3rd Edition

LatheCity

Safely Working with Benchtop Systems – Booklet II

Working with

Exotic Materials

On Lathe & Mill

www.LatheCity.com

Uwe Burghaus


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LatheCity
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Disclaimer

The book has been written carefully and all projects and procedures have been tested thoroughly. However, as always, the author and publisher cannot guarantee that the procedures are perfect and without any mistakes. In addition, it is impossible to predict and prevent all the possible problems someone may possibly run into when working with a lathe/mill. **Using a power tool can be dangerous and the proper use is the responsibility of the one who is using the tool. Neither the author nor publisher shall be liable for damage arising herefrom.** If you are not perfectly comfortable with working with power tools, then don't do it! In this case, take a metal working class rather than following a do-it-yourself outline. Or, find a different hobby. I cannot jump in if you make a mistake which results in harming yourself or damaging the tools you use. Don't use half broken or damaged tools, perhaps purchased for cheap at a secondhand store or who knows where. This would be overwhelming to handle in the beginning. Thoughtful work will be your responsibility.

The author makes no representations or warranties with respect to the accuracy or completeness of the contents.

The author is not a professional machinist or engineer. He is a hobby machinist as you probably are. In fact, the author holds a PhD in physics and teaches physical chemistry at a college. Therefore, no information provided herein represents professional advice or best practices in machining. All information is provided to help hobbyists and other non-professionals gain a better understanding of using a miniature benchtop (tabletop) lathe/mill for hobby type work.

This book features in particular the Sherline lathe/mill and accessories. However, none of the statements or procedures may coincide with Sherline Inc.'s opinion or interests.

The author is not an employee of, or agent for any of the vendors referenced in the text and does not sell or represent any of the third party products discussed.

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You will perform all operations herein described at your own risk in any regard. This disclaimer information is given on our website and it is available before and without purchasing any of our products.

Data such as tensile strength are provided only for reference and not to guide your designs. Any design decisions you make regarding materials are at your own discretion and risk.

Brief Introductory Note

The Sherline lathe/mill benchtop/tabletop system is described in this booklet. However, lathe/mill operations are basically the same on any lathe. If you have a larger system, then you will encounter fewer difficulties than those described here. In addition, I do NOT describe lathe/mill operations as such. Thus, it does not matter which system you may have. Here lathe/mill work on a variety of materials is described in a generic (mostly system-independent) fashion. If you are looking for an introduction to lathe or mill work in general, then consider Vol. 1 or Vol. 4. This booklet is for advanced hobby machinists and not for the very beginner.

The section about milling is somewhat short simply because work on a benchtop mill is severely restricted to work on free machining alloys unless one invests in expensive specialty end mills. I did include some notes about these.

Most images illustrate projects rather than showing bare materials. In addition, a few project descriptions are included. I write about unusual aspects of the work here. The projects are therefore also unusual in nature. However, that's a matter of opinion.

Notably, the layout of all LatheCity books is in color. All photos and images are in full color. Due to the rather small number of books that we sell, all LatheCity books and manuals are printed on LASER printers and then bound with spines. This is, in a way, cheap and expensive at the same time.

The books are printed when ordered and shipped out the same or the next day. This desktop publishing procedure reduces our risk – we do not stock up 2000 books and sell only 50. This approach is nearly essential to the survival of a small, part-time business. We also update the books once a year or so. This is how we save on costs.

However, our approach to printing is expensive. The color LASER printouts are especially expensive. Our profit per book is not large, due to expenses such as toner cartridges, commission fees, credit card fees, etc. Gray-scale books are still sold at a very competitive price level! The full-color books are significantly more expensive. At the moment, there is little that we can do about this discrepancy. Our profit is about the same for gray-scale or color printed books.

Full color gives one another dimension when writing a book. We did use color not only for the images but also for the text. We applied the following convention in the LatheCity books: chapter titles are in red, subtitles in blue, and keywords are in **blue** bold-face font.

Customer corner A list of all the web links and computer codes included in the LatheCity books can also be found in the customer corner at

http://www.lathecity.com/CustomerCornerMain.php. Thus, one does not need to type computer codes or web links. To lock-in there, use the password that came with the original book.

Customer feedback can be found here:

http://www.lathecity.com/CustomerFeedback.html

These are the opinions of E-bay consumers of our products, which were collected by the E-bay evaluation system and not by LatheCity. To provide us directly with feedback, try this link:

http://www.lathecity.com/CustomerSurvey.html

LatheCity is small enough to take you seriously!

Second Edition

The 2nd edition of this booklet addresses some of the customer comments we received. In addition, the booklet was reformatted to include pictograms and wider page margins, which make it more appealing. A section about millwork was added. The entire text was proofread again, carefully (see the acknowledgement section for details).

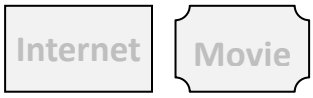
Third Edition

Besides small correction here and there, I added a few more descriptions of materials such as free machining stainless steel, solid carbide, and a few tables as well as a long section about materials properties and cutting tools (selecting the right insert, specialty cutters). Furthermore, text boxes with chemistry type information were added included notes about materials science and nanoscience. If you are interested in that, read the textboxes, if not skip these. Perhaps remember, I am a physical chemist and college teacher … I could not hold back - sometimes, professional disability or something, I guess. However, all this is written, of course, for non-experts in that field.

About 150 copies of the LatheCity books were sold in the first year after publication which is probably what one would expect for special interest books marketed only by the author. Interestingly, perhaps, a number of international orders came in from Turkey, Greece, Sweden and UK to Japan and Australia. We try to keep the shipping costs as low as possible for all of our customers. In the meanwhile also a book about tabletop milling and artwork projects is available.

Generic list of pictograms used in the LatheCity books

Object of a given chapter / brief introduction. Start of a project.



Internet addresses of potentially useful sites. However, web sites may be infected by computer viruses. Use them at your own risk.

Safety notes. It is not my intention to bother you and this book is meant for adults with advanced machining skills, not for children. Therefore, it's your decision whether you read the safety notes or not. However, don't blame me if you did not take the few minutes to do this and end up in hospital. All procedures are performed at your own risk.

Engineering terms or topics are described here. You may skip these if you are only interested in the operation of the tool. Remember, though, that knowledge also always provides protection (safety), if you know what you are doing... right.

Projects: engineering / artwork projects.

Comparison of lathe and mill operations. Most of us started with lathe work, i.e., these comparisons can help gaining a deeper understanding (even of lathe work).

Summary of the chapters.

Tips and tricks.

The idea of using pictograms is allowing for fast browsing through the book as well as making it more appealing to read. Only text is hard to digest and boring after a while.

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Required safety notes

Fig. 1: Safety glasses. Use versions with ANSI Z87 label. ASNI is short for American National Standards Institute. Chemistry goggles, as also shown here, are not recommended for metal work, since they may block the vision too much

Please note that **initially you may be at a higher risk** than folks doing this for living since you will be on your own. Typically hobbyists do not attend safety classes or safety briefings. Therefore, at least read the following.

When it comes to safety the “buddy system” is essential. Actually, nobody should work alone with power tools. This is obviously difficult to organize for a hobbyist. Therefore, you are at a higher risk and have to manage the risk yourself.

However, everyone can learn how to work safely with power tools. Otherwise I would not offer this type of textbook. In one of the safety briefings I attended, the instructor, a professional machinist, outlined almost proudly how many accidents he had throughout his career ... well ... I still have all my fingers and would like to keep it that way. What about you? Therefore, READ the following general safety notes and hints about how to prepare yourself before switching on your lathe. **PLEASE, take this seriously it only takes 20 minutes.**

Specific safety notes for every procedure are part of every subchapter. Naturally the notes in the beginning are more extensive and

become shorter toward the end of the book since I assume that you learn safe working practice along with the operation of your power tools. (In addition, safety concerns are often similar for different procedures.) This is one of the main goals and part of the title of this hobby machinist primer: "Safely working ..."

Working at a public university myself, I have to participate regularly in safety classes and I am at present (2011) in fact the safety liaison for our chemistry department. However, again I am a hobbyist myself when it comes to metal work. I still have all 10 fingers and two eyes, but there is no legal guarantee that the following notes are complete or even correct. **Read the disclaimer note above.**

- **Use** goggles / **safety glasses** (see Fig. 1). Chemistry goggles, which are also shown here, have the disadvantage that they may block your vision too much which again can generate a safety hazard. You need comfortable glasses and perfect vision. You need to look around. Glasses approved for metal would need to be closed all around the face (at the top, sides, and bottom) and in the U.S. they have the label **ANSI Z87** on them. Some versions additionally block UV light which was interesting to me, since I also work with glass pieces, using glue hardened by a UV lamp. In any case, a UV filter is better for our eyes, I believe.
- At most safety briefings you may come across the term "**situation awareness**", as a general strategy to reduce risks. Knocking over a leg of a storage rack when walking through a metal shop, which carries 500 pounds of steel, would not be it. Heavy footwear is unfortunately very uncommon except in an industrial setting. (We also don't want to overdo it in a hobby shop.)
- Let someone know that you are working in your garage and/or basement. Why? First, you are setting up "a buddy system" in doing so. Second, you are making sure that nobody disturbs you at a critical moment, startling you from behind.
- Have a working phone in reach. Check if your cell phone is working properly in your basement. Where is the closest hospital/emergency

room? Emergency number in the U.S. is? Right, 911. At some locations the number may be different.

- Make your shop kid safe. Talk to your kids about the risks. Make sure that they do not sneak around a corner and surprise you when the lathe is running, etc. They often don't see the difference between "playing" and "safe working practices."
- Read the application notes and manuals that came with the tools and/or accessories before starting to use them. Learn the applications and limitations as well as the specific potential hazards of every tool.
- Don't use a tool for a purpose it was not designed for.
- Don't modify a tool yourself.
- Don't push a tool beyond the limits it was designed for. A mini metal lathe is designed to work on small metal stock.
- Don't modify the electrical connections of your tools. Electrically ground all tools. If a tool is equipped a with three-prong plug, then it should be plugged into a three-hole receptacle. If an adapter is used to accommodate a two-prong receptacle, the adapter wire must be attached to a ground connection.
- Don't remove safety guards. Keep guards in working order. (I could tell you stories where a student did exactly that to "save time" and lost several fingers in the process. This is not a joke, but I will spare you the details. Fortunately, I was not involved in this accident, in this case, at a chemistry lab abroad ...) Don't remove safety guards. However, the little safety shields that sometimes come with a lathe provide only very limited protection. Use always goggles, in any case.
- Make it a habit of checking to see that keys and adjusting wrenches are removed from the chuck before turning on any machine/lathe. In the case of a lathe, turn the spindle by hand before turning on the lathe making sure that it runs freely. Don't underestimate the power and torque generated even by a benchtop/tabletop lathe. A key left behind in a chuck can easily fly off traveling at a significant speed for 10 ft (3 meters) or more. Full size lathes used to train students professionally are often equipped with **spring lock chuck keys (self-ejecting keys)**.

□ **I did read the safety notes.**

□ **I did understand them.**

□ **I did read and accept the disclaimer statement.**

These pop out of the chuck when not pushed down, i.e., it's impossible to leave them in the chuck unintentionally. Typically the chuck key would hit the instructor rather than the student running the lathe which may explain why this feature is eagerly installed in training metal shops. (Don't put your nose over the spindle anyhow.) In any case, just kidding I do like all instructors, safety first. Unfortunately, mini spring lock chuck keys are not available for benchtop lathes, as far as I know.

- Cluttered work areas and benches are a safety hazard. This is indeed true.
- Do not use power tools in damp or wet locations. This can be an issue for garage or basement shops. Solve the problem if it exists at your location.
- Keep work area well illuminated. This is extremely important for safety issues and any proper work. Do you need new glasses?
- All visitors should be kept at a safe distance from the work area.
- Again make your workshop kid proof. Use padlocks, master switches, remove starter keys. This is of particular concern for hobby work. I would in principle encourage you to awaken the interests of young adults for practical and creative work. Fortunately, perhaps in this case, many of them prefer to play dull computer games instead. However, teaching young adults to work with metal tools is particularly difficult and a major safety hazard for everyone involved in this process. At least don't do this in the very beginning. You must be very confident yourself, first. Make sure that they are old enough and have no access to the tools alone.
- Again, do not force tools or attachments to do a job for which they were not designed. Use the proper tool for the job.
- Avoid loose clothing, necklaces, gloves, or jewelry that could become caught in moving parts. We all know this, but taking care of it every day is another thing.
- By the same token, fluffy cloth appears to attract small cut off metal pieces like a magnet. They stick deep in the fabric and can scratch/cut you fingers and skin.
- Wear protective head gear to keep long hair styles away from moving parts! If you would like to see a sad story in this regard, go to:

Internet

http://blog.makezine.com/archive/2011/04/yale-student-killed-in-lathe-accident.html

It takes milliseconds to pull you into the running chuck if something gets caught in the chuck. A benchtop system is safer in this regard than a full size system, I guess, but … (A lathe running at 1600 RPM makes 26 RPsec or ~40 milliseconds = 0.040 sec for one revolution.)

- Use safety glasses i.e. goggles designed for metal work. Yes, this is on the list more than once.
- Use a face or dust mask if cutting operation is dusty.

Fig. 2: Full face shield with plastic foil that needs to be peeled off

- When using a metal grinder you will generate sparks. Use a full face shield and goggles for these operations. Make sure not to have lots of cardboard boxes, gas containers for you snow blower / lawnmower, paint, solvents, etc. in your basement or garage hobby shop. The sparks generated by grinders or metal saws can ignite a fire. It may start to burn long after you left the shop … Full face shields often have a plastic foil on the shield which needs to be peeled off. Otherwise the shield may not be transparent (Fig. 2) – just a note in case you didn't realize. (I have seen students running around …)
- Use clamps or a vise to hold work. It is much safer than using your hand and frees both hands to operate the tool. This is more of an issue for the use of a drill press, milling machine, or saws than for a lathe, but it must be included here.
- Keep your proper footing and balance at all times. Wet floor? Cable? This is dangerous.
- Keep tools sharp and clean for best and safest performance. Follow instructions for lubrication and changing accessories. A sharp knife is dangerous, indeed. However, a dull lathe cutting tool may be even more dangerous. (Why? It does not cut properly. It will over-heat, etc.)

- Use only recommended accessories. Read the manual carefully and completely. Use of improper accessories may be hazardous.
- Unplug tool before servicing and when changing accessories such as blades, bits or cutters. Definitely.
- Make sure switch is "OFF" before plugging in a power cord. Double check.
- Again turn spindle by hand before switching the motor of the lathe on. This ensures that the work piece or chuck jaws will not hit the lathe bed, saddle or cross-slide, and also ensures that they clear the cutting tool.
- It is not recommended that the lathe be used for grinding**.** The fine dust that results from the grinding operation is hard on bearings and other moving parts of your tool. For the same reason, if the lathe or any other precision tool is kept near an operating grinder, it should be kept covered when not in use. I do occasionally use a polishing sponge (safer than sandpaper) to polish pieces, but I don't overdo it.
- Make sure that all locking and driving attachments are tightened. However, also be careful not to over tighten these adjustments. They should be just tight enough. Over tightening may damage threads or warp parts, thereby reducing accuracy and effectiveness.
- Don't allow long stock pieces to stick out far in back of the spindle of the lathe. Long, thin stock that is unsupported and turned at high RPM can suddenly bend and loop around. This WILL indeed happen. You may be amazed that an aluminum or steel rod bends like nothing.
- Wear proper safety glasses. All folks working for living in metal shops can unfortunately tell you stories such as this one: a piece of metal hit the backside of glasses (somehow) and the reflected piece hit the eye of the machinist. They had to pull the piece out of his eye in a hospital. This is not a joke. You need safety glasses specified for metal work, even if you wear optical glasses. You need glasses fully closed at the sides, the top, and bottom. Goggles that fit over optical glasses are often not very comfortable and restrict the vision. These are better than nothing, but you can purchase goggles with optical lenses. If you work every day in your shop, then invest the money to purchase really comfortable and safe glasses. Your eyes are worth the investment.

- This may sound as a talk to a teenage girl/boy, but ... you need proper eye protection before you switch on the lathe for the first time. Safety glasses are perhaps the most important safety feature in a metal shop. Don't start without them with any work on a lathe. Any home improvement store carries them. (These glasses should come together with any lathe package. Unfortunately, they don't.)

This is a long list, but don't blame me if you did not read it and end up in a hospital.

- Don't work when you are tired. Rushing home, having a heavy dinner and a few beers, then going down to the basement shop in your house … obviously not a good idea. Don't do it. Metal work requires your full attention, even if it is a hobby.
- You may realize that the fingers of the machinist are really close to the spindle when cutting certain shapes, in particular when you eventually polish pieces. The edges of the chuck are sharp and turn at perhaps 1800 RPM. It would cause very serious injuries when hitting the rotating chuck with your fingertips. Sherline also offers a tool post for polishing (P/N 8976) which I did not, however, use myself. Polishing operations on the Sherline lathe are, by the way, not recommended by Sherline, mostly due to issues of metal dust which may end up in the motor controller box causing shorts. In addition, a dust mask is generally required for all sanding/polishing operations. Using a sanding sponge is somewhat safer than using sand paper for polishing since you can even touch the chuck with the sponge and the fingertips are still at an o.k. distance. Sanding sponges are available in any home improvement store.
- One last thing. Please be aware of that you will carry chips (small cut off metal pieces) with you all over your house. Don't ask how – chips stick to everything, somehow. Aluminum chips are "rather" soft and probably often (but not always) "harmless", but steel chips are sharp as razor blades. Never clean up chips with your bare fingers, never.
- This kind of list can never be complete. Read the disclaimer statement.

Safety notes can also be found on various web sites, a few links are given here:

Internet

http://www.mini-lathe.com/Mini_lathe/lathe_safety.htm
http://www.zeraware.com/
http://www.americanmachinetools.com/how_to_use_a_lathe.htm
http://www.fricknet.com/lp/safety_posters.php?gclid=CPTW6ZfFhaYCFQTNKgodFQoIpA

Safety products can also be purchased on-line, for example, perhaps look at e.g.:

http://www.envirosafetyproducts.com/product/magnifying_safety_glasses_magnifying_safety_glass

Milling specific L/M

- In simple terms, lathe cutting tools cut even metal because of the pressure generated when pushing the turning tool into steel. Therefore, lathe cutters are actually not that sharp. Mill cutters work more like a saw (in simple terms): they are very sharp. Don't touch mill cutters with your bare hands, use a rag.
- The cutting tool and not the work turns on a mill. Therefore, a mill will generate metal-chip-shrapnel to a much larger extent than a lathe. This is most evident when using a so-called fly-cutter which I will describe later on. Long sleeve shirts and safety glasses provide some protection.

CAUTION – LASER operation

A number of even hobby type tools come in the meanwhile with strong light sources or LASER pointers build in. Also LatheCity has these accessories.

- Read and obey the operation instructions from the manufacturer of the LASER pointer that came with the LASER pointer. See the label printed on the LASER pointer and the instructions card. In addition, consider the following.
- A LASER pointer is not a toy. Keep out of reach of children and mentally handicapped people as well as pets.
- Do not stare into LASER light beam. This will cause damage to your eyes.
- Do not direct the LASER light beam towards the eyes of another person or animal.

- Remember that a LASER light beam reflected from an object will be as dangerous as the primary LASER beam.
- Remove batteries if the LASER is not in use for an extended period of time in order to prevent corrosion.
- Do not disassemble or try to repair the LASER pointer. The LASER pointer does not contain replaceable parts.
- Protect against water, dust, heat, and sunlight.
- Do not direct the LASER pointer towards the sky or streets. This can interfere with traffic, airplanes, etc.

Part 2: Turning

Booklet 2

The world beyond aluminum – lathe work

Object: providing some assistance in lathe work with materials besides aluminum. Irrespective of the small size of a tabletop lathe, you can cut basically "anything" on a good small lathe. (Read the chapter about safety, first.)

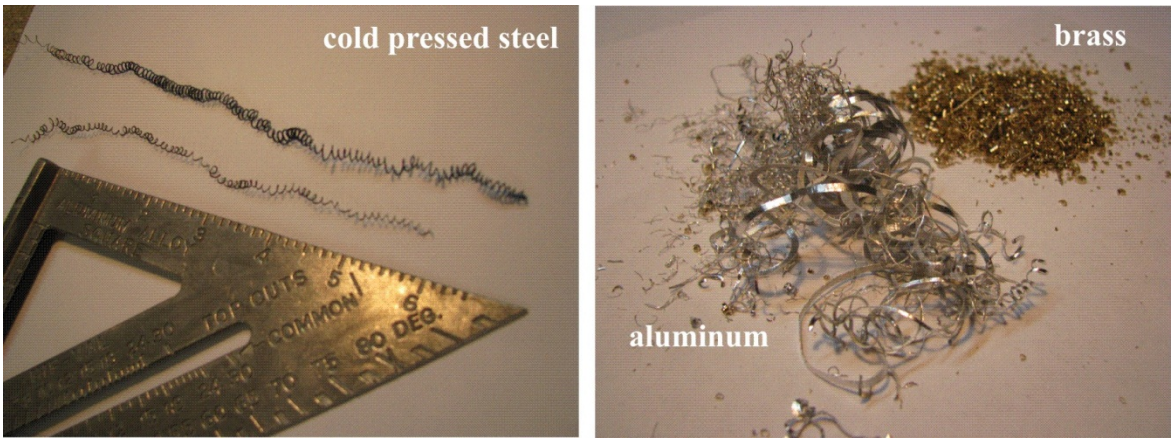

Fig. 1: Cut-off chips. Left to right: cold pressed/rolled steel, aluminum, brass. The shape of the chips depends not only on the materials, but also on a large number of other factors including the turning speeds, depth of cut, rake angle, etc. You can find "chip maps" in engineering books, detailing what turning speed and cutting depth results in the most easy to handle chip type. Here for aluminum and brass a HSS tool was used (and for the steel a brazed carbide cutter), with 2800 RPM and 0.020" (0.0010" for steel) as the cutting depth. The feed rate is difficult to control on a manual lathe. Chip breakers are in use, preventing the chips from wiggling up around the part and blocking the cutting operations. Chip breakers are just geometric features worked into the insert – nothing too exciting. I have been told, however, that production engineers change the materials rather than the cutting conditions to avoid issues with chips

STOP

After you have gained some experience, you typically start experimenting with more exotic materials. However, be careful and expect (bad) surprises when using exotic materials.

The wrong plastic can melt easily or breaks like glass, steel chips can be very hot burning your skin as hot oil splashing out of a cooking pan, stainless steel chips can be very sharp, too soft wood crushes/splinters, etc. In any case, be careful and at least use safety glasses.

I would suggest starting to experiment with materials in the following order of increasing machining difficulties: plastic → brass → cold pressed/rolled steel → stainless steel → specialty materials

Experiment with small diameters (O.D. ¼", 6.35 mm) and short pieces (2" or 50.8 mm) first. Use safety glasses.

The following is an alphabetic list of rather pragmatic and practical suggestions for working with a variety of materials, written by a hobbyist. As always, you will work on your own risk – read the disclaimer statement and the general safety notes. Materials may be toxic or carcinogenic, read the MSDS (Materials Safety Data Sheet). Some materials are flammable or may generate toxic fumes or dust, i.e., safety equipment may be required. When using (special) cutting tools, read the application notes and/or manuals which come with these tools. Some materials cannot be cut on a lathe, including glass rods. This can be very dangerous. I do assume in the following advanced machining skills – this is not for very beginners. If you have just started to work with a lathe then get volume one of this book series first.

Fig. 2: Morse #0 taper as extensions of the tailstock spindle cut from SAE 4140. See vol. 1 for details about how to cut a Morse taper, or perhaps get the LatheCity angle protractor (Morse taper/arbor cutter)

Alloy steel

What is typically available is "alloy 4140" or **SAE 4140** which is a chromium-molybdenum steel. Apparently, its machinability depends very much on the hardening procedure used. Typically it is sold as cold drawn and annealed steel, which has "good" machinability on a lathe, as I read somewhere. It has a higher strength than cold pressed (or cold rolled), low carbon steel varieties (see below). In my experience, this alloy steel is quite difficult to cut on a benchtop lathe. The tip of HSS cutters, for example, is ground off in about 30 seconds when using a somewhat larger cutting depth. Hobby machinist type brazed carbide cutters work o.k., but don't give a nice finish, in my experience. Using inserted tip carbide cutters (inserts) or inserted tip ceramic cutters works well assuming that the work piece is running perfectly true: the smallest vibrations and the cutter chatters. Use a 4-jaw independent chuck or this will not be fun, in my experience. On my own machinability scale (scale of

unpleasant stuff to work with), alloy steel has a top (most unpleasant) ranking – perhaps, I just had a bad day when working with this stuff. You will soon develop your own machinability scale.

Aluminum alloys – 6061 / 7075

Aluminum is widely used for its good machinability, high strength-to-weight ratio, and basically no corrosion occurrence since the surface is protected by a transparent aluminum oxide layer. Casting and wrought aluminum alloys are distinguished. Different labeling systems are used: xxxx-Xxxx vs. xxx.x for wrought vs. cast aluminum alloys. Casting aluminum alloys are tailored towards the casting manufacturing process (pouring a liquid metal into a mold/template), e.g. their melting temperatures are lower than those of wrought aluminum alloys. Wrought aluminum is typically used for hobby type applications. The first 4 digits specify the composition of the alloy, similarly to steel. For example:

6000	series includes magnesium and silicon
7000	series is aluminum alloyed with zinc
2000	series are aluminum alloys including copper

The symbol following these numbers specify the heat treatment used in the production. For example:

F	as fabricated (which I have never seen)
H	cold rolled
T	heat treated (most common type for hobbyists)

Aluminum alloys available in small quantities on the hobby market include:

6061-T6	(Perhaps the most common, it is an aluminum-magnesium-silicon alloy, it is solution heat treated and artificially aged. It has good machinability including good welding properties.)
2024-T351	(Aluminum-copper-manganese, not weldable, that version apparently corrodes, average machinability, high strength.)
6061-T6511	(Aluminum-manganese-silicon, general purpose aluminum alloy, good weldability, tensile strength about half of 2024-T351.)
7075-T651	(Aluminum-zinc, high strength.)

Brinell hardness of about 60 is common for most Al varieties, but it can be as large as 150. Variations in the yield strength are more significant (20 kPSI to 50 kPSI) as well as corrosion properties, and weld ability.

All aluminum alloys I have worked with so far can be cut easily using HSS lathe tools.

Detailed outlines of the metallurgy of aluminum can be found. You may want to check out:

Internet

http://en.wikipedia.org/wiki/Aluminium_alloy
http://www.aluminum.org/
http://www.matweb.com/reference/aluminum.aspx
http://www.hmwire.com/aluminum_alloys.html
http://www.alfed.org.uk (look for “Aluminum Federation”)

Part 4: Materials Properties

Booklet 2

Cutting tools and cutting materials

Object: the quality and size limits of the lathe design by itself are certainly essential. However, in particular with lathes and mills, the best systems would still be very restricted in performance without cutting tools that keep up. As a quite unique feature of the Sherline benchtop lathe series, a large variety of different cutter and tool posts are available. All the notes here reflect my own opinion and knowledge. Summarized in the following are the different types of lathe/mill cutting tools and materials that can be used on a tabletop system.

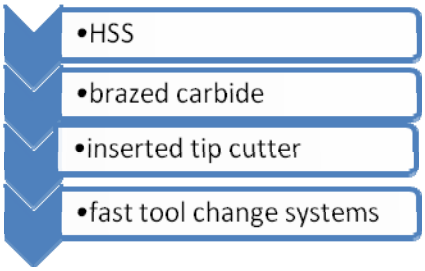

Fig. 1: Basic choices of cutting tools. The professionalism, but also the costs increase from top to bottom

Cutting tools on a lathe

High-speed steel

Carbon steels were historically used for cutting tools. However, carbon steels start to temper at rather low cutting temperatures and are too brittle for use in motor machine tools, in my opinion. Therefore, **HSS (high-speed steel)** tools are the first best choice for hobby benchtop machining. (Don't mix up HCS or something and HSS. Some home improvement stores sell high carbon steel tools – these are good perhaps to work on drywall, but … just my opinion. You may not easily find HSS in a local store – order it in.) HSS tools have already been developed starting early in the 1900th century. Most HSS tools are of the M-series, i.e., they are molybdenum based high-carbon steels. M HSS tools are available for about half of the price of W (tungsten) based HSS tools and have apparently very similar performance. HSS tools maintain their hardness up to rather high temperatures. High cutting speeds result in high tool temperatures, which explain the name, HSS: HSS tools still work at high cutting speeds/temperatures. HSS tools are more than sufficient for working with aluminum and even some steels can be cut nicely on a lathe as well as plastics, wax, and a few other interesting materials (see lathe section). HSS tools

can be sharpened and grind on less expensive hobby type grinders, form tools can be made to cut specific shapes (see Vol. 2).

Carbide turning tools

The hot hardness and wear resistance of HSS tools is, however, limited. Therefore, for more difficult to machine materials HSS tools are replaced by **carbide cutters**. The development of carbide cutters started in the 1930th. I have rarely seen HSS tools (except for end mills) in professional metal shops, since stainless steel is typically used for engineering type applications. Carbide tools typically consist of tungsten carbide sintered together with a mix of other carbides such as TiC, TaC etc. A color code for carbide grades does exist, following the ISO (International Organization of Standardization) standards. The tool shanks are tinted in red, blue, or yellow. The blue version is good for stainless steel; yellow cutters are for particularly difficult-to-cut materials. That code is used for brazed carbide cutters.

Fig. 2: Different types of (right hand) lathe cutting tools. From left to right: ceramic inserted tip cutter, carbide inserted tip cutter, two brazed carbide cutters, and HSS cutting tool. All from Sherline, except the blue brazed carbide cutter (on the right) which is from Harbor Fright Tools. Shown also are two inserts. The diamond shaped one with two cutting edges is from Sherline ($10 in 2011). The triangular shaped one with three cutting edges was purchased from MSC industrial supply ($5.59 in 2011). The grade of the inserts is unknown to me. Vol. 4 (milling operations) discusses how to make holder for inserted tip cutters since purchasing less expensive inserts of various shapes and sizes requires having a variety of tool holders on hand. This quickly becomes quite pricy and it is not too hard making those tool holders with a small mill (see vol. 4)

The simplest carbide cutters are **brazed cutters**. Here a piece of carbide is permanently attached to a tool shank. Brazing is somewhat similar to soldering. However, for standard soldering tin-lead alloys are used, whereas for brazing a brass (copper-zinc) layer (or some other alloy) bonds the carbide layer to the tool shank. The latter technique requires much greater temperatures, per definition, temperatures above 800 F (430°C), which is the main difference

Appendix

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T

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X, Y

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Factory direct sales.
PayPal and your credit card company offer a seller's protection, as far as we know. LatheCity offers a 30-day-money back guarantee on tool products.

Uwe Burghaus, born in West Berlin, Germany, obtained his education in Physics and Physical Chemistry at the Free University of Berlin.[*)] He obtained a PhD in 1995, after conducting his graduate studies in surface science at the Fritz-Haber Institute of the Max Planck Society in Berlin. After postdoctoral positions in Genoa (Italy) and Santa Barbara (USA), he went back to Germany to complete a habilitation/tenure in Physical Chemistry. Now at North Dakota State University, he started to establish a surface chemistry group in 2003 and obtained tenure in 2009. His group is currently focusing on studies about nanostructured catalysts. (His research/university home page is www.uweburghaus.us if this is interesting to you.)

His hobbies include machining furniture from metal and glass as well as occasionally manufacturing pieces for his research group by himself. He is not a professional machinist by training. However, his hobby developed into a small part-time business in 2012. LatheCity currently sells books about metal working, software tools, and lathe/mill accessories for tabletop systems as well as affordable jewelry: everything that's fun to make and may find customers. The strength of the business is custom-designed tools. Stop by at www.LatheCity.com

[*)] It's (still) called "Free University" not because we don't need to pay tuition in Germany (education is free!), but because it was located in the western part of Berlin (West Germany), as opposed to East Berlin. The FU Berlin was founded with the help of the US after the end of the 2nd world war – Google the details, please. (I got a few funny e-mails and did add this explanation …) LatheCity books are unfortunately not for free, sorry – I also live in the US now … ☺

Acknowledgements

First edition

Proofreading of this LatheCity booklet by A. Erickson is acknowledged.

I will continue to update and improve on the texts over time. These updates will be made available to our customers as a free newsletter – assuming that one of the textbooks was purchased from LatheCity. Go to the customer's corner and use the password provided with your purchase. We will not bother you with e-mails, but the updates can be downloaded from our website.

Writing a book about metal working typically does not improve the reputation of a scientist (some prefer not to get dirty fingers...) and chemistry college teacher. Therefore, many thanks in advance to open-minded colleagues. However, in the UK, there is apparently a "tradition" to write your own book about "gardening" – the LatheCity books would be my version of this, I guess.

Second edition

The proofreading (in part) of this booklet by William D. Gardner (CA) is acknowledged. I met Bill as a customer and got to know him somewhat via e-mail. He is a hobby machinist and also runs a small part-time business. Although he is using a larger lathe/mill, LatheCity books (featuring mostly Sherline's systems at that time) interested him, and he proofread some of our books. His suggestions are highly appreciated, and the number of typos was further reduced thanks to him.

Synopsis. Described in detail is how to work safely with difficult to machine and exotic materials on a metal lathe and mill; and, where to purchase those materials in small quantities. In addition, a section about cutting tools and materials properties is included. Textboxes explain some of the chemistry, material science, and nanoscience background.

Materials discussed include: Alloy Steel, Aluminum, Bronze, Brass, Solid Carbide, Cast Iron, Steel, Ceramics – Macor, Cork, Copper, Free Machining Materials, Pure Manganese, Magnets (Superalloys), Plastics, Rocks, Sandwich Structures – Hardened Steel, cutting High Speed Steel, Stainless Steel, Styrofoam, Sterling Silver, Tool Steel, Ledloy, Titanium, Wax, and Wood

Convince your wife/friend about spending thousands a year on greasy equipment: make her/him a pair of earrings cut from Sterling Silver or Titanium or machine your own solid carbide tools. How that can be done is described here.

The author is a physical-chemistry college teacher and hobby machinist, as you probably are. This booklet of the LatheCity book series is, however, written for more advanced homeshop machinists.

LatheCity
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Booklet 2 – Working with Exotic Materials on a Lathe and Mill
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