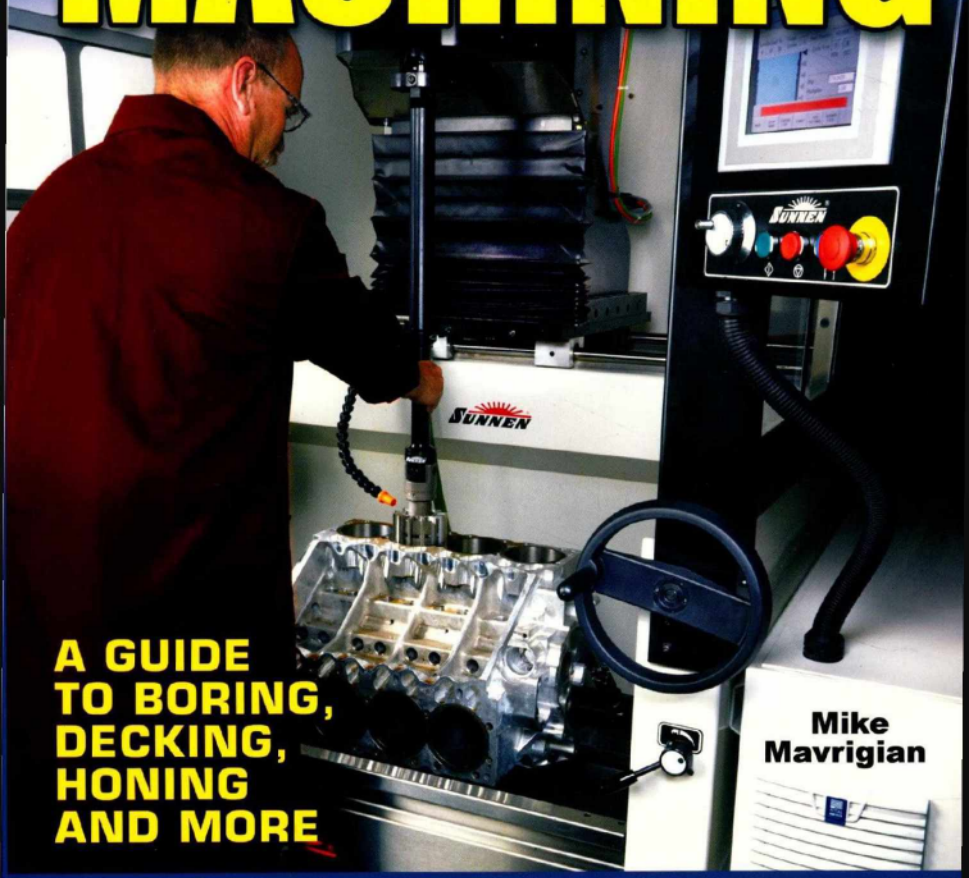
SA378

PERFORMANCE HOW-TO

S-A DESIGN

Automotive MACHINING



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Mike Mavrigian

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Automotive MACHINING

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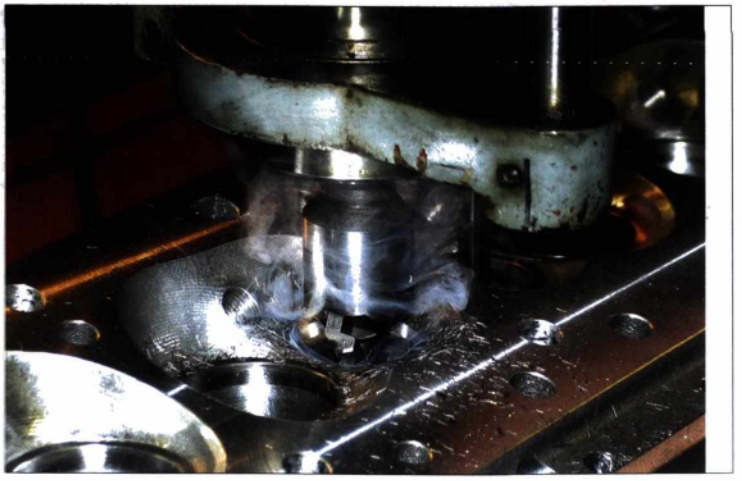
Mike Mavrigian



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Title Page:
Valveseats may be ground with an abrasive stone or cut with seat cutters. Cutters provide a more precise finish.

Back Cover Photos

Top:
With a deck plate installed and torqued, honing with the appropriate grade of stones begins. To reduce the effect of heat transfer between cylinders, bores are honed in an alternating manner. Cooling liquid is constantly applied during all stages of honing. This transfers heat from the block and aids in keeping the honing stones clean.

Middle Left:
After a bore gauge has been set up to match the crank main journal diameter, the gauge is inserted into the installed main bearing to determine the bearing ID relative to the crank main journal.

Middle Right:
The piston dome is receiving a custom dome profile on a CNC lathe.

Bottom:
This example shows a 4-barrel single plane intake manifold mounted via a fixture plate, ready to be custom ported. Machining at a variety of angles is possible, since both the head and base move in various axes, achieving intricate cuts at varying angles. (Photo Courtesy Centroid)

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CONTENTS

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Introduction

As an engine builder, you need machine shop services for a stock rebuild, modified, or high-performance engine. Whether you're an avid enthusiast or considering machining as a profession, this volume covers all critical operations of engine machining, so you have a clear understanding of the process and how to perform certain procedures yourself.

Although professionals are often required to perform automotive machining processes, it does not preclude the avid enthusiast from performing some machining and being closely involved in the machining process during an engine rebuild or high-perfomance build.

A typical automotive machine shop contains hundreds of thousands of dollars of machining equipment. Even a hard-core consumer cannot afford, nor is it practical, to buy this equipment. As a consequence, an at-home engine builder needs to contract a qualified machine shop for engine machining services. If you're investing thousands of dollars in an engine build, you need to thoroughly understand these engine machining procedures, so you can guide the process and confirm that the correct results have been achieved. When your head, block, intake manifolds, and many other parts have been machined, you need to inspect, measure, and verify that the components are to specification.

Once all machining is complete, the assembly will be performed either by you or the machine shop. These critical components need to precisely fit together. The tolerances between components is exacting and

can be as little as .0001 inch. It is incumbent upon you to invest in a set of tools to measure and verify the work that has been performed. This includes a C-clamp micrometer, caliper micrometer, dial indicator, dial bore gauge, bore gauge fixture, depth gauge, feeler gauge, pushrod measurement tool, machinist's straightedge, torque wrench, torque plus angle gauge, ultrasonic tester, and other specialty tools and materials for engine building. With these tools, you are able to analyze and evaluate the machine shop work. Equally as important, these tools provide the means to take critical measurements during engine assembly. As a result, you are able to assemble the engine with precision, and this helps ensure that you have a strong-running and reliable engine.

The information provided in this book is intended both for the aspiring engine machinist and the performance consumer. It provides valuable insight into the processes involved in engine machining and assembly. You are given a complete tour of machining necessary for a typical engine build, and beyond that, you are shown the steps to machine engine parts for a build. All the parts of the engine must be compatible and complementary; a certain set of parts requires precise machining so the engine can operate as designed.

In many cases, an engine builder starts with a thoroughly used and tired engine that's in need of a rebuild. In this book, you are instructed how to properly clean all engine components using bead blaster, soda blasting, chemical, and ultrasonic cleaning methods. You're shown how to inspect and evaluate the engine block to ensure that it's a worthy rebuilding candidate. In addition, you learn about the inspection of all components in the engine, so you can identify past problems, current solutions, and determine which parts are worth saving and which ones are not.

When it comes to block machining, main bore aligning, cylinder and cam tunnel honing, and boring are covered. Cylinder sleeving is often required in the engine building process, and that is also revealed. Truing the surfaces of the block deck ensures a seal between the block and the heads. A crankshaft is subjected to all kinds of opposing loads and as it accumulates hours of operation, it can bend, the journals can wear, and suffer other problems.

Measuring, machining, and other parts of crankshaft preparation are covered in detail. Connecting rods are the highest stressed components in an engine, and therefore, if yours are to be reused, they must be thoroughly inspected and properly reconditioned. In particular, the selection and installation of the connecting rod bolts must be done correctly to ensure that there is no failure because a connecting rod failure will likely destroy the entire engine.

You are shown how to install guides, machine and install valveseats, true the deck surface, measure the combustion chambers, and all the other critical steps to returning heads to their full health. Pistons and rings must be properly fitted to the bore of a particular engine block, so the process for fitting the ring to the cylinder and ring filing is covered.

Chapters provide information on rotating assembly balancing, blueprinting, clearance checking, CNC machining, port matching, pushrods, connecting rods, and more. Also included is an overview of final engine assembly tips.

With this comprehensive volume, you will be able to disassemble, inspect, and evaluate the engine components. And with this information, you will be able to make the best high-performance building and engine rebuild decisions, so you ultimately have the best engine to suit your needs. Once the machining has been performed, you will be able to take all the parts, properly fit them, and conduct a professional-caliber final assembly.

CHAPTER 1

ENGINE COMPONENT CLEANING

Prior to test fitting and/or final engine assembly, cleanliness is absolutely critical. This includes every component involved (block, crankshaft, connecting rods, pistons, camshaft, timing system, oil pump and pickup, oil pan, valvecovers, intake manifold, cylinder heads, rockers, pushrods, lifters, timing cover, etc.). There is no such thing as "too clean."

A variety of cleaning methods are available, depending on the application. These include hot tanks, spray cabinets, ovens, airless shot blasting, cabinet media blasting, tumbling, and manual cleaning involving hand or power tools.

An airless shot blaster slings steel (or stainless steel) shot onto the block or cylinder heads as the part is rotated while secured in an adjustable cage. Compressed air is not used. Following shot blasting, the part must be tumbled in a rubber-lined drum to shake any remaining steel shot from the part.

Airless Shot Blasters

An airless shot blaster cabinet uses a high-speed impeller that blasts steel shot at the parts as the parts slowly rotate in a cage. This machine does not use compressed air. The steel (or stainless steel) shot is about .030 inch in diameter. After the part has been blasted, the part must then be tumbled in a large tumbling drum to remove any remaining shot. Airless blasting with steel shot is intended for cast-iron parts only and should not be used on softer aluminum parts. Components may only be airless shot blasted after they have been degreased and are thoroughly dry.

Hot Tank Cleaning

Solvents heated at approximately 170 degrees F break down contaminants faster than room-temperature solvents. However, solvents must be chosen carefully to be compatible with ferrous (steel or iron) or nonferrous (alloys) components. After a part has been cleaned in a hot tank, it must be rinsed in hot water and then blow-dried. At this point, steel or cast-iron surfaces tend to surface rust very quickly, so application

of a rust inhibitor is required as soon as possible. Hot tanks are available in various types, including hot-soak and hot-soak with agitation and spray jets.

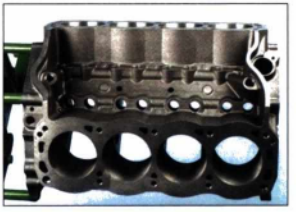
Jet Spray Cabinets

A "jet" spray machine uses heated solvent and a series of high-pressure spray nozzles. The parts being cleaned are secured in a cage or appropriate mount, on a turntable. The part is rotated during the wash and rinse cycle. Liquids, depending on the application, can include hot water and/or solvents appropriate for the material being cleaned. High-caustic solvents may be appropriate for steel or cast-iron; a detergent-based cleaner is best for aluminum parts.

Cold Solvent Wash

Commonly available parts washers that use a cold (unheated) solvent are useful for degreasing smaller parts such as connecting rods, pistons, camshafts, etc., but this requires allowing the parts to soak and then be hand-brushed or scraped to remove grease and other solvent-soluble contaminants. However, since no pressure is involved, this may or may not remove contaminants from blind holes or passages. Also, this process is

A hot jet spray wash is commonly used to clean blocks, cylinder heads, crankshafts, and more. The table rotates as high-pressure heated solvent or detergent is sprayed.



This block has been oven cleaned, tumbled, and washed in a jet spray cabinet to a like-new finish.

Threaded Holes

Regardless of the cleaning method, all threaded holes in the engine block should be inspected and cleaned. Be sure to clean all threaded bolt holes and give special attention to the cylinder head deck and main cap threaded holes. Using a rifle-style bristle brush, scrub all female threaded holes. To make sure that threads are in good condition, and to remove any contaminants/debris, it's a good idea to run a chasing tap through all threaded holes.

Do not confuse this with a cutting tap. Common cutting taps tend to remove metal, which is to be avoided. Chasing taps are specially designed to both clean and re-form existing threads without removing excess material. Especially for main cap bolt holes and the block's cylinder head deck bolt holes, using a chasing tap helps to ensure that the threads are clean while retaining the necessary strength and integrity.

Scrub the block exterior with a clean, soft brush soaked in hot water and Dawn and rinse. I'm not trying to promote the brand of detergent, but for some reason, Dawn seems to do the best job of removing oils and grease. When all internal and exterior surfaces have been thoroughly rinsed, blow clean compressed air through all bolt holes, passages, and exterior surfaces. At this point, when the block is dry, immediately apply a thin coating of clean engine oil to main saddles, lifter bores, and cylinder bores to prevent surface rusting. Cast-iron blocks tend to oxidize (surface rust) very quickly when clean and dry, so this is a good time to mask and paint the block exterior. If the part is not to be painted, apply a thin coat of a rust inhibitor to all surfaces, especially if the part is stored for a while prior to assembly.

All threaded holes in a block should be chased to ensure cleanliness and thread condition. Here, a block's cylinder head deck hole is being chased. Drive the tap with a hand driver only. A variety of sizes is needed to cover all holes. The most critical threaded holes include the block's head deck holes and the main cap holes.

time-consuming and is not generally used in an engine builder's shop.

Ovens

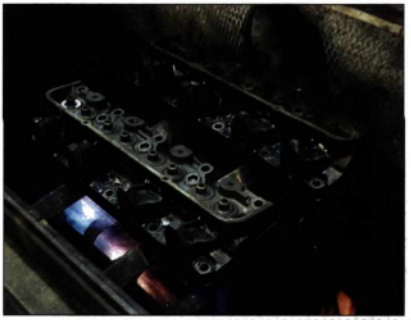
Often referred to as thermal cleaning, a dedicated oven can be used to degrease an engine block or cylinder heads. A dedicated cleaning oven "cooks" the component, turning grease, oils, paint, and other contaminants to ash. The component is initially heated to about 375 degrees F to cook off surface vapors, which are then oxidized in a separate chamber at about 1,300 degrees F. The oven's primary chamber then rises to a higher preselected temperature of about 600 to 700 degrees F, for steel or cast-iron components. When the cleaning cycle is complete, which usually takes about three hours or so, all sludge contaminants have been reduced to easily disposable ash. After the component has cooled, it is then washed/rinsed in a hot tank to remove remaining particles.

Aluminum components require more care because extreme temperatures can result in distortion. Typically, aluminum castings cook at about 500 degrees F. This lower temperature also reduces the chance of valveseats and guides loosening in cylinder heads. Regardless of material (steel, iron, or aluminum), the oven temperature must drop very slowly after the cooking stage until reaching room temperature, to prevent metal distortion.

Although a hot tank accumulates sludge and requires periodic cleaning and proper disposal, the use of a cleaning oven eliminates the need to dispose of hazardous waste (sludge), making ovens a bit more environmentally acceptable.

Soap and Water

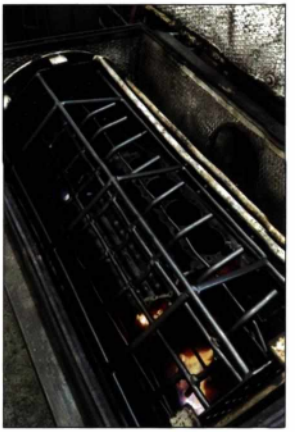
There are instances where washing/scrubbing and rinsing by hand are applicable, such as performing a final wash and rinse of an already-machined engine block prior to assembly. Using very hot water (as hot as your hands can tolerate) and Dawn dishwashing liquid can produce excellent results. With the block on a stand that allows you to rotate the block, shoot hot water



Although most cleaning ovens are designed to rotate the part during the heat cycles to evenly heat the part, some engine builders like to preheat some parts to cook off any residual oils, prior to glass bead blasting.

This block has been degreased, but surface rust and some contaminants remain.

The same block has now been shot blasted and tumbled. The block is now ready for machining.



This Chevy big-block has been stripped down and placed into a cleaning oven. The block is secured within a tubular cage. With the cage mounted in the oven, the machine rotates the block during the thermal cleaning process to distribute heat evenly, cooking off all grease, paint, rust, and sludge.