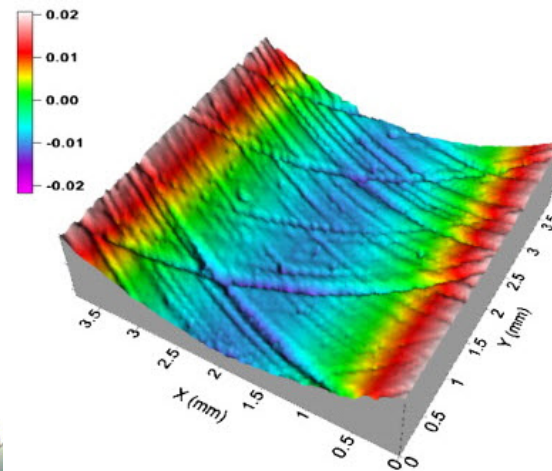
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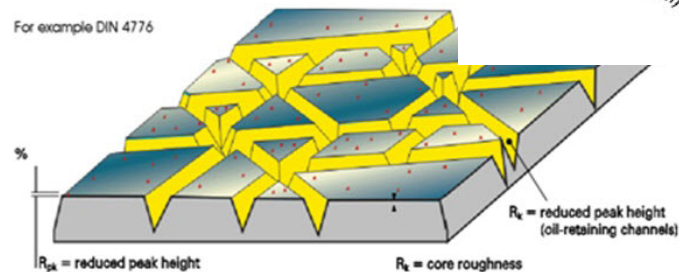
Texture and Crosshatch

- Oil Retention Trenches

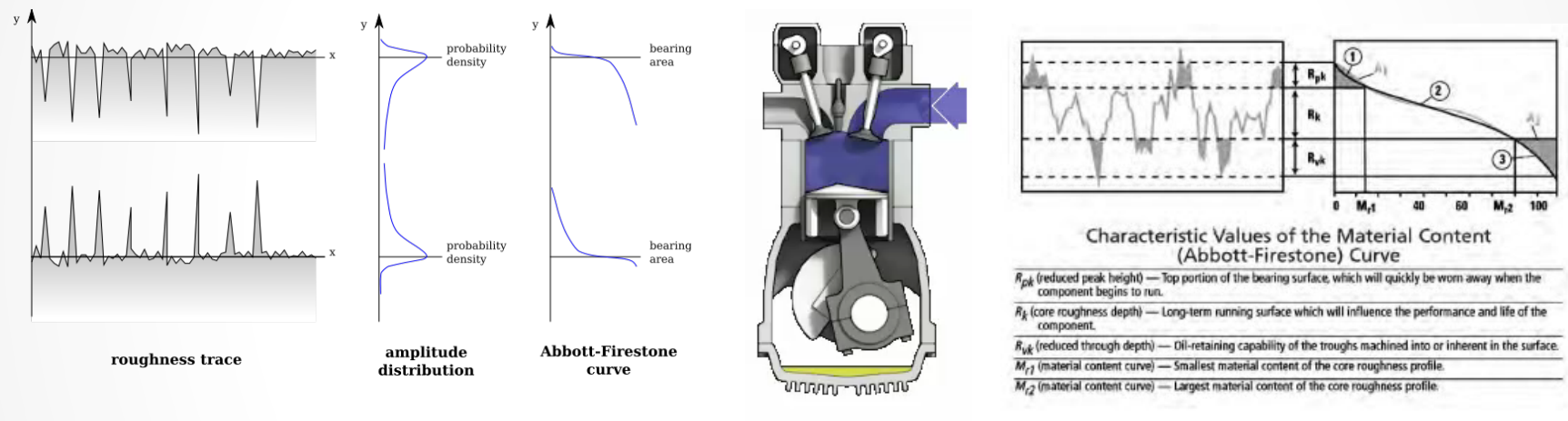
- Depth
- Width
- Vo



For example DIN 4776



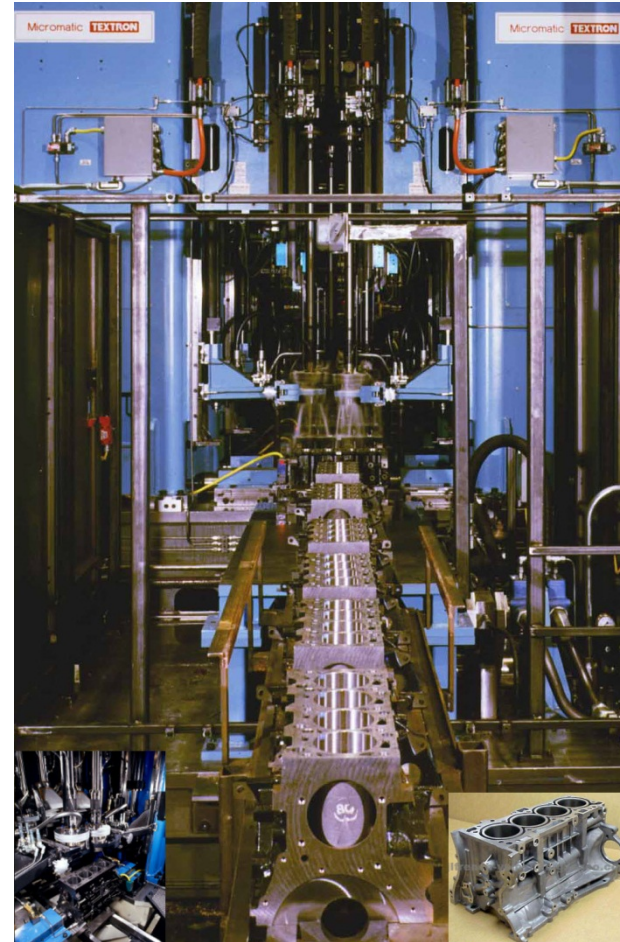
Generate Bearing Surface



The BAC (Bearing Area Curve) describes the surface texture of an object. It is used in evaluating and determining sealing and bearing surfaces used in the engineering and manufacturing of piston cylinder bores.

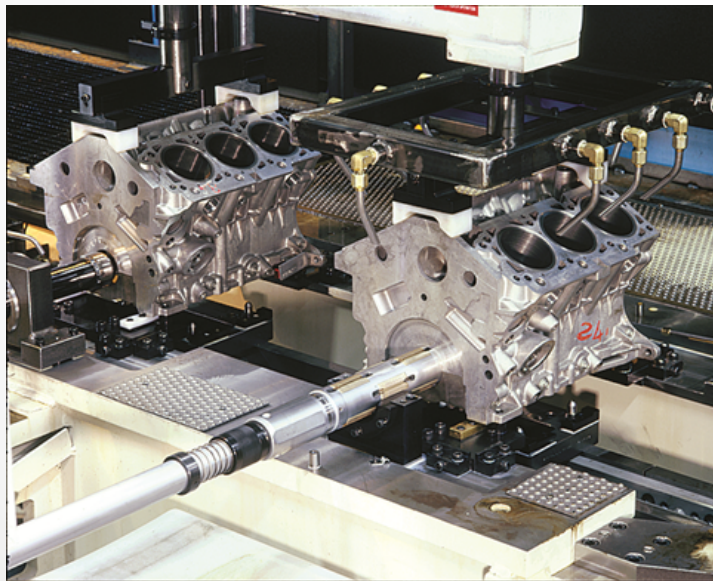
Honing of Engine Blocks

- In the 1920's the art of honing ignites as a booming market for automotive engines required honed cylinder bores
- Today transfer style block machining lines have remained the standard methodology for producing high volume engine blocks.



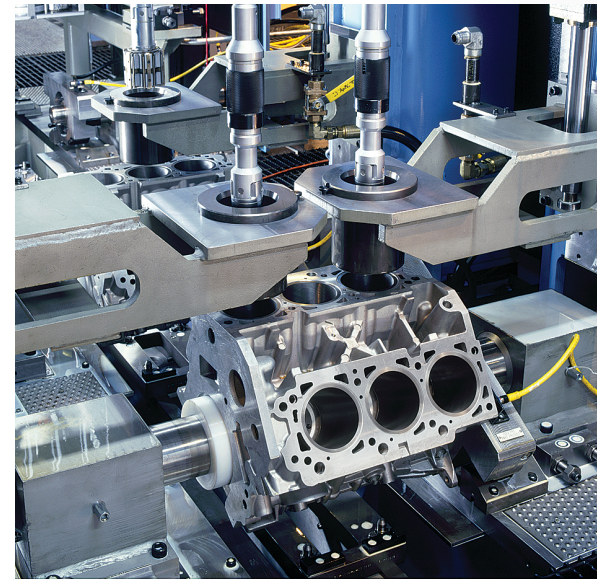
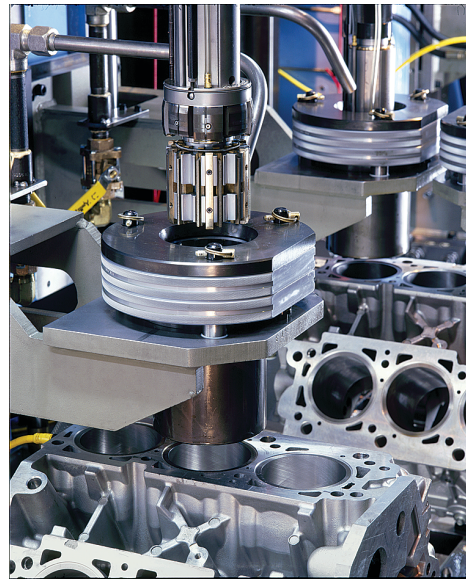
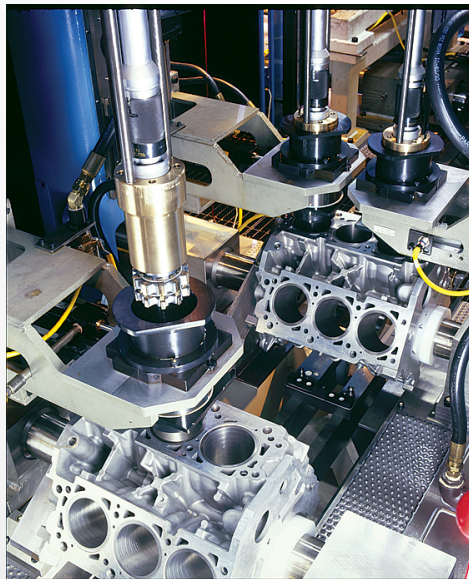
Block Transfer Hone

- Bates Microsizing® of Crankbore Journals
- Diamond Reaming



Block Transfer Hone

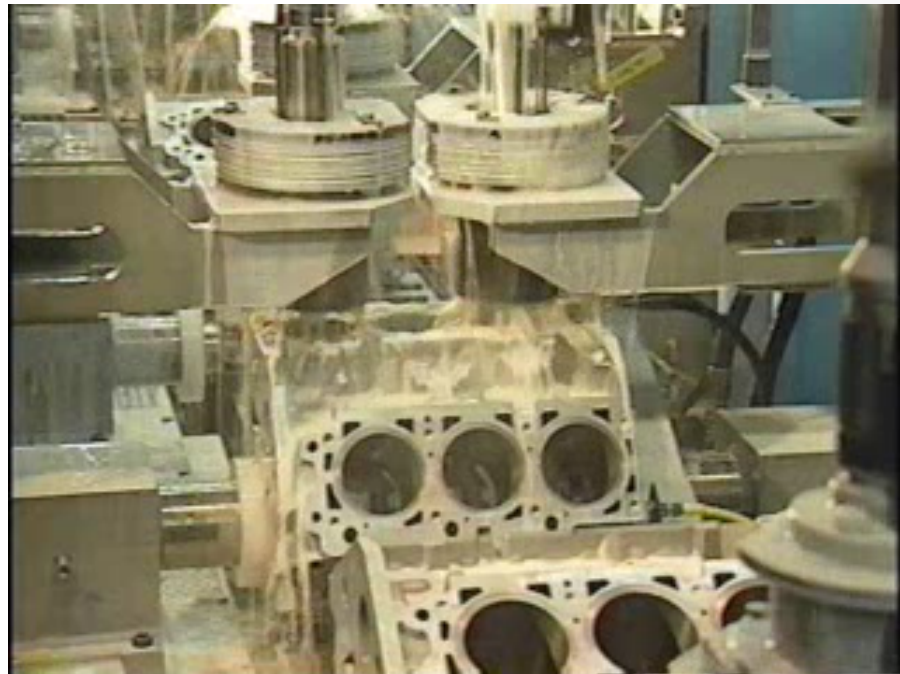
- Rough Pass
 - Stock removal and bore geometry
- Semi-Finish
 - Stock removal and valley underlayment
- Plateau
 - Bearing surface generation



Block Transfer Hone

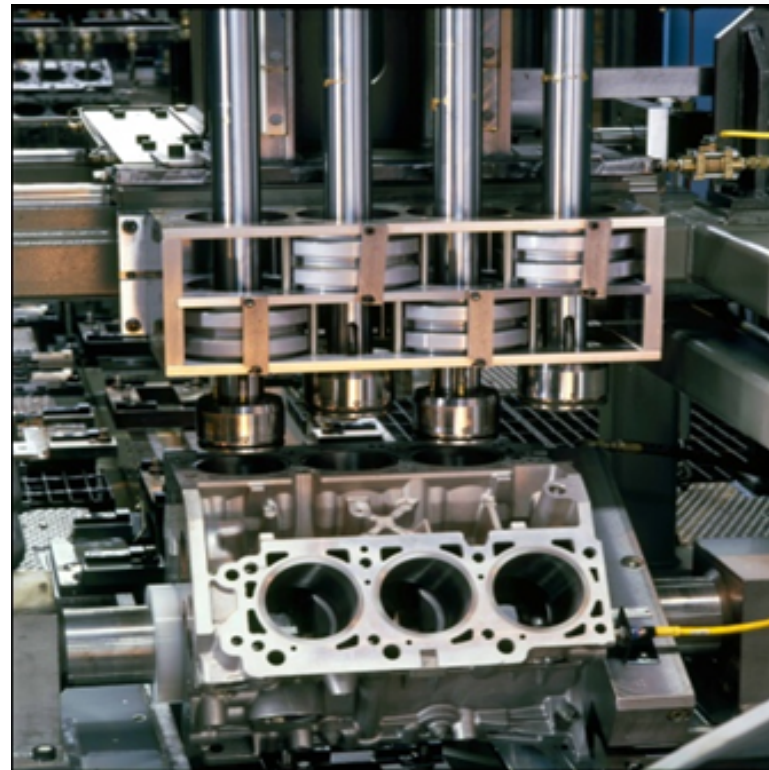
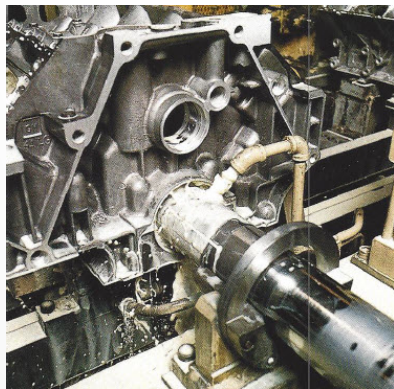
Most Sophisticated and Multi-faceted Operation

- Part positioning and location
- Tool motion control and positioning
- Abrasive feed control
- Air Gage Sizing
- Clamp, lift and transfer



Post Process Air Gaging

- Cylinder bores
 - X Y
 - 5 levels
- Crankbore journals



Agile/Flexible Honing

Integration of complete hone process under your control using your existing CNC machining centers



Agile/Flexible Honing

- HMC and VMC
 - Makino
 - Mazak
 - Others
- Lathes
- Vertical chucker
- Many other CNCs



V8 CGI Block IMTS 2012



V8 CGI Block Honed on a Makino a81 HMC with
Bates CNC Hone Tool and Air Gage System

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Consolidation of Operations

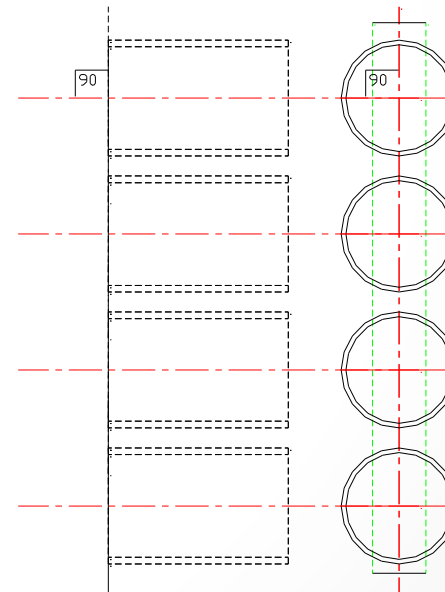
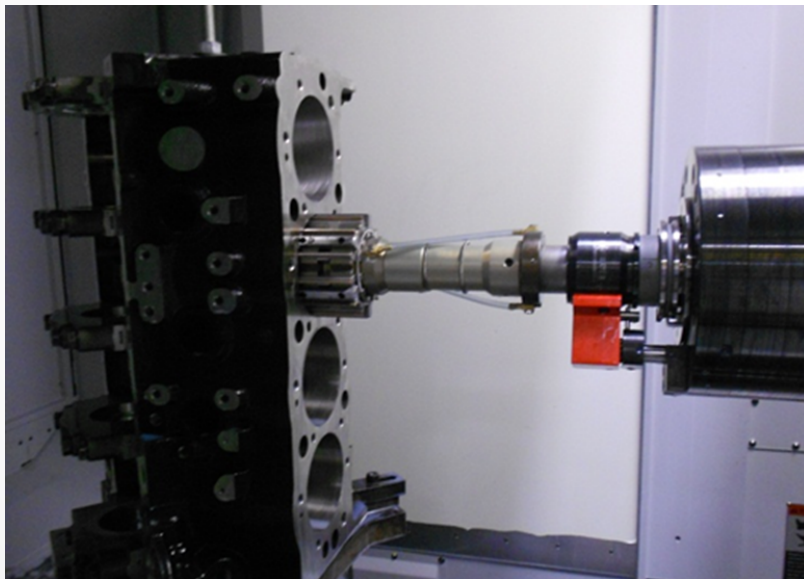
- Bore, ream and hone in common set-up
 - Reduced fixturing costs and set-up issues
- Single point of failure or inflexibility
- Reduced work in process and routing
- Eliminate dedicated equipment
- In-house control and containment
 - Support and training
- IP and confidentiality

Financial - Logistical

- Agility in capital deployment
 - Commonality of machine tools, spare parts and control programming
- Increased throughput and reduced cycle time potential
- Common water based fluids
- Single source responsibility
 - Inventory control

Enhanced Quality

- Machining of all critical features in same clamping w/o transfer from machine to machine.



Enhanced Quality

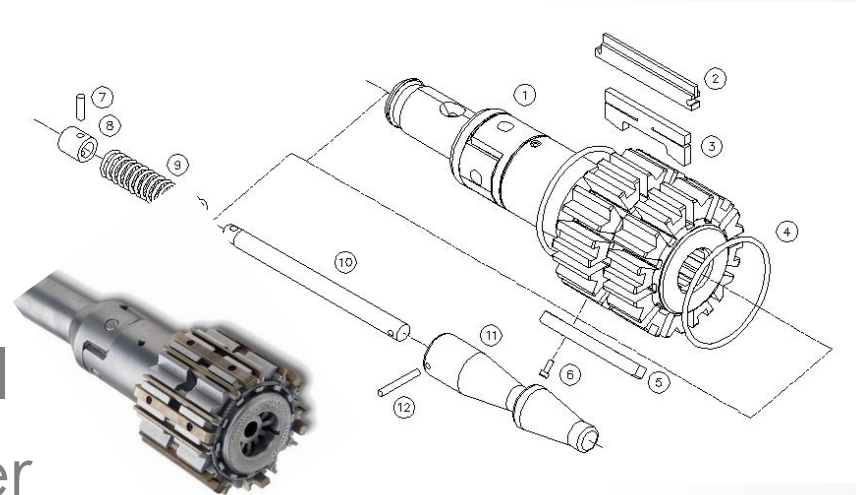
- Eliminate accumulative tooling and positional stack-up errors
- Live in process Air Gage sizing
- Reduced operator interface
- Ability for closed loop process leading to higher Cpk and quality standards

Precision Hone Tooling



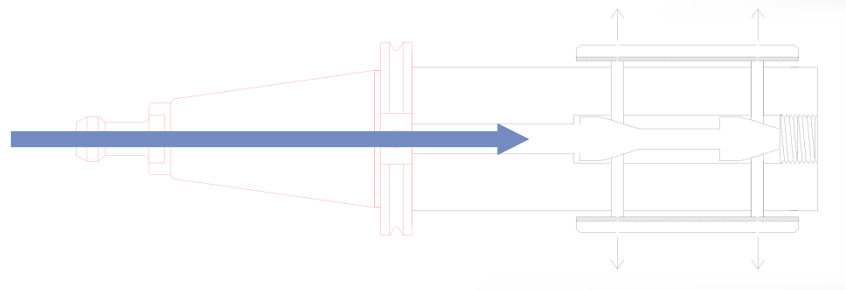
Precision Hone Tooling

- Designed to replicate existing production tooling
- Tool float is controlled by adjustable universal
- Adaptable to customer preferred tool holders (HSK, Cat, etc.)



Coolant Driven Expansion

- The CNC hone tool expands the abrasive stones using a controlled “through the spindle” coolant pressure against a feed cone.



Coolant Adjustable Hone

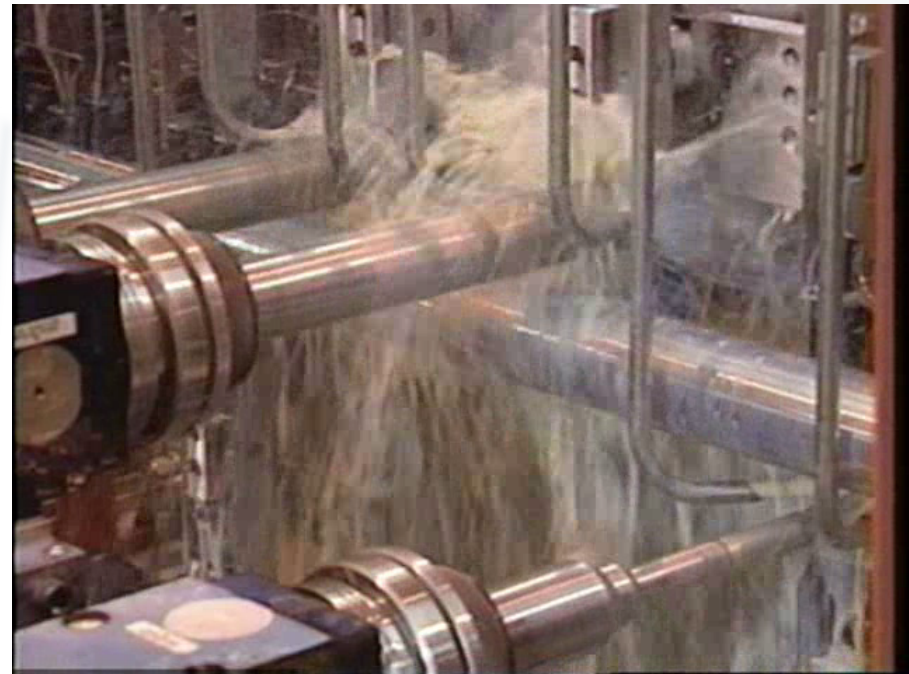
- Machine programmed to monitor and adjust coolant pressure
 - Stock removal rates
 - Consistent surface finish (DOC)
- Correlate spindle load to surface finish Rvk and Rk
- Potential for closed loop control of surface finish and size

Microsize® Tooling

- Fixed diameter and rigid tooling using bonded or electroplated abrasives
- Standard tool for use in connecting rods and crank-bores
- Long life and highly repeatable sizing tool
- Expandable to accommodate abrasive wear
- Alternative technique to finish reaming or boring

Microsize® Tooling

Bore Sizing of Connecting Rods



Flexible Honing Solution

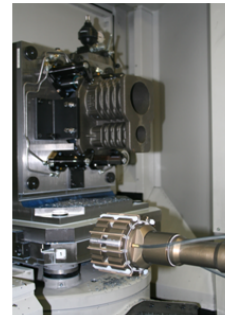
CNC Machine Integration

Machine Integration

- Thru spindle coolant
 - High or low pressure
 - 100-1000
 - Constant and maintained with no surging (3 psi)
 - Pressure pre-check at spindle face.
- Temperature and viscosity constant



HMC and VMC requirements for use of the Bates Hone Tooling Systems



The items described below are required as part of your CNC machine tool to allow compliance in running the Bates CNC style hone tooling and Precision Air Gage Systems (PAGs). Any costs or liabilities associated with these and any other machine modifications, control integration, programming, etc. will be the responsibility of the customer.

Thru-Spindle Coolant System

Machine must have an adjustable coolant pressure system. A constant working pressure required to expand the stones will be determined during the initial tool set up. Once set, the machine must maintain this pressure to the spindle face during the honing cycle. Working pressures are related to the tool size and work piece material but typically have been running in the range of 14-28 Bar (~200 to 400 psi).



Coolant Filtration System

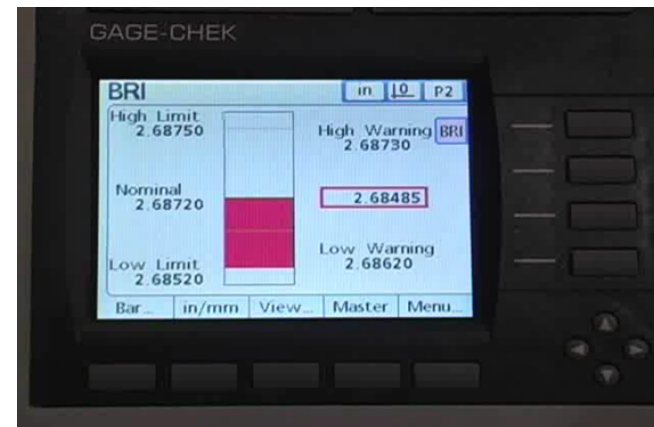
Additional canister style filtration down to 10 micron may be required to filter out the finest chip produced in the process. For applications where part finish is rougher less filtration may be acceptable.

Stroke Count Honing

- A typical hone tool is reciprocated (one stroke down and back) at a rate of between 15 to 40M/min
- A hone cycle is dependant on stock removal required, part hardness and final surface finish
- Tool reversal (upper and lower) must be accurate, repeatable, seamless and sharp. There should be no hesitation during the reciprocation cycle
- Crosshatch angle is generated between reciprocating motion and tool rotation
 - 20 to 45 standard

Air Size Honing

- Automatically hone to programmed bore size
- In process bore shape and size capabilities
- Cost effective, easy to use and maintain
- Data collection
- Potential to feedback and close loop with prior operations

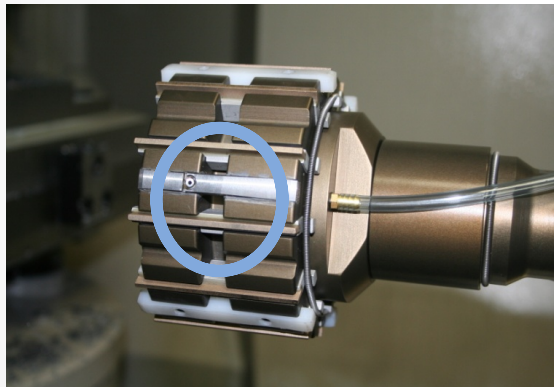


In Process Gaging

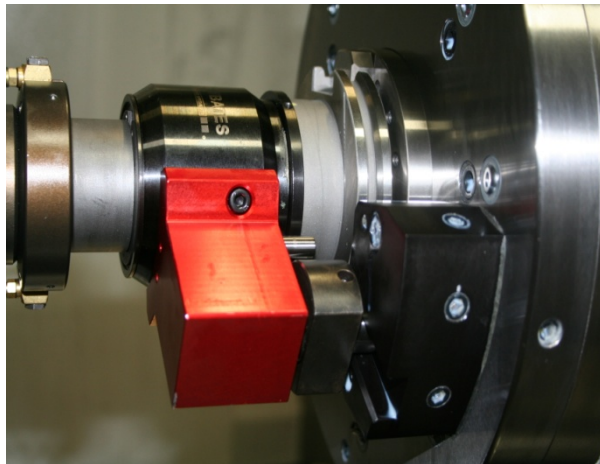
- Hone tool with on board in process gage
- Tool can be positioned in X – Y and at various depths within the bore to build bore shape data information
- Tool changeable
- Diameter data supplied to Gage Chek for SPC purposes
- Machine logic adjusts finish boring bar automatically to compensate for insert wear

Air-gage Components

Air
Orifices



Rotary
Union

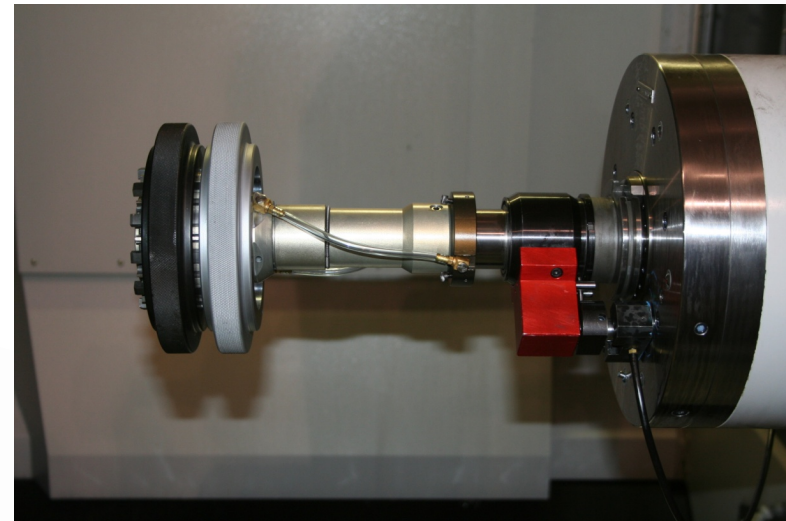


Stop
Block



Hone Tool Mastering

- Air gage tooling must be min/max mastered during initial part set-up.

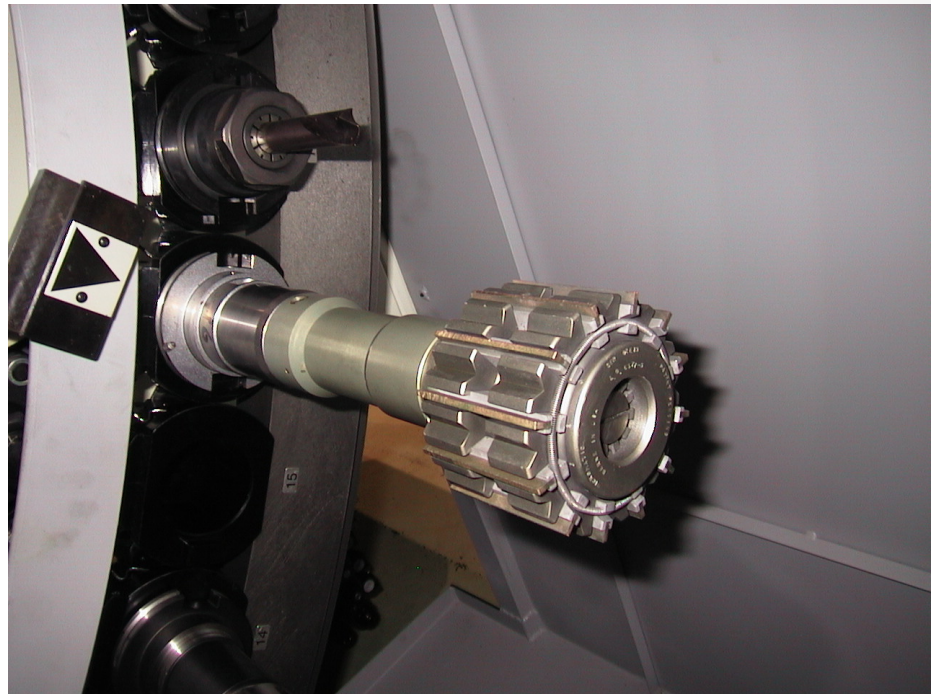


Machine Code Awareness

- Soft or heavy tool change out
- Tool orient
- Air purge restrictions
- Tool entry to bore centerline
 - Tool float accommodation to part centerline

Tool Storage

- Tool carousel or magazine
 - Length
 - 12-14 lb
 - Weight
 - Cylinder tool
 - Position
 - Cleanliness
 - Attachment
 - Speed



Coolant Filtration

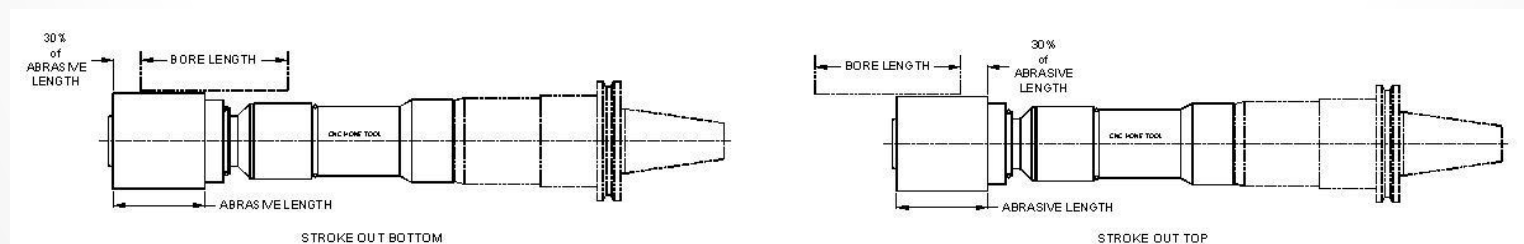
- Enhanced requirement for clean coolant is needed to assure free expansion of tooling
- Honing produces fine chips referred to as swarf. Swarf is abraded metal material which is of a slight mud consistency
- The filter system must be rated to capture the smallest chip produced in the process
 - Bates recommends ~10 micron

Flexible Honing Solution

Tool Set Up

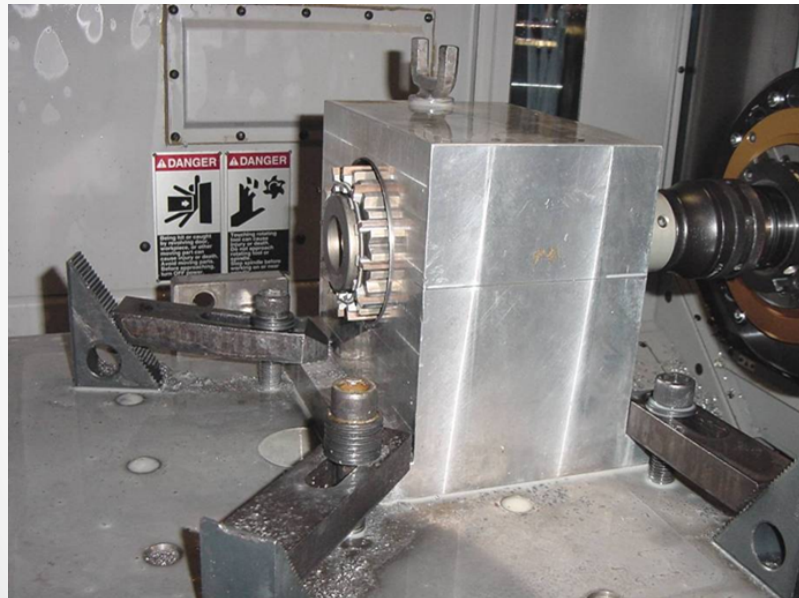
Tool Stroke Positioning

- Bottom Z depth at the position with 1/3 of the hone stone length extending out the bottom of the bore
- Top Z location by extending 1/3 of the hone stone length out the top of the bore
- The movement between the bottom and top Z locations will be considered as the stone reversal points in your hone stroke reciprocation program



"Z" Positioning

Bottom Z



Top Z



Initial Tool Runoff

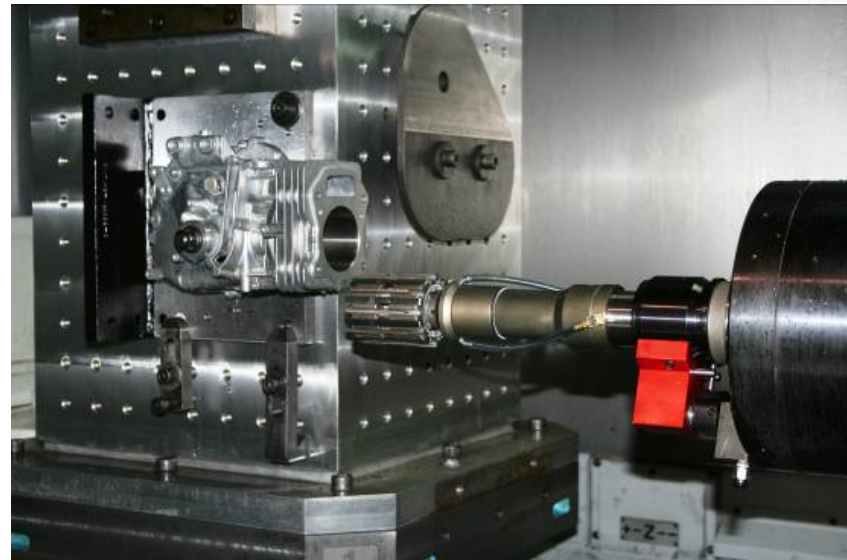
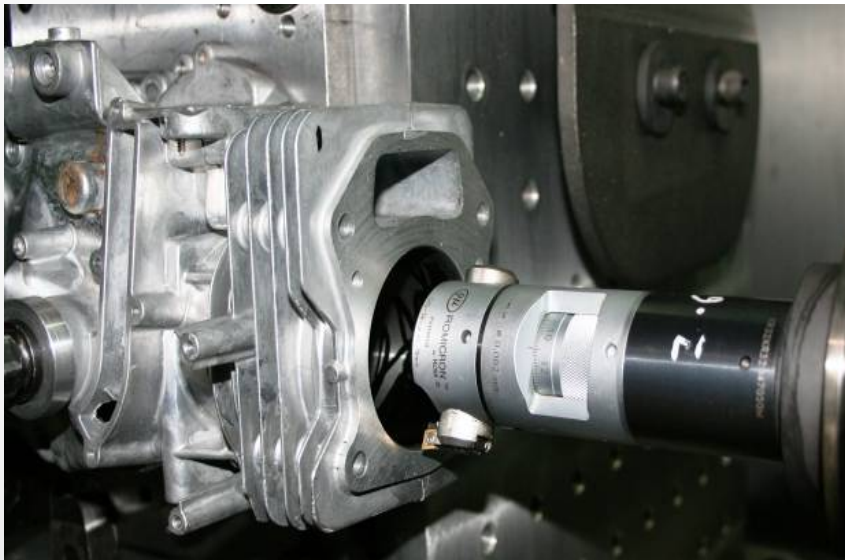
- Calculate stroke reciprocation rate, spindle speed, and reversal points based on factory recommendations
- Set the air gauge master or determine number of strokes required to achieve finish size
 - Stock removal is dependent on abrasive grade and feed pressure
 - Initially run a (10) stroke reciprocation program
 - Record incoming and finish bore sizes and to determine the stock removal rate per stroke
- Inspect geometry and surface finish and make adjustments as needed to spindle speed and feed pressure
- Bore geometry issues such as taper, barrel, and hourglass can be corrected by adjusting stroke reversal positions

Process Capability

Closed Loop Boring-Honing

Closed Loop Boring-Honing

- CNC Honing Tool with Diameter Feedback
 - Pre gauge to validate prior operation bore size
 - In-process gauge to finish size and signal out
 - Machine automatically adjusts the insert to compensate for wear



CNC Honed Part Quality

- Bore diameter for CNC honed cylinders tend to be more accurately centered around target value for diameter and display best cylindricity.
- CNC honed bores display highest process capability for diameter when no in-process size controls are used
- Ra for conventionally honed bores and CNC honed bores are marginally equal. Data from both processes are influenced by pre-honing part geometry and surface finish as well as coolant preparation.

CNC Honed Part Quality

- Historically, .003" (0.076mm) stock was needed to bring bores to size and rectify any bore distortions remaining after clamping, metal cutting and grinding operations.
- CNC honed bores required .0018" (0.046mm) to achieve the same result in a single honing operation.
 - Influenced by reduction in bore distortions due to clamping and unclamping
- The end result was less stock removal, increased abrasive life and a reduction of cycle time to 30 seconds per bore.



*... thanks you for the
opportunity extended to us
in presenting our flexible
CNC hone tooling products
to you. We appreciated your
time and attention.*

Please visit our websites

www.batestech.com

www.lapmaster.com

www.barneshoning.com

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