

Machine Shop Practical

Using a Lathe to Create a Stepped Bar

Session 1

10/10/2017

Instructor: Gareth Staddon

Session Aims:

- Introduction to workshop.
- Discuss Safe Working Procedures.
- Discuss Personal Protective Clothing & skin care
- Discuss Health and Safety risks
- Discuss various lathe components
- Watch demonstration on operating a lathe safely and correctly

Workshop Safety

There are numerous hazards in the machine shop which can pose a real threat to the health and safety of all people involved. Learning how to work safely in a workshop environment is vital. Many accidents that happen in the workplace are down to complacency and are usually preventable if the correct measures are taken.

To ensure the highest standard of safety can be adhered to, Safe Working Procedures (SWP's) are available for each individual machine and tool. Demonstrating competence when using specialist equipment is crucial. Machine operation should only be carried out whilst under the supervision of an instructor.

Understanding where the Emergency Stop Buttons are located and how to quickly and safely stop any machine in use is also very important.

Personal Protective Clothing

it is imperative that the correct PPE is worn when working in the machine workshop. This includes steel toe cap boots, overalls or laboratory coats, and sensible full-length workshop trousers. Steel toe cap boots protect from heavy/sharp objects, overalls and lab coats offer full arm and body protection from hot flying particles ejected from machines or tools and sufficient protection from sharp or hot objects can be provided by workshop trousers.

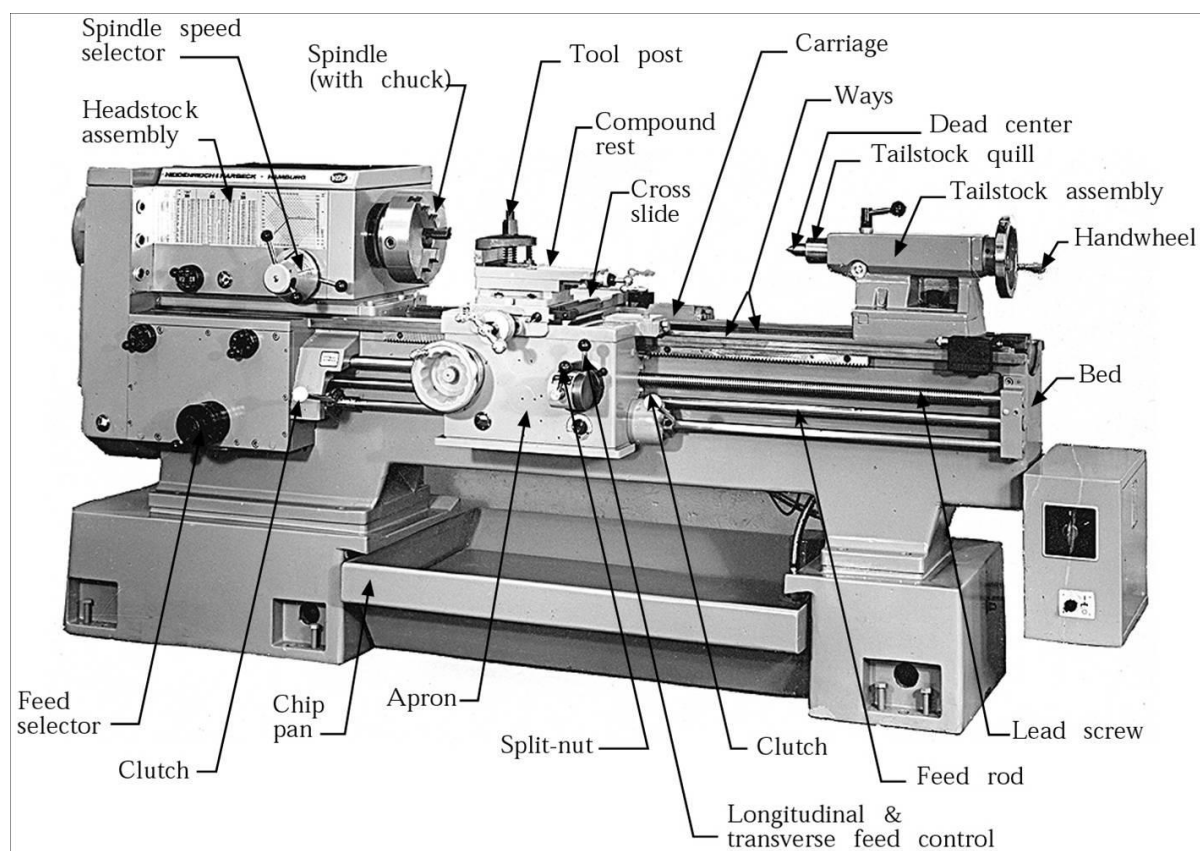
Due to the nature of the machines in this workshop it is mandatory to wear full eye protection. Swarf can be ejected from milling machines and lathes at a high velocity and temperature and is incredibly unpredictable. There is a high risk of damage to the eyes if no protective glasses are worn. Any long hair must be tied back to avoid entanglement. Jewellery should be removed prior to entering the workshop to also avoid entanglement. Another reason jewellery should be removed is in case of an electric shock. Any items of clothing which have tassels or draw strings should be tucked inside overalls/lab coat.

Due to the harshness of materials and chemicals inside the workshop, correct skin care procedures should be demonstrated. Dermatitis is the largest threat to skin, causing dryness and irritation.

Barrier cream should be applied before every session to combat this. After every practical session hands should be thoroughly washed using Deb Lime provided. This is a specially formulated degreasing soap with slightly abrasive properties. Finally, the restore cream should be worked into dry hands as a moisturiser. Some chemicals used in workshops are carcinogenic, so gloves should be worn if ever handling these. COSHH data sheets can be used in the event of adverse effects from chemicals or substances.

Lathe Demonstration

Before the task is started a full demonstration is performed paying attention to the correct working procedures. Each part of the lathe is named, and a brief description of each function is given. Basic operations are performed to familiarise with the machinery and any questions about the lathe can be answered prior to using it. It is important to understand how a specialist machine is used prior to operating it. Explanations of what not to do are also included in the demonstration.



Positioning the part and tightening the “3 Jaw Chuck” correctly is very important. Failure to do this could result in the workpiece being ejected from the lathe causing serious injury or damage. Using the chuck guard is also very important. Distractions whilst using the lathe can cause damage to the headstock, tailstock or cutting tool and may even cause injury. Under no circumstance should any attempt be made to remove swarf from the lathe by hand. Operating a lathe requires full attention.

Conclusion

This session has given the foundations to carry out the assigned task in a safe and efficient manner. Essential information has been understood clearly and all questions in relation to the operation of the lathe and general workshop safety have been answered. PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Lathe to Create a Stepped Bar

Session 2

17/10/2017

Instructor: Gareth Staddon

Session Aims:

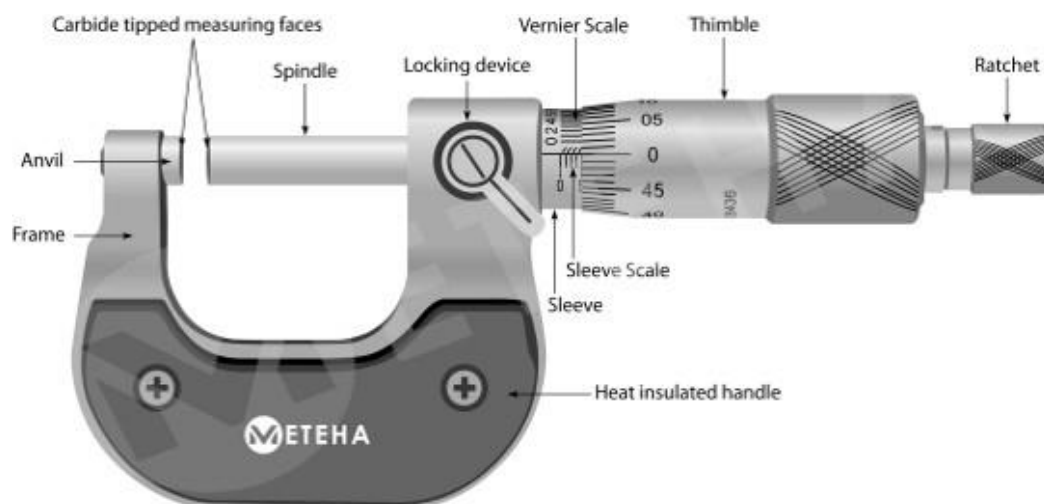
- Demonstration of accurate measurements
- Issue technical drawing
- Begin first steps of task

Health and Safety

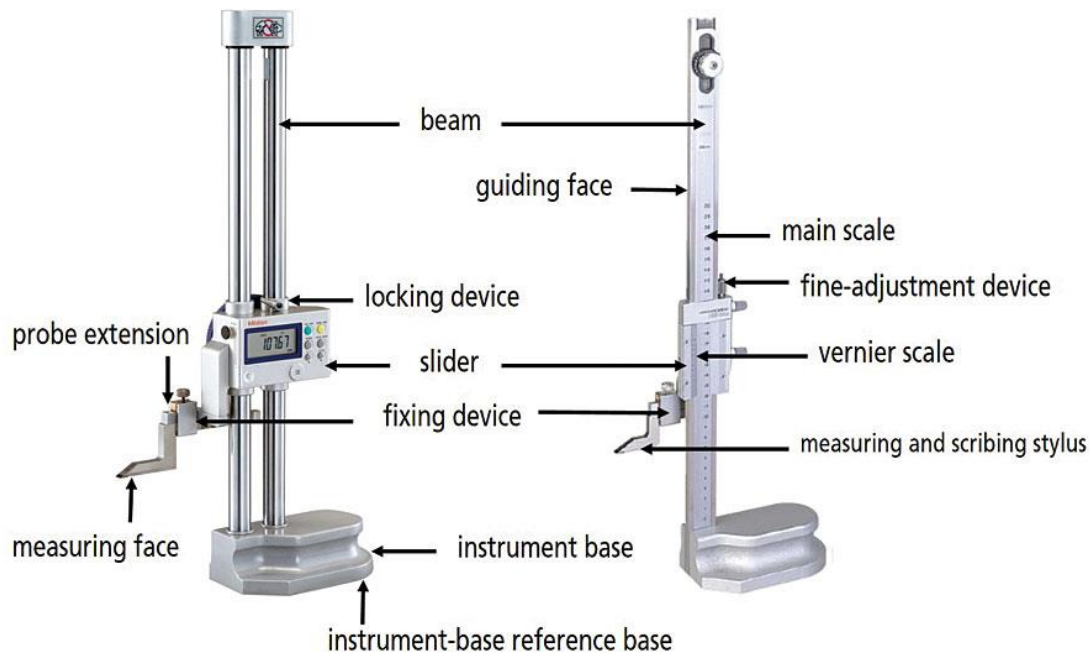
Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement.

Accurate Measurements

The assigned task requires highly accurate measurements to be made. A height gauge and micrometer are the main two apparatus to be used. Using a micrometer correctly is crucial to reaching the tight tolerances set. Incorrect dimensions are achieved when measurements are not made correctly. It is also possible for a micrometer scale to be misread so checking dimensions and readings regularly is important.



Height gauges should be on a perfectly flat and level surface, calibrated to zero whilst the measuring face is touching the surface and then raised and lowered at least once to ensure calibration is correct before any measurement is made. The digital output reduces the risk of misreading measurements. It is still very important to measure frequently throughout the process to minimise mistakes.

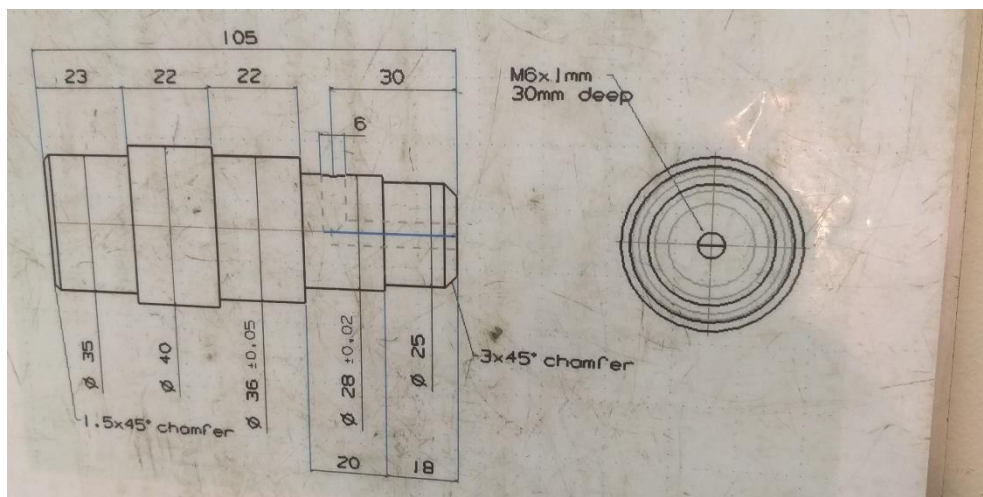


Materials and Equipment

The material used for this task is a solid steel cylinder approximately 110mm in length and approximately 45mm in diameter. The cutting tool used in the lathe is made from carbide. A micrometer, digital height gauge and the Digital Read Out system incorporated within the lathe are also used in this session.

Technical Drawing

The technical drawing and instructions for the task are provided. Note the specific tolerances.



Facing the Piece

The piece should be positioned in the lathe with a short projection from the chuck. This will provide sufficient grip for the lathe to be operated safely. If a long projection is selected there is a risk of the piece working loose and being ejected. The chuck should then be correctly tightened and the guard pulled down into place. A right hand knife edge tool is inserted into the tool post and set to the correct height (The correct spindle speed and feed rate are already set).

The first lathe operation is to remove a small amount of material from the face of the piece. This needs to be done to both sides to ensure both faces are flat for measuring. Move Z axis to touch material. Zero the Z axis on the Digital Readout System (DRO). Set value to 0.500mm, check the value is correct. Move cutting tool along the X axis past the edge of the material. Move Z axis handwheel to 0.000mm. Start Lathe and initiate automatic feed for X axis. Observe facing process to ensure correct operation. Once the cutting tool reaches the centre of the piece disengage the lathe (switch to neutral) and step on the foot brake. Lift guard and remove piece from chuck. Turn piece through 180°. Insert back into chuck and tighten correctly. Repeat the steps from the first operation to achieve smooth surfaces on both faces.

The height gauge can now be used to accurately measure the overall length of the piece. The reading recorded from this is 108.71mm. The desired length to satisfy the technical drawing is 105mm (+/- 0.200mm).

Cutting to Correct Length

The piece should be positioned in the lathe again with a short projection from the chuck. The chuck should then be correctly tightened and the guard pulled down into place. Move Z axis to touch material. Zero the Z axis on the Digital Readout System (DRO). Set value to 108.710mm, check the value is correct. Move cutting tool along the X axis past the edge of the material. Move Z axis handwheel to 108.000mm. Start Lathe and initiate automatic feed for X axis. Observe facing process to ensure correct operation. Once the cutting tool reaches the centre of the piece disengage the lathe (switch to neutral) and step on the foot brake. Lift guard and remove piece from chuck. Measure again with height gauge, 107.01mm. repeat last step setting the value for Z to 107.01mm and cut down to 106.000mm. recheck with height gauge, 105.93mm.

Satisfy the Tolerance

As the length becomes close to the desired value, the increments should decrease from 1.000mm to 0.300mm. Decreasing the increments means a higher accuracy can be achieved and lowers the risk of going outside of the lower limit of the tolerance set, when comparing between the DRO and height gauge.

The next cut gives a result of 105.58mm so the increment is now decreased to 0.200mm. The result of the next cut is 105.35mm. The 0.200mm increment is used for a final time which gives the result of 105.03mm. This final cut brings the overall length within tolerance. 105mm $\pm$ 0.200mm.



Conclusion

The Digital Read Out system built into the lathe has slight discrepancies with the Digital Height Gauge. This can be due to various reasons. There are many moving parts on the lathe and the cutting tool and piece are under significant pressure whilst a cut is being made. There may be a possibility of slight movements whilst in operation. The piece must be made to suit the measurements of the Digital Height Gauge and Micrometer, so it is important to continuously check and adjust the values between the lathe and the height gauge. Failure to continuously update the DRO could result in tolerances being missed.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. The lathe bed was cleared of swarf using a dustpan and brush and the surrounded area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical
Using a Lathe to Create a Stepped Bar

Session 3

24/10/2017

Instructor: Gareth Staddon

Session Aims:

- Achieve first stepped dimension

Health and Safety

Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement.

First Stepped Dimension

The piece should be positioned in the lathe with at least 38mm of projection but no more than 45mm. The reason for this is a cut needs to be made in the Z axis and if the projection is too short, the cutting tool will interfere with the spindle or chuck, causing significant damage to the machine and possible health and safety risks. With the projection set, the chuck should be correctly tightened and the guard pulled down into place. A right hand knife edge tool is inserted into the tool post and set to the correct height (The correct spindle speed and feed rate are already set).

Move Z axis to touch material. Zero the Z axis on the Digital Readout System (DRO). Set value to 23.000mm, check the value is correct. Move cutting tool along the X axis just a fraction inside the edge of the material. Start Lathe and initiate automatic feed for Z axis. Observe facing process to ensure correct operation. Stop the auto feed when the readout shows <5.000mm and manually remove material until the Digital Read Out shows 1.000mm. Disengage the lathe (switch to neutral) and step on the foot brake. Move the Z axis turn handle back to 23.000mm and measure the diameter of the faced surface with a micrometer, 44.670mm. zero the X axis and set to 44.670mm. check the value has been entered correctly. Move X axis to 44.000mm and start lathe. Initiate Z axis auto feed and again stop when its within 5.000mm to manually remove material down to 1.000mm.

Repeat the process of measuring the diameter with the micrometer, comparing to the DRO and adjusting accordingly. Remove 1.000mm across the X axis each time until the diameter is down to approximately 36.000mm.

Satisfy the Tolerance

The increments should drop down to 0.300mm to ensure the tolerance is met and the final cuts should be made, again measuring with a micrometer after every cut. The final micrometer reading for the diameter of the step is 35.170mm.



Now the correct diameter is achieved, the length (Z axis) can be reduced gradually until the tolerance is met. Without touching the X axis from the previous cut, move the Z axis manually to within 1.200mm and reduce to 0.900mm. This will make all the previous cuts in this process align to meet at a flat surface. The piece can now be removed from the lathe and measured with a height gauge.

To achieve an accurate measurement, the height gauge must be calibrated to the top of the piece (standing up on a flat level surface). Once calibrated and zeroed, the piece can be moved outwards slightly, and the height gauge can be dropped to land on the first step. The reading will show a negative number due to the height gauge being dropped down, but the number displayed shows the exact measurement for the length of the step, 23.78mm.

Insert the piece back into the chuck, tighten correctly and drop the guard down. Move the X and Z axis back to their previous positions. Start lathe and manually move Z axis down by 0.200mm then repeat measurement with height gauge. Remove material in 0.200mm increments until the height gauge shows that the value for the step is within the tolerance of 23mm $\pm$ 0.200mm. The final cut gives a measurement of 22.87mm which is just inside the lower limit.





Conclusion

This session went well. The cuts made in both directions require slightly more concentration than a cut being made in one direction. As always, regular measurements are extremely important to adjust the increments for the tight tolerances. Both the Length and the diameter of the step are within tolerances.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. The lathe bed was cleared of swarf using a dustpan and brush and the surrounded area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Lathe to Create a Stepped Bar

Session 4

31/10/2017

Instructor: Gareth Staddon

Session Aims:

- Centre drill piece
- Continue cutting stepped profiles

Health and Safety

Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement.

Centre Drill

To cut the remaining stepped profiles, additional support is required to compensate for the excessive protrusion of the piece when clamped. If the lathe is turning and the cutting tool applies pressure, there is a risk of unbalancing the piece. This could result in unwanted movement or even an ejection. To ensure the piece remains fully supported and stable whilst work is carried out, a small blind hole should be cut into the exposed end concentrically so that a live centre can be used.

Place piece into the 3-jaw chuck and tighten. Insert the drill bit, tighten the Jacobs chuck and fit the centre drill component into the tailstock ensuring it is completely secure. engage chuck guard and start the lathe. Move the tailstock carefully until it becomes in contact with the surface of the piece. It is important to take extra care when drilling as excessive heat can result in damage to the drill bit.

Use the handwheel to operate the tailstock so that the drill bit cuts into the material. Work the drill backwards and forwards in small increments as more material gets removed. Extra care should be taken to keep the drill cool. There are no dimensions on the technical drawing for this process, so an approximation is required.



There are two purposes for this hole:

- To ensure the live centre can be seated correctly to the piece for additional stability
- Used as a pilot hole for the 30mm blind hole in the technical drawing

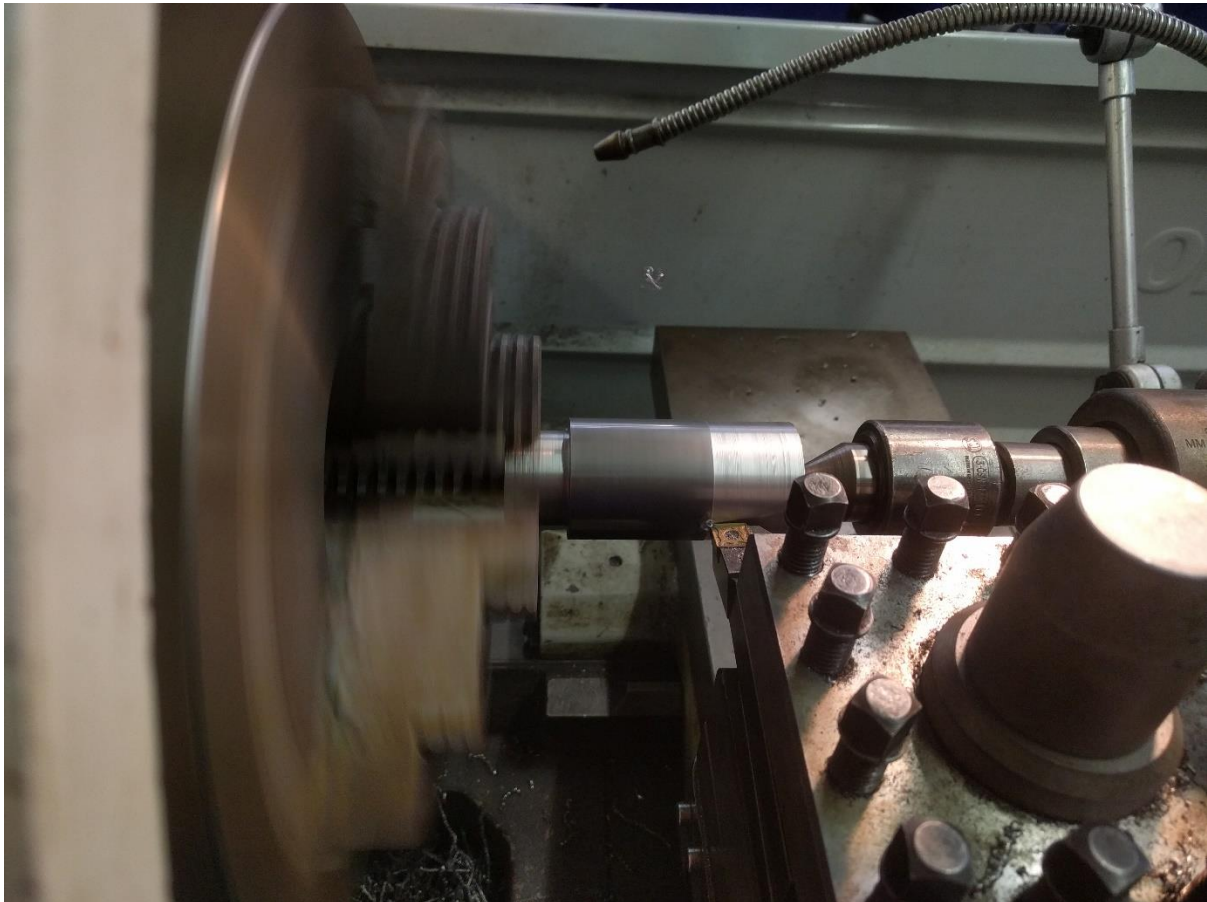
Remove the drill from the tailstock and fit the live centre, checking for security after. Slacken the 3-jaw chuck slightly so that the piece moves around freely, without falling out. Move the tailstock towards the piece until the tapered live centre fits concentrically into the new blind hole. Push the piece as far onto the taper as possible and tighten the spindle chuck. Use the tailstock handwheel to take up any further slack between the piece and the live centre then lock the tailstock in position. It is important to clamp the piece approximately half way onto the smaller profile and not tight against the edge of the larger step. If the lathe is turning and there is contact between the cutting tool and the spindle jaws, damage to the machine can occur. This is also a serious health and safety risk due to flying objects.



Start the lathe and observe the live centre spinning, as well as the piece rotating with no imbalance. A concentric hole with a correctly clamped piece should turn without any throw.

Second Stepped Dimension

The second profile is 40mm in diameter and 22mm in length. This is the widest step so to reduce machine time, the diameter for the remainder of the piece can be cut at this stage. Move both the X and Z axis to touch the surface of the piece and zero the Z axis on the digital readout. Move the X axis to right to the edge and start the lathe. Set the Z axis auto feed and face the entire length of the piece. Observe the digital readout and stop the feed before it gets to within 2.00mm of zero. Turn the Z axis handwheel until it cuts to the end of the material. It is important to stop the auto feed so that full control can be gained to prevent any interference with the spindle.



Move the Z axis back to zero. Measure the freshly faced piece, 44.35mm. Zero X axis digital readout and input micrometer reading. Move X axis to 44.00mm and face again. Measure with micrometer, 43.97mm. Repeat this in 1.00mm increments, measuring and amending each time using the micrometer and digital readout. When the diameter is approximately 1.00mm from the desired dimension, (40.00mm) reduce increments to 0.300mm and measure with micrometer each time. The tolerance for this step is ± 0.200 mm. Final measurement is 40.158mm, within tolerance.

Conclusion

In today's machine workshop session a variety of Lathe components were introduced and used to complete the second stepped profile. A lot of thought was put into positioning the piece on the lathe to provide the safest solution and the live centre is an excellent support for over projected parts. Drilling a concentric hole with the lathe is incredibly accurate providing the surface on which you clamp is perfectly even.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. The lathe bed was cleared of swarf using a dustpan and brush and the surrounded area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Lathe to Create a Stepped Bar

Session 5

14/11/2017

Instructor: Gareth Staddon

Session Aims:

- To complete the remaining stepped profiles

Health and Safety

Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement.

Third Stepped Dimension

The piece should be secured into the lathe by following the same method for the step created in the previous session. With the spindle chuck and tailstock secure with live centre in place, lower the chuck guard and start the lathe. The part should turn concentrically if the set up procedure has been carried out correctly. The most efficient way of cutting the final three stepped profiles is to cut them consecutively in one session.

The third step requires a length of 22.000mm (+/- 0.200mm) and a diameter of 36.000mm (+/- 0.050mm). As the final two steps are both smaller than this, the length does not need to be achieved until the next step. The length for the previous step must be made now. This can be calculated by measuring each profile up until the last step, which is 60.00mm.

Move the Z axis to touch the end of the piece, then zero on the digital readout. Set the Z axis to 60.000mm. Move the X axis to the edge of the piece and set the Z axis to auto feed. Observe the digital readout and stop the feed before it gets to within 2.00mm of zero. Turn the Z axis handwheel until it cuts to 0.200mm.

Move Z axis back to 60.000mm and measure the diameter with a micrometer, 40.100mm. Input to the X axis on the digital read out and move X axis handwheel until it reads 40.00mm. Start Z axis auto feed and cut down to 1.00mm. Measure diameter with micrometer and repeat this process in 1.000mm increments until 37.000mm is reached.

For the first time in the technical drawing the tolerance has changed to 0.050mm. This means as the diameter gets close 36.000mm, smaller increments must be used to achieve the set tolerance. Measuring after every cut is extremely important. 0.500mm should be taken off, a measurement read from a micrometer and the digital read out adjusted again accordingly, then 0.100mm increments should be removed until the diameter is 0.200mm. then the increments should be dropped further to 0.050mm. A measurement should be taken after each cut until the tolerance is met.

Fourth Stepped Dimension

The piece should remain in place from the previous step to maintain concentricity.

The fourth step requires a length of 20.000mm (+/- 0.200mm) and a diameter of 28.000mm (+/- 0.020mm). The length for the previous step must be made now. This can be calculated by measuring each profile up until the last step, which is 38.000mm.

Move the Z axis to touch the end of the piece, then zero on the digital readout. Set the Z axis to 38.000mm. Move the X axis to the edge of the piece and set the Z axis to auto feed. Observe the digital readout and stop the feed before it gets to within 2.00mm of zero. Turn the Z axis handwheel until it cuts to 0.200mm.

Move Z axis back to 38.000mm and measure the diameter with a micrometer, 35.820mm. Input to the X axis on the digital read out and move X axis handwheel until it reads 35.000mm. Start Z axis auto feed and cut down to 1.00mm. Measure diameter with micrometer and repeat this process in 1.000mm increments until 29.000mm is reached.

This time the tolerance has changed to 0.020mm. This is the smallest tolerance for the entire piece so even smaller increments must be used. Measuring after every cut is extremely important as usual. 0.500mm should be taken off, a measurement read from a micrometer and the digital read out adjusted again accordingly, then 0.100mm increments should be removed until the diameter is 28.100mm. The increments should be dropped further to 0.020mm. A measurement should be taken after each cut until the tolerance is met.



Final Stepped Dimension

The piece should remain in place from the previous step to maintain concentricity.

The final step requires a length of 18.000mm (+/- 0.200mm) and a diameter of 25.000mm (+/- 0.200mm). The length for the previous step, and the length for this final step can be made now.

Move the Z axis to touch the end of the piece, then zero on the digital readout. Set the Z axis to 18.000mm. Move the X axis to the edge of the piece and set the Z axis to auto feed. Observe the digital readout and stop the feed before it gets to within 2.00mm of zero. Turn the Z axis handwheel until it cuts to 0.200mm.

Move Z axis back to 18.000mm and measure the diameter with a micrometer, 27.480mm. Input to the X axis on the digital read out and move X axis handwheel until it reads 26.000mm. Start Z axis auto feed and cut down to 1.00mm. Measure diameter with micrometer and repeat this process in 1.000mm increments until 26.000mm diameter is reached.

For the final step the tolerance has reverted to 0.200mm. 0.500mm should be taken off, a measurement read from a micrometer and the digital read out adjusted again accordingly, then 0.100mm increments should be removed until the diameter is 25.200mm.



Conclusion

With the introduction of tighter tolerances, achieving the final dimensions took a lot longer. The 0.050mm tolerance was met after some careful measurements but the tightest tolerance of 0.020mm was missed by 0.421mm, meaning the final diameter measurement for the fourth step is 27.559mm.



The reason for this mistake is a misjudgement of one of the micrometer readings whilst dropping down in 0.500mm increments. If this was a part designed to be used in an assembly and required the 0.020mm tolerance to accommodate another part, the whole process would have to be restarted due to failing to meet the design. This proves just how important measuring correctly is, and how a measurement should always be checked twice before allowing a dimension to be recorded. The rest of the work today went according to plan and the session aims were achieved in the timescale.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. The lathe bed was cleared of swarf using a dustpan and brush and the surrounded area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Lathe to Create a Stepped Bar

Session 6

21/11/2017

Instructor: Gareth Staddon

Session Aims:

- Chamfer both ends of the piece
- Centre drill blind hole
- Drill second intersecting hole
- Tap thread into hole.

Health and Safety

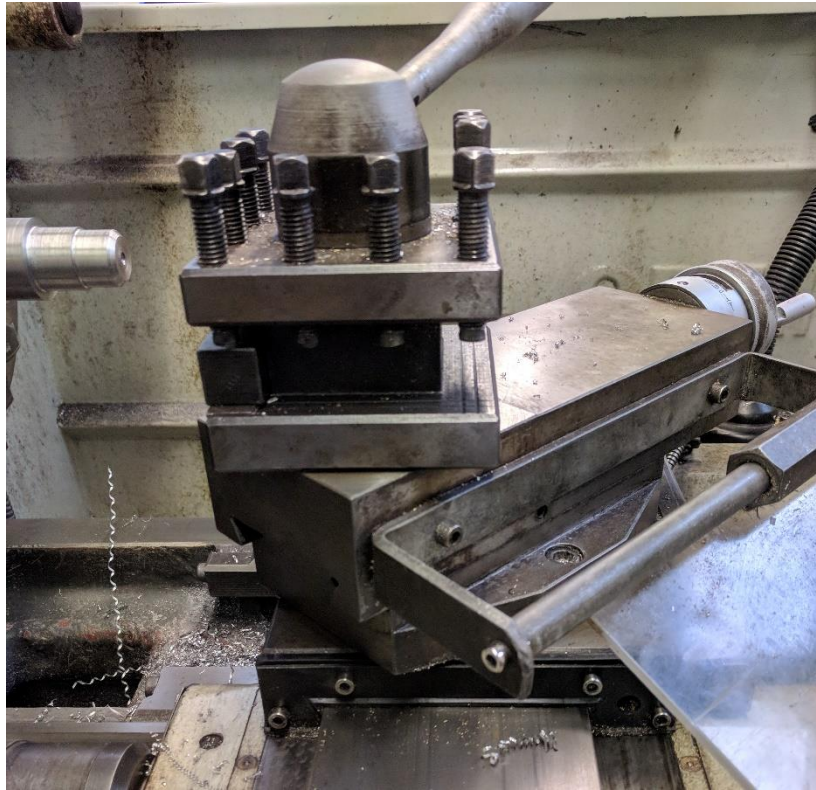
Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement. Pillar drill demonstration and briefing of safe working procedure was given before use.

Chamfers

As part of the technical drawing, a chamfer of different sizes should be cut to each end of the piece, both at a 45° angle. With the piece securely clamped into the spindle chuck, the compound rest should be offset so that the angle can be achieved.

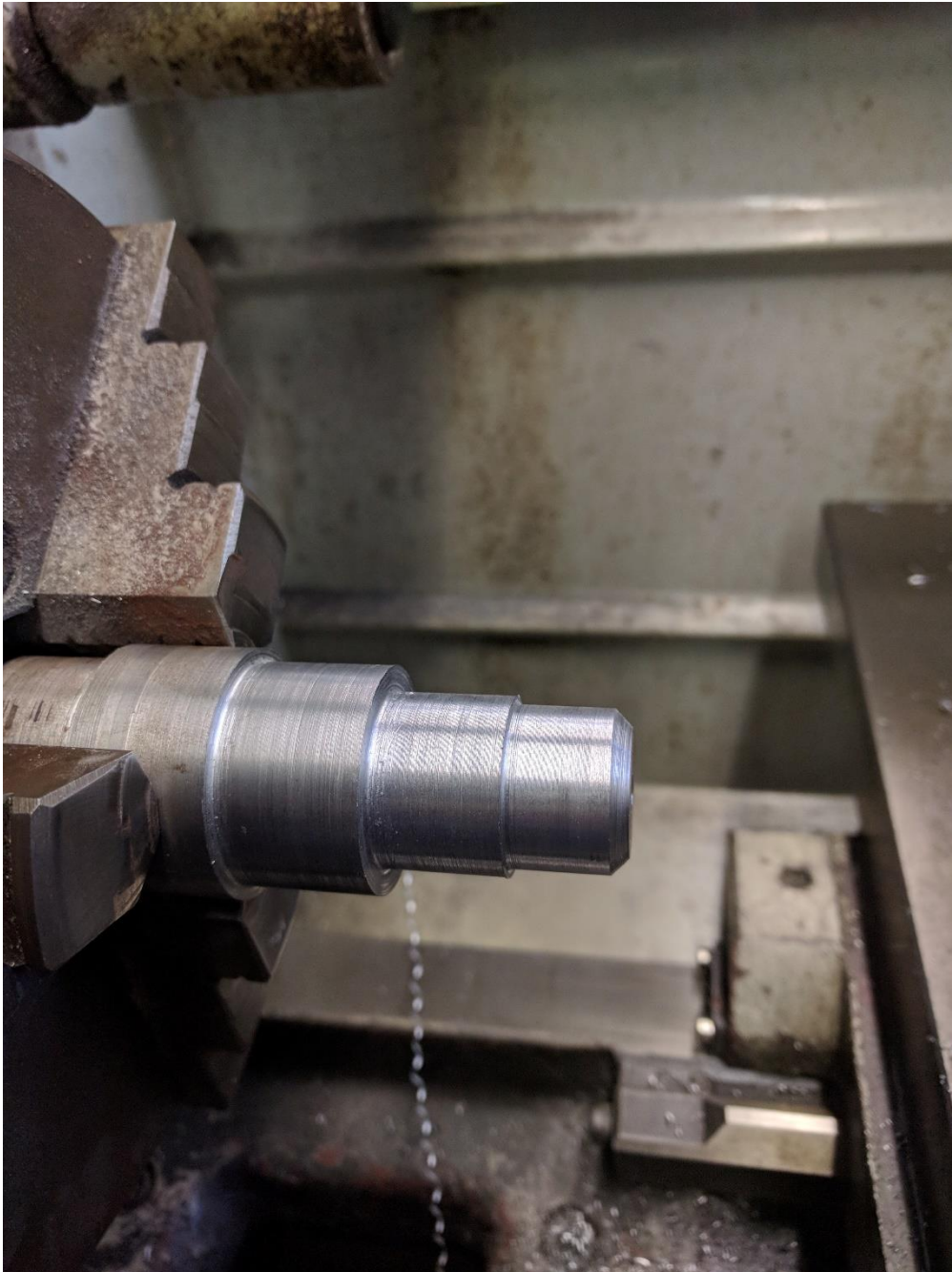


The tool post must be adjusted to be parallel with the face of the piece. When the desired chamfer setup is complete, all components are fully secured and locked into position.



For the first chamfer, the dimension is 1.5mm x 45°. Move the X and Z handwheels until the cutting tool touches the extremity of the piece on the outer most edge. Set the Z axis to 1.500mm and turn the compound rest handwheel back so that the cutting tool is clear of the piece, move the Z axis handwheel to 1.00mm and start the lathe with the chuck guard down. Turn the compound rest handwheel inwards slowly until the chamfer has been cut through the piece. Stop lathe and return compound handwheel back clear. Move Z axis to 0 and repeat to complete the chamfer.

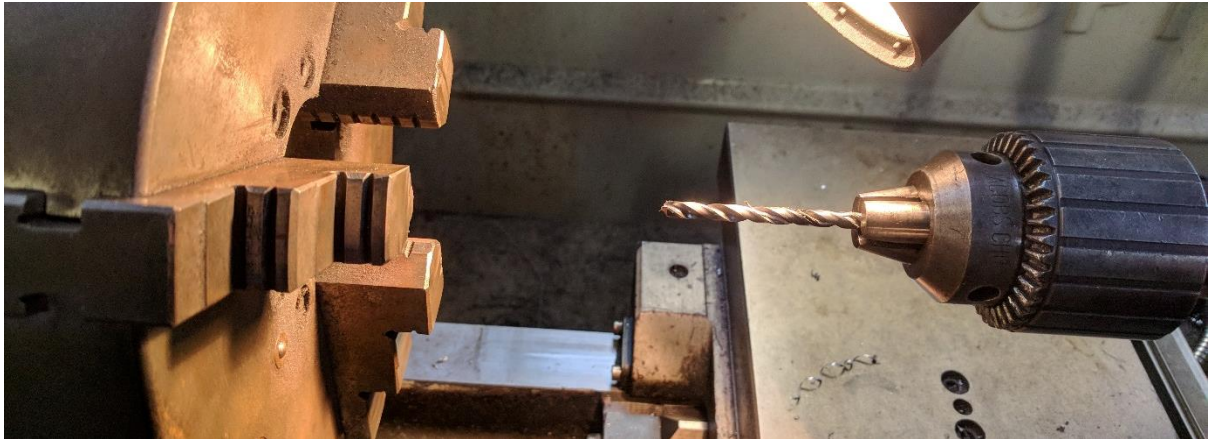
Remove the piece from the spindle chuck and turn 180° to expose the other end. Ensure the piece is clamped tight and repeat the chamfer process but this time set the Z digital read out to 3.000mm.



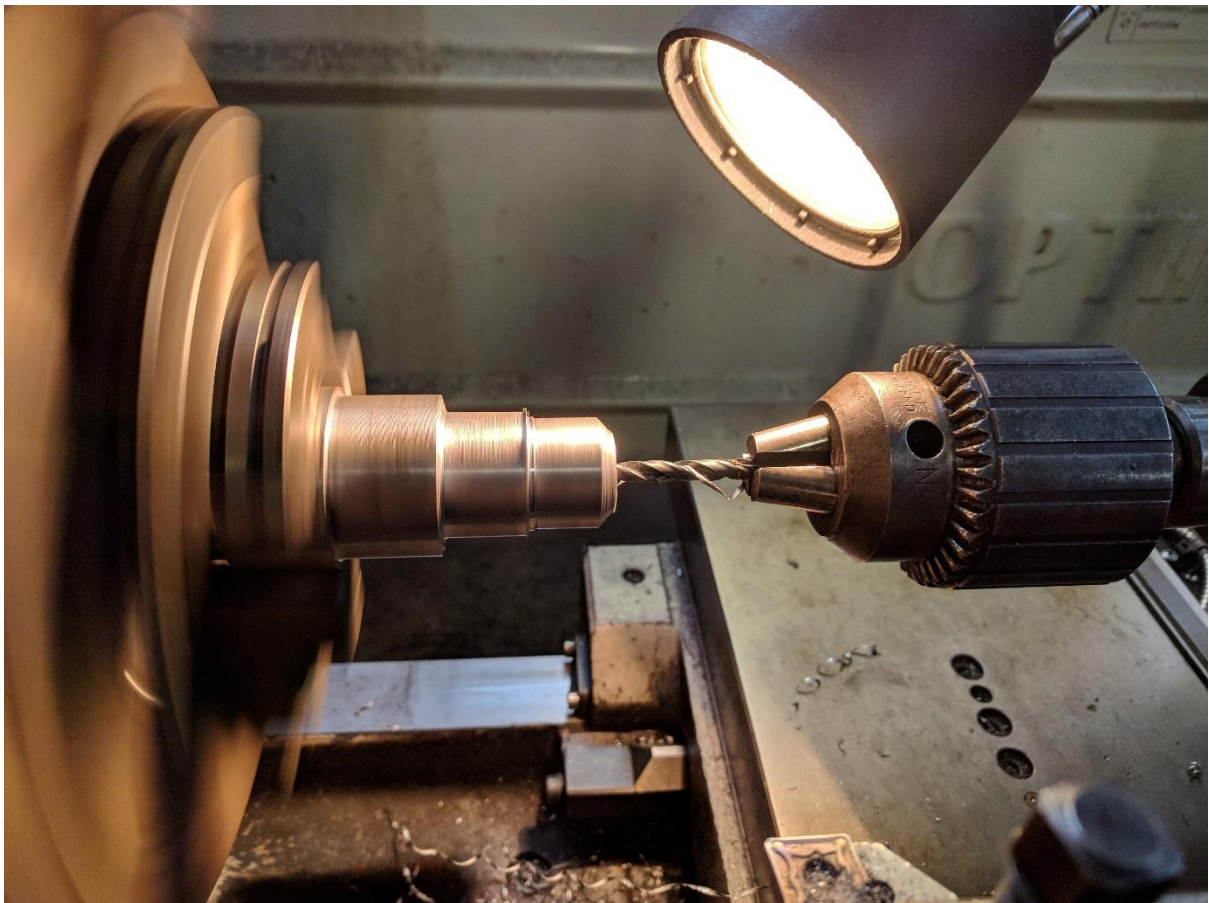
Centre Drill Blind Hole

The blind hole must be concentric to the piece so the easiest way to drill this is by using the tailstock on the lathe. A 5mm drill bit should be used and a pilot hole has already been made for this. The depth of the hole should be 30mm.

Insert the drill bit and tighten into the tail stock.



Insert the piece and tighten spindle chuck. Before starting the lathe, move tailstock up to the piece to make sure the drill piece is concentric to the existing hole. With the tailstock touching the surface of the piece, note the tailstock reading, 10.000mm. Start the lathe. Use the tailstock handwheel to drill into the piece slowly, working back and forth to keep the drill cool.

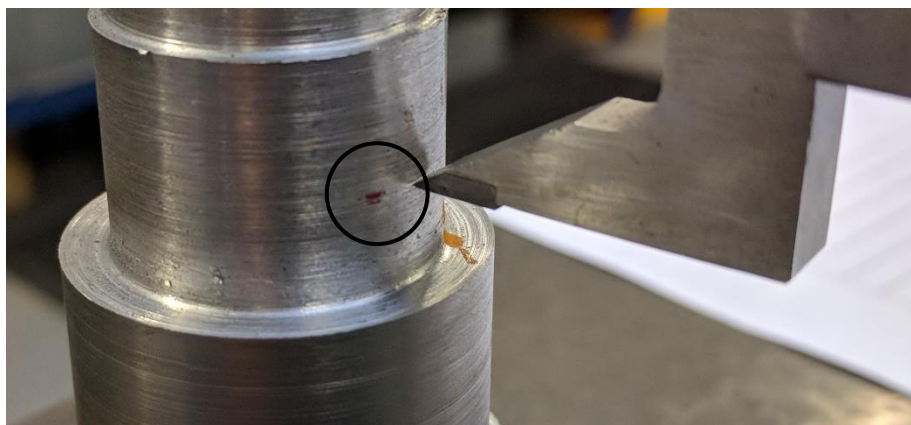
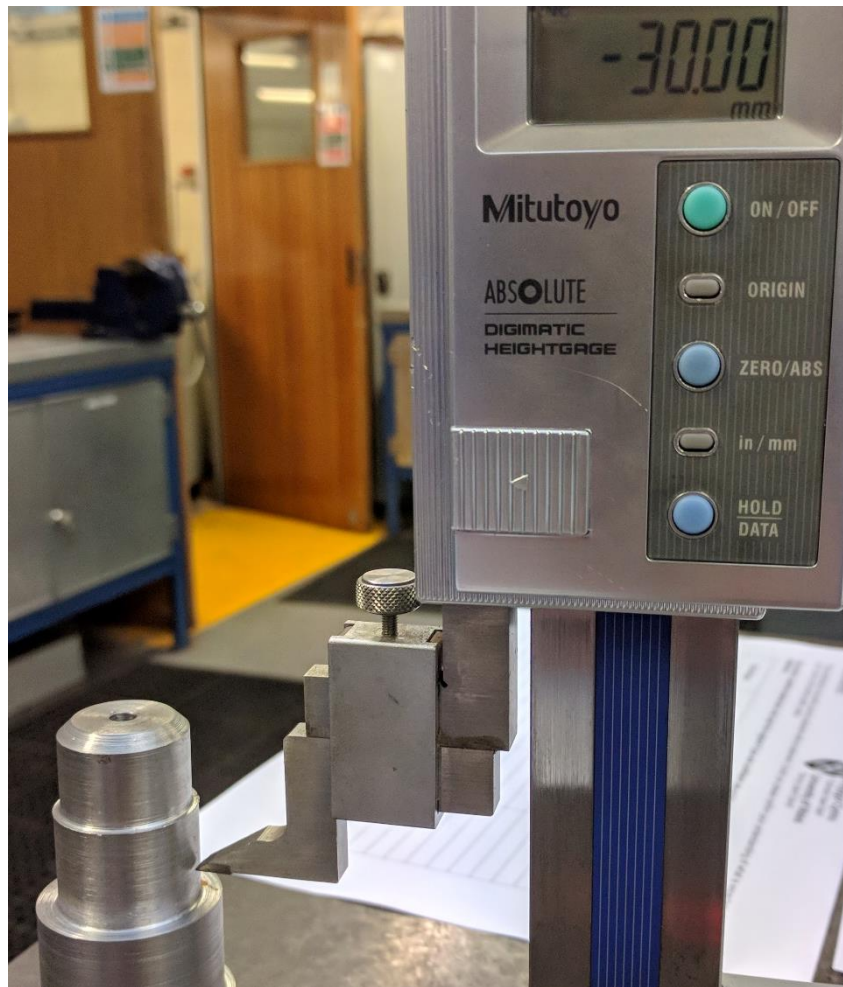


Observe the tailstock measurements as the drill goes further into the piece. To make the hole 30.000mm, the tailstock needs to move up to the 40.000mm mark. Once this is achieved, wind the drill out of the piece and stop the lathe. Remove the piece and use a Vernier to measure the depth of the hole, 30mm.



Intersecting Hole

As part of the technical drawing an intersecting hole should be made 30mm from the end of the piece, so that the hole meets the end of the existing hole. To do this, a measurement of 30mm needs to be made. Using a height gauge, move the measuring face to the top of the piece on a flat surface and zero the gauge. Move the slider so that it reads -30.00mm and mark out this point on the surface of the piece.



Carefully place the piece in a vise with the marking facing upwards and clamp tight. Use a centre punch on the marking to provide a surface for the drill bit to seat.

Insert a 6mm drill bit into the pillar drill and clamp the piece into the drill vise making sure that it is not only secure, but level and central to the drill bit, directly in line with the centre punch mark. move the drill head down so the drill bit touches the centre punch mark and use a ruler to adjust to lock nuts to 14mm (half of the profile diameter being drilled). By doing this, the travel limit is set so that the drill will stop in the exact centre of the piece. This means the holes should intersect perfectly and form a 90° hole.



Tapping The Thread

The final process to satisfy the technical drawing is to tap a M6 x 1mm thread, 30mm deep into the 5mm hole. Put the piece into the vise and clamp it well. The hole should be facing vertically upwards to make tapping as easy as possible. It is extremely important to use lubrication throughout, as a lot of friction will create excessive heat and could result in snapping the High Speed Steel taps.



All three types of taps must be used in their correct order, so that the thread can be made cleanly. To start, the tapered tap must be used. This has the first 5 to 10 grooves ground down to make the initial cutting easier. Work the tap carefully to begin with whilst trying to make sure it stays central. As it is worked back and forth, it should become easier and easier to cut. The plug tap is next. This is the intermediate tap for use when a thread is already present but not fully formed. Lubrication fluid should be applied again to reduce the risk of a break. Finally the Bottom tap can be used. This will provide a fully cut thread once turned through the entire 30mm.



To finish the piece a small needle file should be used to de-burr every edge so that it's smooth to touch.

Conclusion

The final processes in making this piece has included various methods and tools. The session went really well without making any mistakes along the way. Having a lot of previous experience with using a pillar drill and tapping threads really helped today. It is important to feel for the resistance through the T-handle when tapping a thread as any excessive resistance could mean there is a problem.

The piece is finished completely and besides the one mistake with the tightest tolerance, overall a good standard of work has been achieved. Awareness of health and safety and all aspects of correct procedures within the machine shop has been raised and understood fully.

No health and safety issues were presented in today's session and PPE was worn at all times, including safety glasses. The lathe bed and pillar drill was cleared of swarf using a dustpan and brush and the surrounded area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Milling Machine to Create a Stepped Profile

Session 1

28/11/2017

Instructor: Dave Cooper

Session Aims:

- Discuss safe working procedures.
- Discuss personal protective clothing & skin care
- Discuss health and safety risks
- Stepped profile briefing
- Prepare work piece
- Mark out dimensions
- Centre punch hole markings

Workshop Safety

There are numerous hazards in the machine shop which can pose a real threat to the health and safety of all people involved. Learning how to work safely in a workshop environment is vital. Many accidents that happen in the workplace are down to complacency and are usually preventable if the correct measures are taken.

To ensure the highest standard of safety can be adhered to, Safe Working Procedures (SWP's) are available for each individual machine and tool. Demonstrating competence when using specialist equipment is crucial. Machine operation should only be carried out whilst under the supervision of an instructor.

Understanding where the Emergency Stop Buttons are located and how to quickly and safely stop any machine in use is also very important.

Personal Protective Clothing

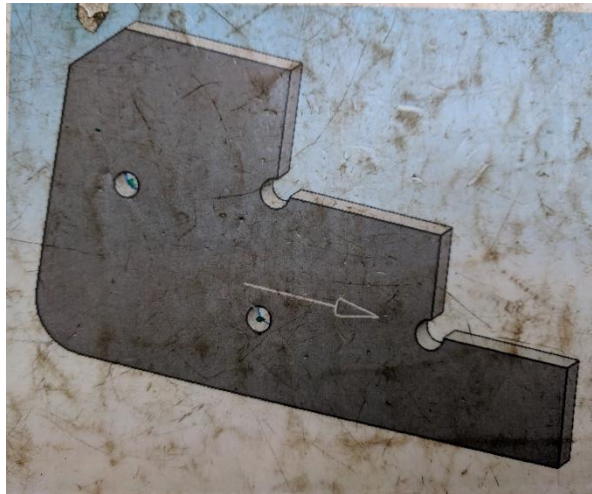
It is imperative that the correct PPE is worn when working in the machine workshop. This includes steel toe cap boots, overalls or laboratory coats, and sensible full-length workshop trousers. Steel toe cap boots protect from heavy/sharp objects, overalls and lab coats offer full arm and body protection from hot flying particles ejected from machines or tools and sufficient protection from sharp or hot objects can be provided by workshop trousers.

Due to the nature of the machines in this workshop it is mandatory to wear full eye protection. Swarf can be ejected from milling machines and lathes at a high velocity and temperature and is incredibly unpredictable. There is a high risk of damage to the eyes if no protective glasses are worn. Any long hair must be tied back to avoid entanglement. Jewellery should be removed prior to entering the workshop to also avoid entanglement. Another reason jewellery should be removed is in case of an electric shock. Any items of clothing which have tassels or draw strings should be tucked inside overalls/lab coat.

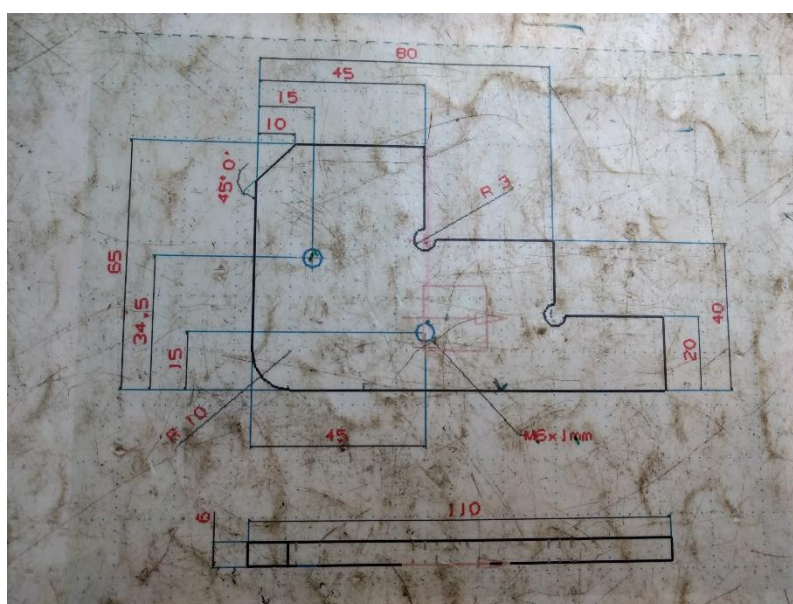
Due to the harshness of materials and chemicals inside the workshop, correct skin care procedures should be demonstrated. Dermatitis is the largest threat to skin, causing dryness and irritation. Barrier cream should be applied before every session to combat this.

After every practical session hands should be thoroughly washed using Deb Lime provided. This is a specially formulated degreasing soap with slightly abrasive properties. Finally, the restore cream should be worked into dry hands as a moisturiser. Some chemicals used in workshops are carcinogenic, so gloves should be worn if ever handling these. COSHH data sheets can be used in the event of adverse effects from chemicals or substances.

Stepped Profile Briefing



Dave assigned the task and explained the processes involved in creating the piece from the technical drawing. This enables students to understand the methods involved, giving an opportunity to ask any necessary questions before work begins. During each session, there will be various points where a new tool or machine must be used. It is imperative that Dave is informed before any operations are undertaken on unfamiliar tools as a matter of safety. All steps in the process are made under supervision with the correct working procedures and PPE. The technical drawing must be followed to create the piece accurately, paying attention to measurements and tolerances.



Prepare the Work Piece

A bright mild steel bar with approximate dimensions of 115x76x6mm is used in this task.



The piece is pre-cut to these measurements from a length of 6mm bar using a saw. Before any measurements and markings can be made, it is important to make all edges of the piece flat, as any burrs or nibs may result in inaccurate measurements. A needle file is used to do this, until all edges are smooth to touch and appear even.



With the edges prepared, a square block can be placed on a flat bench, and the piece inspected to find the corner that appears to be closest to having two flat sides, with minimal gaps between the bench and block, at a 90° angle. Mark the corner with a scribe. This will be the reference point for each dimension.



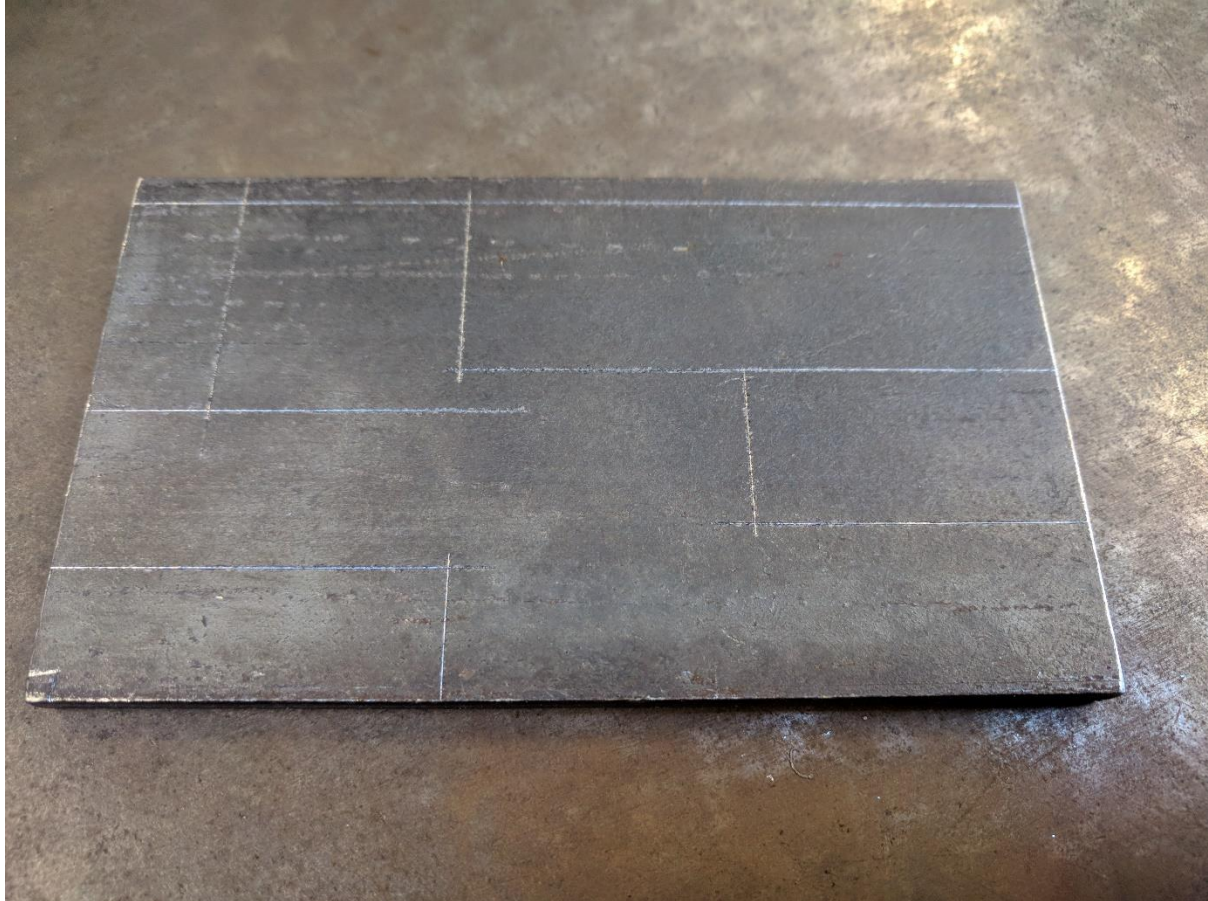
Mark Out Dimensions

In the previous task using the lathe, height gauges were used for measuring purposes only. For this task, another feature will be used. The height gauge measuring face is also a scribing stylus so when a measurement is made, the gauge can be locked in position and used to mark out the piece against the engineering square. The height gauge should be calibrated to zero before measurements are made.



There are various methods to complete this stage. The most efficient and reliable system is to complete all horizontal lines from the technical drawing first, starting at the bottom. Lines for holes should be marked out by only scribing to the point where the references intersect. Lines for cutting material to be marked out by fully defined marks to the edges of the piece. This helps to distinguish between the two, however, a coloured marker can be used afterwards if preferred. This would highlight the lines to be cut to avoid confusion.

When all horizontal markings are measured and complete, the piece can be turned through 180° to mark out the vertical lines. Marking out from a technical drawing containing many dimensions is difficult. Using a systematic process helps to eliminate errors. If markings are made incorrectly the finished piece will be inconsistent with the technical drawing. This can result in a waste of material and time.

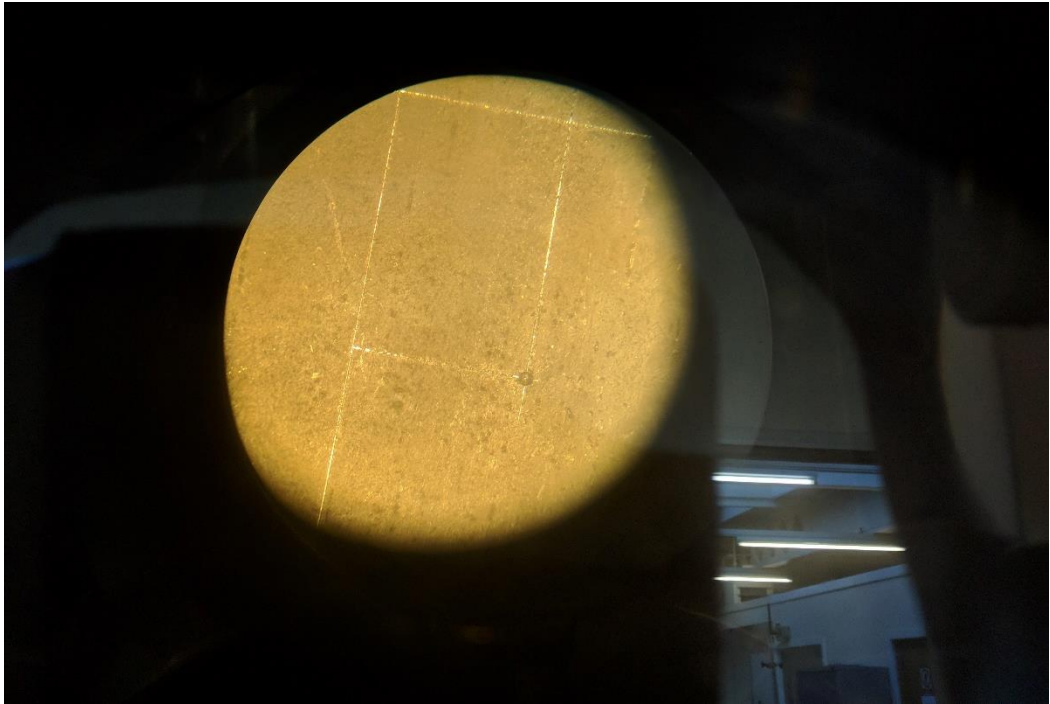


Centre Punch Hole Markings

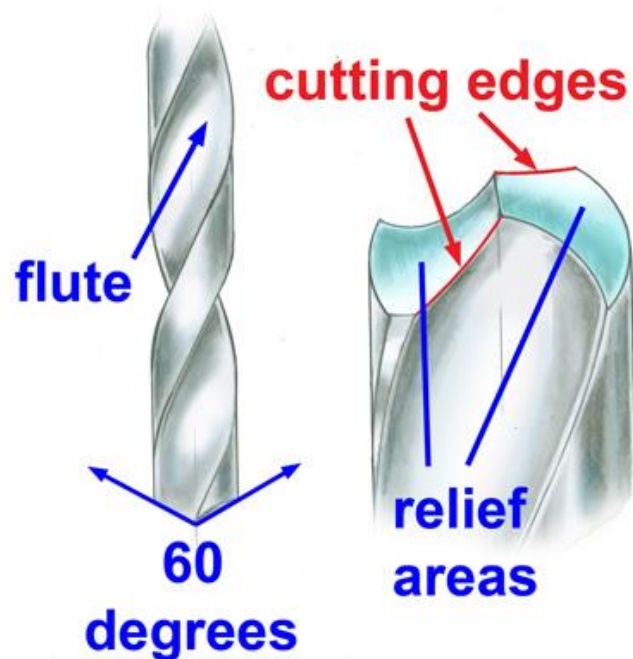
Before any holes can be drilled a centre punch must be used to mark the position for the drill bit. Carefully line the centre punch up as close to the intersection as possible. Lightly tap the top with a hammer to form a shallow mark on the piece. Place the piece under the view finder to magnify the centre punch mark. The mark may be slightly off centre when magnified.

The first hole is above the centre and to the left. Take the piece back to the bench and seat the centre punch into the mark. tilt the centre punch down and to the right. This will drift the marking to the middle. Use the view finder to check its altered position.

With the new mark fully centred, a slightly firmer tap with a hammer will fully form the tapered indentation required. Repeat this process for the remaining three holes until complete, using the view finder to accurately adjust each marking accordingly.



The mark made from a centre punch gives the drill bit a perfectly central point to seat onto. This means a highly accurate hole will be formed. Without this indentation the drill bit may slide around whilst rotating which may result in misaligned holes. The centre punch has a tapered head of 60° to match the taper of a drill bit. Having the same angle of taper means the drill bit will be increasingly less likely to move whilst rotating and the cutting edges will be in direct contact immediately.



Conclusion

A good amount of progress was made in this session. Using skills and experience from the previous task gave confidence in measuring and marking out accurately. Each measurement was checked twice without any mistakes being made. The tolerances provided from the task instructions, (+/- 0.200mm) are met by the scribed lines. The final centre punch indentations are precise. With a short amount of time remaining before the end of the session I made the decision to stop and offer guidance to peers as I felt competent with this process. As the next stage in this task is to drill the holes, I decided from experience to complete all holes in the same session rather than having to remove the piece part way through. This reduces the risk of making a mistake, with each session being a week apart. I have also gained further understanding in drill preparations.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. Work surfaces were cleared of swarf and debris using a dustpan and brush. The surrounding area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Milling Machine to Create a Stepped Profile

Session 2

05/12/2017

Instructor: Dave Cooper

Session Aims:

- Drill holes into work piece
- Cut excess material prior to milling
- Operate milling machine to achieve correct dimensions.

Health and Safety

Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement.

Drill holes into work piece

The technical drawing requires a total of 4 through holes to be drilled, two of 3mm radius, and two 5mm holes, in preparation for tapping m6x1mm threads.



Insert 5mm drill bit into pillar drill chuck and tighten. Clamp bar into drill vice correctly. Locate the two centre punch marks on the bar that require an m6x1mm tap. It is important to double check the technical drawing before proceeding and is good practice to start with the smaller holes first to minimise the risk of errors. With the drill switched off, align the centre punch mark with the centre of the drill bit. If the drill is misaligned there is a risk of inconsistencies or potential drill bit failure. Ensure the correct speed setting is selected for the material. Turn on the drill and slowly work into the bar with applied lubrication oil. After cutting through the material, slowly retract the drill bit and then switch of the machine, reposition for the next hole and repeat the process.



With both 5mm holes complete, swap the drill bit to 6mm and repeat the procedure for the remaining two holes.

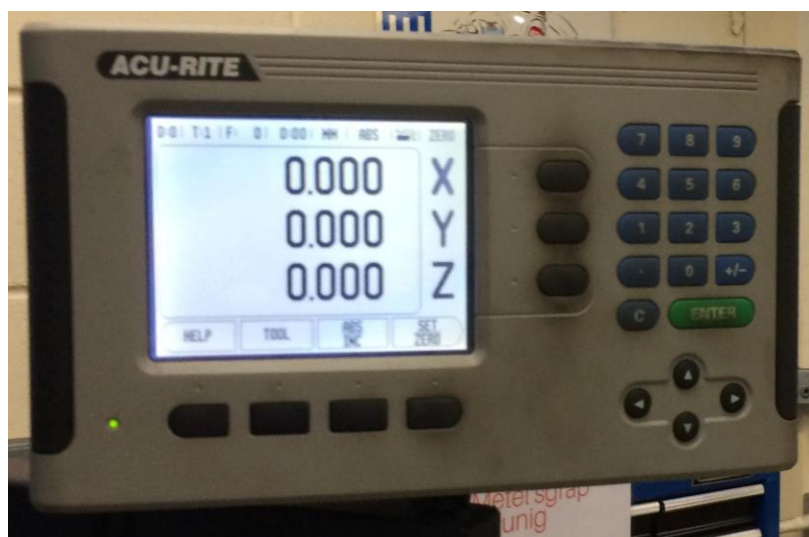
Cut Excess Material

To speed up the manufacturing process, it is necessary to use a hacksaw to remove the large areas of excess material. Sandwich the work piece with two bars and clamp in the vice. By doing so, the vice teeth will not leave any marks on the piece. With the bar in place, use the hacksaw to cut vertically from the edge, to intersect the hole. Although it is recommended to remove as much material as possible, care must be taken to avoid cutting over the scribed lines. The next vertical cut can be made to intersect with the other hole, before turning the piece through 90° to make the final cuts. With the excess material removed, the piece is now ready for milling.

Milling the Piece

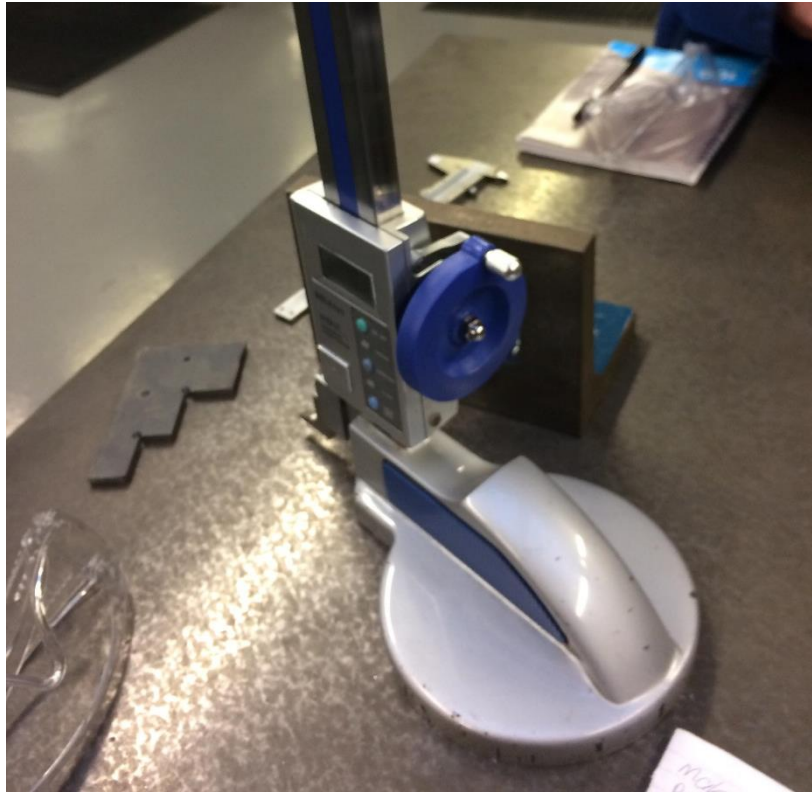


The bar is inserted into the machine vice and tightened correctly. The X, Y and Z axis are moved to align with the centre of the piece, and the first scribe line. The machine is started. The Z axis handle is turned carefully until it touches the material and then set to zero on the Digital Read Out (DRO).



By doing so, the amount of material being removed can be monitored. The X axis is brought to the edge of the piece and the Z axis raised by 0.3mm, Then the X axis is moved across the piece before returning to the edge again. The Z axis is moved in further increments and the process repeated until the scribe line is reached. The piece is removed and placed on the flat table to be measured with the

height gauge, 65.6mm. The piece is placed into the machine vice and the Z axis is moved until the cutting head touches the material. The Z axis DRO is set to 65.60mm and material is removed in 0.2mm increments until 65.2mm is achieved, then checked on the height gauge. As the tolerance is 0.2mm, 65.1mm within spec. The Piece is placed into the machine vice again and these steps are followed with regular height gauge measurements, until all dimensions are satisfied for all parts of the technical drawing.



Conclusion

Today's session was very productive. Familiarity with the pillar drill, height gauges, DRO, and other equipment improved efficiency of work. Having worked on the lathe for several weeks prior to this task, transferable skills were used in operation and the DRO system used on both lathes and milling machines are identical. Repetitive actions promoted efficiency and towards the end of the milling processes I had gained confidence. The piece has been cut and machined to within the prescribed tolerances and extra care must be taken going forward to ensure no errors are made. In industry, defects at a later stage in manufacturing would result in a large portion of time and resources lost.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. Work surfaces were cleared of swarf and debris using a dustpan and brush. The surrounding area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Machine Shop Practical

Using a Milling Machine to Create a Stepped Profile

Session 3

12/12/2017

Instructor: Dave Cooper

Session Aims:

- Tap two threads
- Curved Edge
- Finish piece

Health and Safety

Steel toe cap boots, work trousers, lab coat and protective glasses are worn throughout. Barrier cream is applied before work commences and a session brief is given by the instructor. Key health and safety concerns are raised such as the risk of injury from swarf and the risk of entanglement.

Tapping the Threads

The technical drawing requires two M6 x 1mm threads to be tapped through the 5mm holes. Put the piece into the vice and clamp it well. The hole should be facing vertically upwards to make tapping as easy as possible. It is extremely important to use lubrication throughout, as a lot of friction will create excessive heat and could result in snapping the High Speed Steel taps.



All three types of taps must be used in their correct order, so that the thread can be made cleanly. To start, the tapered tap must be used. This has the first 5 to 10 grooves ground down to make the initial cutting easier. Work the tap carefully to begin with whilst trying to make sure it stays central. As it is worked back and forth, it should become easier and easier to cut. The plug tap is next. This is the intermediate tap for use when a thread is already present but not fully formed. Lubrication fluid should be applied again to reduce the risk of a break. Finally the Bottom tap can be used. This will provide a fully cut thread once turned through the entire bar.

Curved Edge

The final manufacturing process required to satisfy the technical drawing is a curved edge to the bottom corner of the bar. The indicated chamfer radius is 10mm. To accurately achieve this, a radius gauge is used.



A Scribe mark is etched around the edge of the piece following the gauge template, then material is filed away until a smooth finish is achieved. There are also many other methods to apply radii to metal.

Finishing the Piece

With the stepped profile, tapped threads and curved edge finished, the final process to complete this piece is to check all dimensions are within tolerances and ensure no burrs remain. A needle file is used to run over all machined, cut and filed surfaces and any swarf is removed.

Conclusion

Today's session was a success. The part is finished, and the design specifications have been met. Previous experience in tapping threads helped with this task. Having tapped numerous threads, I could feel for resistance through the tap wrench as feedback for how well lubricated the process was. If any excessive resistance is felt through the wrench, there is a potential danger of overheating the mild steel bar and causing damage or defects. Understanding the process of single direction filing is also important. Hand files only remove material in one direction, so moving it backwards and forwards over the piece is not only a waste of effort but can blunt the filing surface. Correct filing techniques are required to achieve a high quality curved edge.

No health and safety issues were presented in today's session and PPE was worn at all times including safety glasses. Work surfaces were cleared of swarf and debris using a dustpan and brush. The surrounding area was swept to keep the work area safe. Swarf was discarded into a scrap metal bin to be disposed of correctly. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Workshop Practical

Engine Strip and Rebuild

Session 1

16/01/2018

Instructor: Barry John

Session Aims:

- Introduction to workshop.
- Discuss Safe Working Procedures.
- Discuss Personal Protective Clothing & skin care
- Discuss Health and Safety risks
- Discuss various workshop tools and equipment

Workshop Safety

There are numerous hazards in the machine shop which can pose a real threat to the health and safety of all people involved. Learning how to work safely in a workshop environment is vital. Many accidents that happen in the workplace are down to complacency and are usually preventable if the correct measures are taken.

To ensure the highest standard of safety can be adhered to, Safe Working Procedures (SWP's) are available for each individual machine and tool. Demonstrating competence when using specialist equipment is crucial. Machine operation should only be carried out whilst under the supervision of an instructor.

Understanding where the Emergency Stop Buttons are located and how to quickly and safely stop any machine in use is also very important.

Personal Protective Clothing

It is imperative that the correct PPE is worn when working in the machine workshop. This includes steel toe cap boots, overalls or laboratory coats, and sensible full-length workshop trousers. Steel toe cap boots protect from heavy/sharp objects, overalls and lab coats offer full arm and body protection from various hazardous liquids.

Jewellery should be removed prior to entering the workshop to avoid entanglement. Another reason jewellery should be removed is in case of an electric shock. Any items of clothing which have tassels or draw strings should be tucked inside overalls/lab coat.

Due to the harshness of materials and chemicals inside the workshop, correct skin care procedures should be demonstrated. Dermatitis is the largest threat to skin, causing dryness and irritation. Barrier cream should be applied before every session to combat this. After every practical session hands should be thoroughly washed using Deb Lime provided. This is a specially formulated degreasing soap with slightly abrasive properties. Finally, the restore cream should be worked into dry hands as a moisturiser. Some chemicals used in workshops are carcinogenic, so gloves should be worn if ever handling these. COSHH data sheets can be used in the event of adverse effects from chemicals or substances.

Workshop Equipment

For the duration of this task, various hand tools will be used along with heavy engine parts, sharp materials and different measuring devices. To maintain a high level of professional conduct, information and demonstrations for each individual component were given from the supervisor. Correct procedures for damaged and worn tools are to be followed throughout. Any defects should be reported to the supervisor. In the event of heavy objects falling from a bench or engine stand, it is strongly advised to step away and let it hit the floor, as opposed to trying to save it and cause injury in the process.

The correct use of tools is extremely important for safety reasons as well as tool preservation. Extension bars should be used where required to minimise the risk of damaged knuckles/hands. Torque wrenches should be slackened off after use to preserve internal components and the correct selection of tools for the task should be used. Screwdrivers may not be used as pry bars, due to their susceptibility of chipping under improper use. This can cause flying particles which may damage eyes. Heavy items should be lifted correctly, through bending knees and where applicable, two people may be required to share a load for items such as engine cylinder heads.

Work benches must be kept clean and well organised to avoid losing components and no items should be stored on the floor due to trip hazards. All tools must be stored away in their correct locations prior to leaving the workshop.

Conclusion

This session has given the foundations to carry out the assigned task in a safe and efficient manner. Essential information has been understood clearly and all questions in relation to the operation of the engine stand, tools and general workshop safety have been answered. PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Workshop Practical

Engine Strip and Rebuild

Session 2

23/01/2018

Instructor: Barry John

Session Aims:

- Remove ancillaries
- Remove timing belt & associated components

Tools used

- Various spanners
- 1/4, 3/8 and 1/2 inch drive sockets, ratchets and various length extension bars
- 1/2 Inch power bar
- 16mm spark plug socket
- Selection of screwdrivers
- Extensive bit set
- Pliers & Mole Grips
- Rubber Mallet

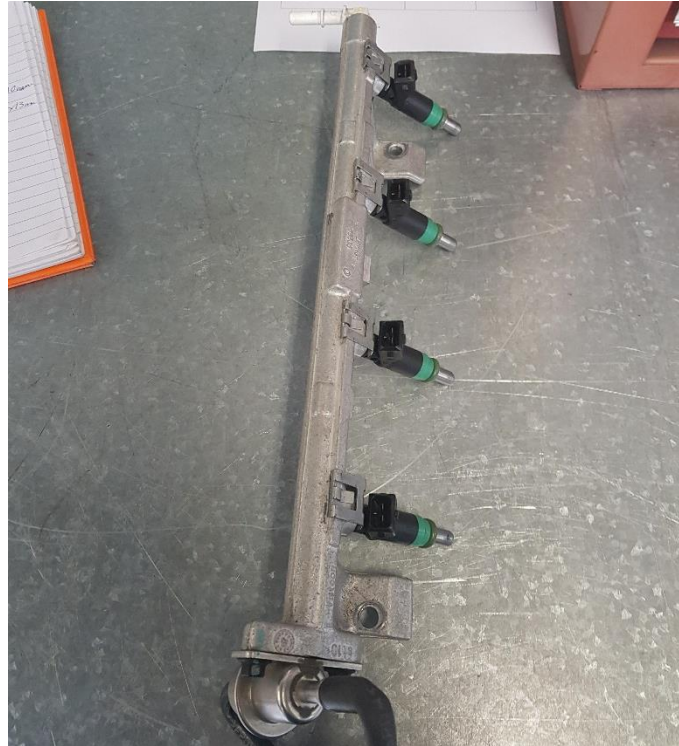
Remove Ancillaries

The first stage of the engine strip down requires all external components bolted to the head and block to be removed. First, the HT leads are removed and stored in correct order along with the coil pack after disconnection. All 4 spark plugs are removed with the correct spark plug socket, checked for condition and stored in correct order. The 10 (13mm) bolts securing the exhaust manifold are removed and then the manifold is carefully pulled away from the rear of the engine, with the tin gasket.



The engine wiring loom is then disconnected completely from the Camshaft and crankshaft sensors, injectors, knock sensor, coolant temperature sensor, fuel rail pressure sensor and all other harness points.

The fuel rail is removed (2x 10mm bolts) from the inlet manifold and all four "O" rings are gently prised out of the seats, with injectors and fuel pressure regulator still attached.



The inlet manifold is removed (10x 10mm bolts) and all rubber gaskets are checked for wear. The throttle body is part of the inlet manifold. The Positive Crankcase Ventilation (PCV) system is then exposed and removed (4x 8mm bolts). The thermostat housing is also removed (4x 8mm bolts) along with the knock sensor.

Timing Belt Removal

To gain access to the top section of the timing belt cover, the 4 water pump pulley bolts (10mm) are removed, as well as the pulley itself. The top timing belt cover is then removed. This in turn exposes the right-hand engine mounting which is taken off. The crankshaft pulley is secured by a single 18mm bolt which is torqued to over 100Nm. Extra care is taken when removing this as the engine stand is on wheels and can potentially turn or fall over when force is applied to the power bar. The lower part of the timing cover can now be removed.

The timing belt, routed around the camshafts, crankshaft, water pump and tensioner is now fully exposed. The tensioner bolt (13mm) is slackened and the tension is released from the belt. The belt is detached, and the water pump bolts are slackened off before removing the pump completely with its gasket. The tensioner is taken off to leave just the camshaft pulleys and crankshaft remaining.

Conclusion

Today's session went very well. The engine is fully prepared to be split in half. All components were stored away carefully, and any bolts have been numbered and labelled to correspond with their locations. Parts were inspected during strip down for wear and damage.

PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Workshop Practical

Engine Strip and Rebuild

Session 3

30/01/2018

Instructor: Barry John

Session Aims:

- Remove cylinder head
- Remove pistons and crankshaft

Tools used

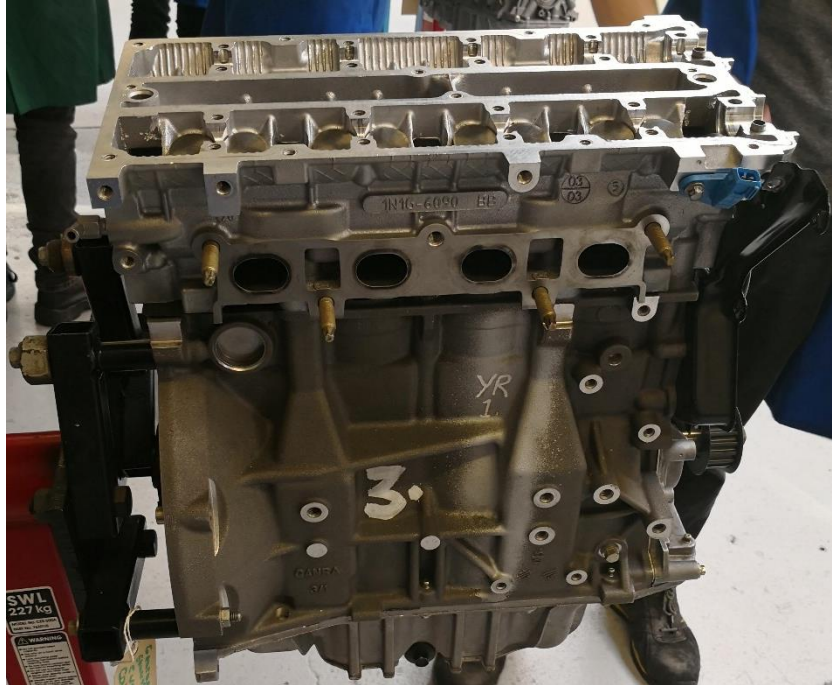
- Various spanners
- 1/4, 3/8 and 1/2 inch drive sockets, ratchets and various length extension bars
- 1/2 Inch power bar
- Selection of screwdrivers
- Extensive bit set
- Pliers & Mole Grips
- Rubber Mallet
- Magnet

Cylinder Head

First the camshaft cover is taken off (8mm bolts) to expose the valvetrain. The cam carrier cap bolts are slackened carefully to release the clamping force on the exhaust and inlet cams. The cams are then removed completely.



A magnet is used to raise the hydraulic lifters out of their wells in the cylinder head. The correct order is recorded to ensure each lifter is returned to its former position when rebuilt. Each lifter is shimmed to a different thickness so failing to fit them correctly can potentially cause clearance issues. The camshaft position sensor is removed from the side of the cylinder head to avoid damage.



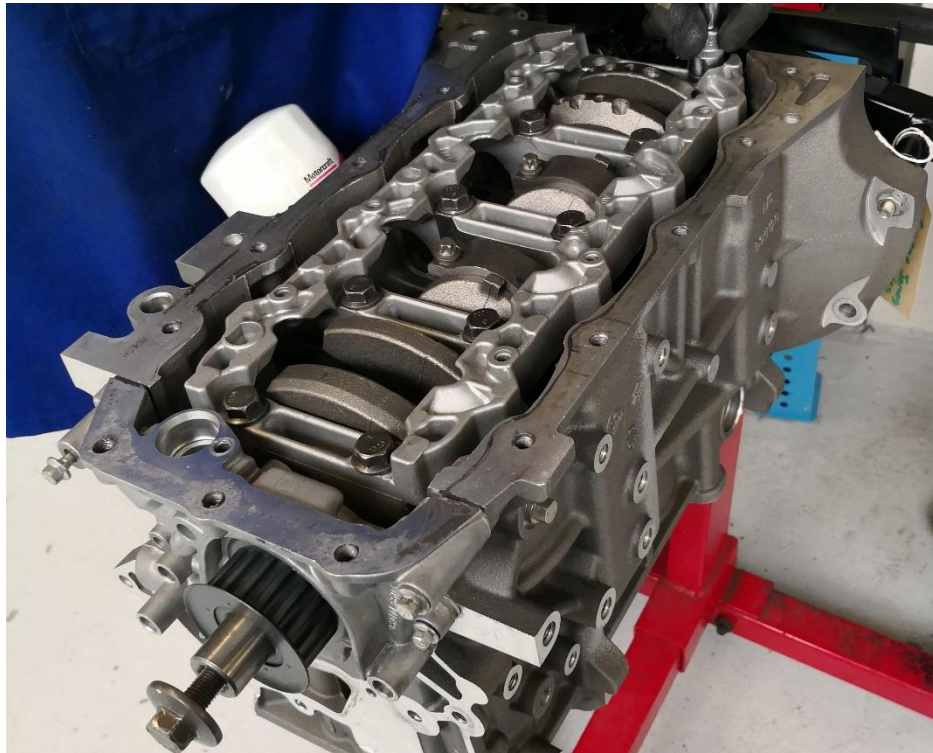
There is a total of 10 head bolts, of head size TRX55. These are slackened and taken out leaving the cylinder head resting on the block. Two people are required to safely lift the head and place it carefully onto the bench. The head gasket is then taken off the block.

Removing Pistons and Crankshaft

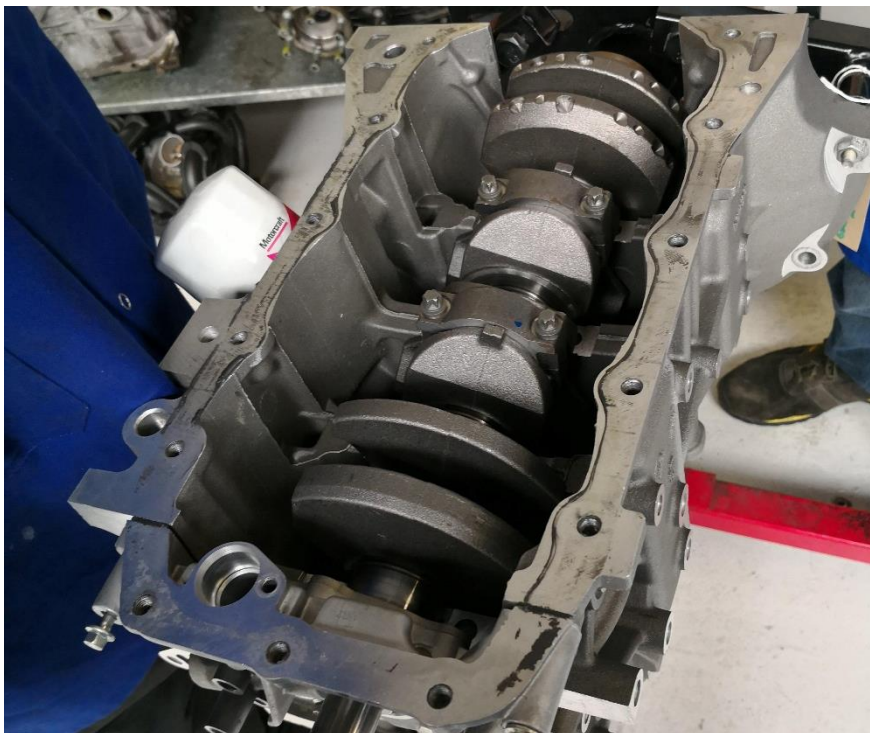
The cylinder block is turned 180° on the stand and the sump bolts are taken out (10mm) The sump is lifted off to reveal the baffle plate and oil pick up pipe. These are taken off to expose the crankshaft.



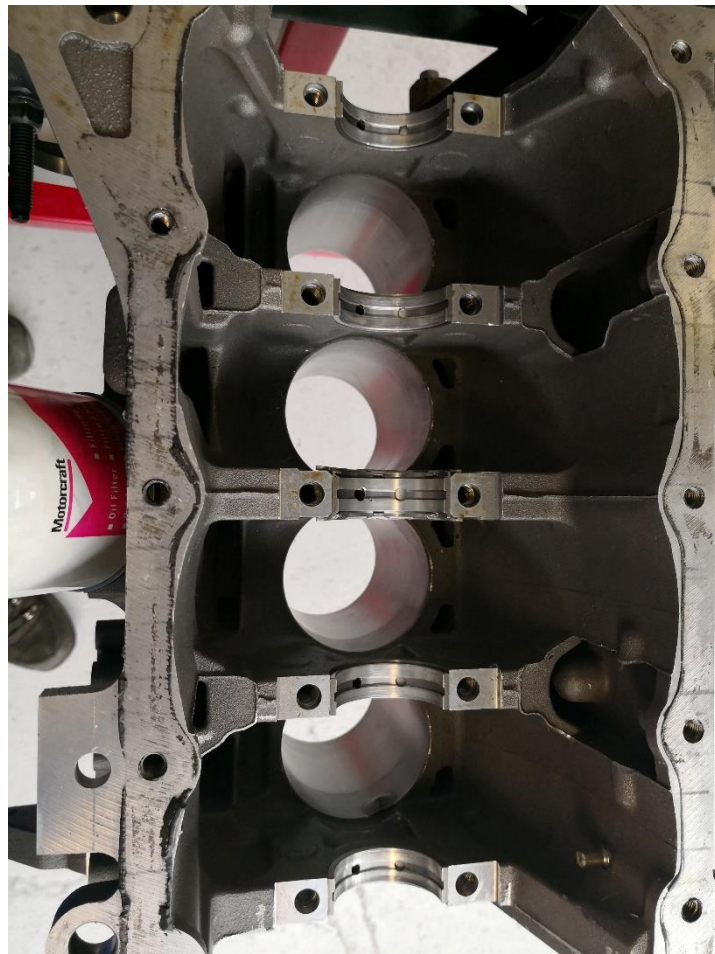
The crank bracket and main bearing bolts are taken off to gain access to the big end cap bolts.



These are removed in turn (E10 bolts) and then the pistons are guided out of each cylinder through the top of the block along with the connecting rods.



The oil pump is taken off the side of the block and the crankshaft is then removed completely and placed onto the bench.



Conclusion

This session was successful. The cylinder head was removed correctly, with no implications. All components were stored away carefully, and any bolts have been numbered and labelled to correspond with their locations. Parts were inspected during strip down for wear and damage.

PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Workshop Practical

Engine Strip and Rebuild

Session 4

06/02/2018

Instructor: Barry John

Session Aims:

- Measure various internal components
- Remove and replace valves

Tools used

- Micrometer
- Vernier Calliper
- Valve Spring Compressor
- Magnetic Tipped Screwdriver

Measuring

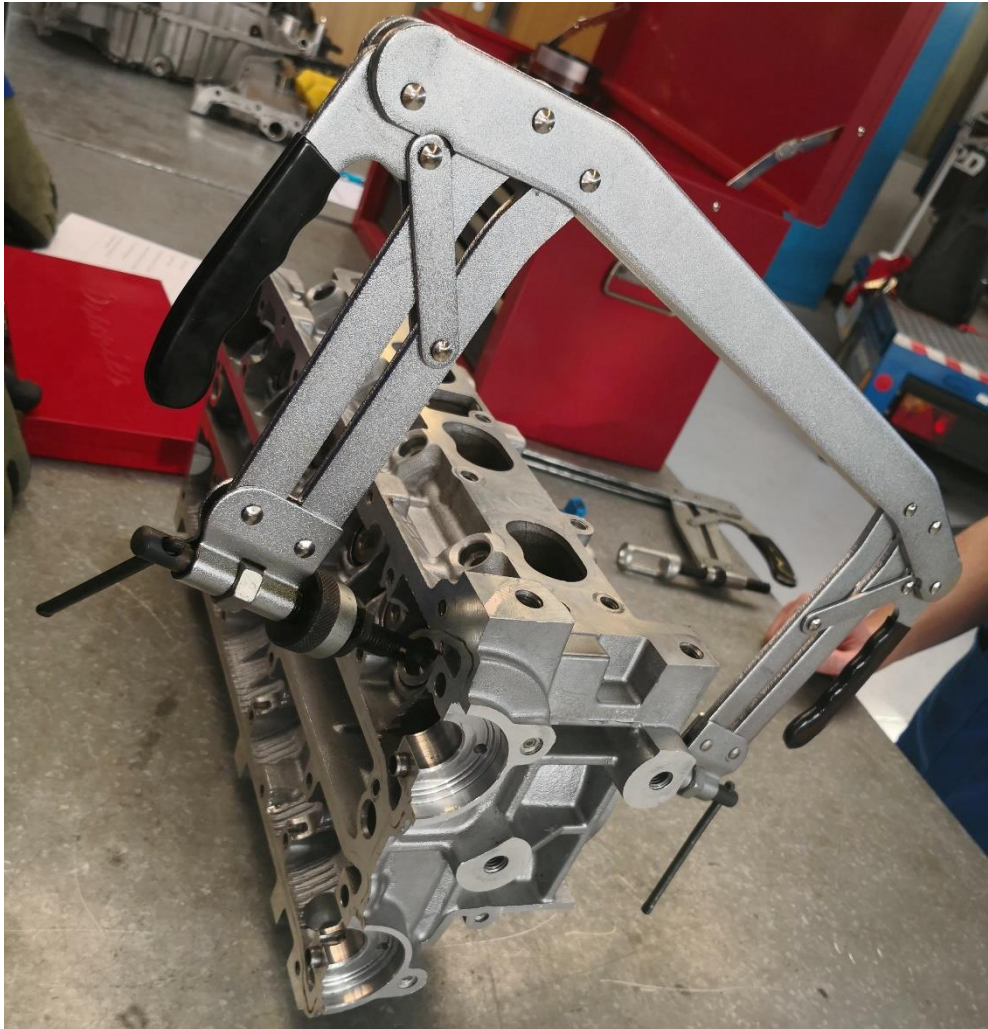
A Vernier calliper is used to measure the piston crown and skirt diameters, Big end shell bearings, main bearings, stroke length and bore size. Results are recorded and compared with manufacturers specifications, then confirmed to be within tolerances.



The stroke length and bore calculations give a total of 1624cc.

Replacing Valves

The cylinder head is turned on its side and the valve spring compressor is used. The valve collets are removed, and the compressor is slowly released. The valve is then taken out and inspected before refitting.



Conclusion

Today's session required precision and consistency. Every measurement was taken twice before recording and the shell bearings were measured across three different parts for consistency. The valve collets can take quite a long time to remove and refit but having prior experience of this task helped. All components were stored away carefully after measuring. Parts were inspected during strip down for wear and damage.

PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Workshop Practical

Engine Strip and Rebuild

Session 5

13/02/2018

Instructor: Barry John

Session Aims:

- Refit pistons
- Refit crankshaft
- Refit Cylinder Head

Tools used

- Various spanners
- 1/4, 3/8 and 1/2 inch drive sockets, ratchets and various length extension bars
- 1/2 Inch power bar
- Selection of screwdrivers
- Extensive bit set
- Pliers & Mole Grips
- Rubber Mallet
- Piston Ring Compressor
- 1/2 Inch Torque Wrench

Block Rebuild

To rebuild the engine correctly, the crankshaft is installed first with the engine upside down on the engine stand. the main bearings and crank bracket assembly is fitted, with a generous amount of assembly lubricant applied to all shell bearings and journals. The main bearing bolts are torqued to 49Nm + 90 deg + 90 deg. This three-stage process is broken down into single stages where all bolts are tightened to 49Nm, before the other two stages are completed in turn.

The crankshaft is then turned through 360 degrees to check for any signs of resistances which may indicate fouling parts or incorrect fitting techniques.

The engine is turned on its side on the engine stand. This is to reduce the risk of the pistons and connecting rods from falling out under installation. It also provides an appropriate position to work at the top and bottom of the block simultaneously. The piston ring compressor sleeve is placed over the piston and clamped tightly, both compression rings and the oil scraper ring are now fully compressed.



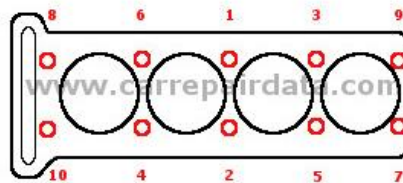
The connecting rod is guided into the bore and the piston is checked for correct orientation and location, before being aligned to the cylinder wall. A firm, but careful tap is given to the piston crown with a rubber mallet to transfer the piston from the compressor into the cylinder. Once inside the bore, it is pushed further towards bottom dead centre, where it is guided into the path of the crank pin journal, then it is connected to the crankshaft through the big end bearing cap, also generously coated in assembly lubricant, and torqued to 29Nm + 90 deg.

This process is repeated until all 4 pistons are installed and the crankshaft is then turned through 360 degrees to check for any signs of resistances which may indicate fouling parts or incorrect fitting techniques.

The sump baffle plate, and oil pick up system is then fitted to the block, followed by the oil sump.

Cylinder Head Refit

The engine is then turned through 180 degrees so that it is upright again. The head gasket is carefully placed onto the block with the correct orientation, ensuring all oil galleries and coolant jackets are appropriately exposed, and nothing is blocked by the incorrect fitment of the gasket. The dowel pins inside the engine block are used to retain the head gasket whilst the cylinder head is carefully lowered until fully seated over the dowels. Two people are required to complete this process safely. The head bolts are then guided through the cylinder head and screwed by hand into the block until flush with their seats. The tightening sequence and torque specific to the engine is observed and followed.



Cylinder head tightening torque 1	15Nm
Cylinder head tightening torque 2	30Nm
Cylinder head tightening torque 3	90°

Conclusion

Today's session was successful. All objectives were completed efficiently. The engine was turned over at various stages to confirm the assembly was correct throughout, which in turn sped the whole process up. If the engine wasn't turned over until fully rebuilt, and it was found to have resistance, it may cost a lot of time to work backwards to find the solution. Regular operational checks reduce the risk of incorrect assembling. Tightening procedures were followed and a methodical approach to each task was implemented.

PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Workshop Practical

Engine Strip and Rebuild

Session 5

20/02/2018

Instructor: Barry John

Session Aims:

- Install Camshafts
- Fit Timing Belt & Associated Components
- Refit Ancillaries

Tools used

- Various spanners
- 1/4, 3/8 and 1/2 inch drive sockets, ratchets and various length extension bars
- 1/2 Inch power bar
- 16mm spark plug socket
- Selection of screwdrivers
- Extensive bit set
- Pliers & Mole Grips
- Rubber Mallet
- 1/2 Inch Torque Wrench
- Ford Duratec Crankshaft Locking Pin
- Ford Duratec Camshaft Locking Bar

Install Camshafts

Prior to the fitment of the camshafts it is critical that the hydraulic lifters are installed into the correct wells. Each lifter is positioned, following the correct order in which they were stored. assembly lubricant is applied during installation as the lifters have a common tendency to stick in one place on initial engine firing, which can cause temporary poor running until enough oil fills them to operate correctly.

The camshafts are then placed into the cylinder head with assembly lubricant applied to the shell bearings. Care is taken to install the correct camshaft to both inlet and exhaust. The camshafts are both positioned so they fall just “off lobe” between cylinders. This reduces resistances when tightening. As the camshafts are both hollow, and brittle, there is a high risk of fracture under improper loading. The camshaft bearing cap bolts are then torqued to 16Nm, starting from the centre and working outwards. Further assembly lubricant is applied to all camshaft lobes. Both camshafts are then carefully turned until the locking bar can be installed to the rear of the cams. Then the camshaft position sensor is fixed into position.

Timing Belt Installation

With both camshafts in place, the camshaft pulley bolts must now be slackened to allow for correct valve timing. Using a 24mm Spanner on the square section of each cam to hold them in position, a 13mm socket can be used to slacken the bolts. This enables the cam pulleys to spin independent to the camshafts.

The Duratec engines use a “Floating crankshaft” format, where there is no woodruff key to locate the crankshaft pulley. This means that without the crankshaft bolt being fully tight, the crank will move independently to components connected through the timing belt, causing piston to valve interference and the water pump being inoperative.

To overcome this issue a locking pin is inserted into the engine block and the crankshaft is turned, with a screwdriver down the spark plug port in cylinder 1. The screwdriver is observed until the piston extends towards top dead centre, where the counterweight on the crankshaft then rests against the locking pin. This results in the crankshaft locking. The timing belt is now installed through the correct routing and the tensioner is then adjusted until correct belt tension is applied.

The camshaft pulley bolts are tightened (whilst holding each cam in place with the spanner) and the crankshaft pulley bolt is tightened. In real world scenarios the crankshaft bolt would be replaced on this engine as it is classed as a “Stretch Bolt” and if the original is refitted it may come lose.

The timing pin and bar is then removed, and the engine is turned over through two complete revolutions. This is due to the camshafts turning at half the speed of the crankshaft.

With one full engine revolution, the timing pin and bar are reinstalled to check for the correct crankshaft to camshaft relationship.

All bolts are checked for tightness and the belt tension is checked once more. The timing belt covers, water pump pulley and left-hand engine mounting are then fitted and tightened.

Refit Ancillaries

With the engine timed correctly, the thermostat housing, PCV system, inlet manifold and fuel injector rail is then installed in order. The spark plugs are fitted into each cylinder and tightened with the HT leads connecting into them and the coil pack. The exhaust manifold and gasket are installed, and the cam cover is fixed into place. The wiring harness is connected back up into all the relevant sensors and checked for security.



Conclusion

Today's session went well. I am already familiar with the timing procedure on Ford Duratec engine variants, so the process was relatively straight forward for me. Every process was double checked before advancing to the next step which significantly reduced any risk of incorrect procedure. The importance of the storage system I used throughout this task made the process much less complicated. Every component was systematically stored away with corresponding bolts grouped together. There was little confusion over the location of each bolt because of this. As the components were installed weeks after initial removal, the importance of the organisation was highlighted. The engine was checked for smooth operation after the rebuild was completed and was successful.

PPE was worn at all times and no issues were found. All tools were put away in the correct places. And hands were washed thoroughly with restore cream applied once dried.

Personal Development Plan

This module has provided an introduction to new machine operations, as well as essential practice in fundamental engineering skills.

A key skill required by engineers is accurate measurement across various planes using a range of digital and manual devices. Having already used a Vernier caliper and micrometer previously, my understanding of the operation and reading methods for each device was extremely useful. Although I am relatively confident with using them, I did make minor errors. This has exaggerated the importance of confirming correct values, achieved by repeating the measuring process more than once.

As well as using familiar measuring methods, there were occasions where I had to operate new devices, such as digital height gauges and the DRO systems incorporated into the milling machine and lathe. Following some initial training in the various functions and capabilities of the devices, plenty of practice using each has improved my confidence.

I will ensure I check all measurements in future, before proceeding to the next process. Further measuring practice will be carried out in extra curricular activities such as Team MCR, for measuring suspension geometry. Future assignments and roles in an engineering job will also depend heavily on this ability.

Having used the lathe and milling machines for the first time during this module, there was a lot to understand regarding the operations involved. Health and safety implications are prominent whilst using machinery, so understanding the risks involved and how to avoid any accidents is the most important factor. The repetitive nature of these machines aids in understanding how they work. For any designs that require manufacturing, a lathe and milling machine are highly likely to be used. Again, projects within Team MCR may require the use of these machines, as well as other projects, assignments and work during my engineering career.

I have extensive experience in the maintenance and repair of road cars, and a large skill set in the tools and methods involved with engine rebuilds. I found the engine task relatively straight forward and my knowledge was transferred to others to help with their understanding. Having the ability to explain processes to people concisely can also be considered as a skill in engineering and is something I regularly practice in my current part time work.

Going forward, I feel I have much to learn within manufacturing processes. I would like to improve my basic lathe and milling machine skills to a good standard through practice. When designing a component, it is easy to overlook the manufacturing processes involved in replicating the design, so having a good understanding of both design and manufacturing methods is equally important for an engineer. I would also like to explore Computer Aided Manufacturing (CAM) further, by taking a CAD file and following the process through to the end product as this is something I have not yet achieved, and I feel will be a vital part of any engineering career.