# Instruction Sheet - MCHE 365 \& I-Tech 344 Lathe \& Mill Machining Operations Hydraulic Piston Pencil Organizer Project 

Last Rev SPRING 2021

- Always flip to $1^{\text {st }}$ page \& leave your drawings \& instructions on your Machine at end of
class. Do NOT Remove them from the machine. See videos on www.manualmachining.com

1. IMPORTANT NOTES: Notify the Instructor if you find discrepancies between the Instructions and the Drawings
2. Always chuck any part as far in the chuck as possible before beginning any machining or drilling operation.
3. Add approximately $1 / 2$ " extra space for overhang pass the chuck jaws to the distance the part will have to be turned.
4. If performing a drilling operation, allow only a short amount of overhang, approximately $1 / 2$ " to ensure that the hole will be drilled dead center.
5. When cutting a diameter, too much overhang can also result in push off of the part away from the cutting tool when the cutting tool applies pressure to the part. This can cause chattering of the cutting tool (a loud noise can be heard). This action will result in the part being cut oversize and will give it a checkered appearance. It can also cause the insert to fracture.
6. Make certain that your cutting tool has been fastened securely with the tool post handle. Nothing should be loose during any machining operation.
7. When placing a part in chuck, tighten it with a chuck key very tight.
8. Never take your hand off of it while the chuck key is in the chuck. This is to prevent the chuck key from being thrown when the lathe is started, striking you and causing serious injury.
9. Do not use the Red Emergency Stop on the starting switch to stop the machine after each machining operation. This can wear out the clutch prematurely. Use the Neutral position instead. Use the Red Emergency Stop only in case of an emergency that requires the machine to be stopped immediately or to oscillate the chuck when you change gears.
10. Always change gears only when the machine is at a full stop.
11. Before turning the power on to the machine, make sure the start switch is in Neutral Position and not in the Red Zone (Emergency Stop).
12. When drilling a part, always use a small amount of oil to reduce friction and heat and to keep the drills sharp.
13. Never Drag Insert across part over a long distance when Lathe is stopped. This may cause the insert to fracture and produce a very rough cut if it cuts at all.
14. Before removing the part from the chuck jaws, always chamfer immediately after machining a diameter to maintain concentricity of the chamfer to the diameter. If for any reason you must remove the part from the chuck before finishing, you should first mark a cross line on the part adjacent to jaw \#1 to realign the part later.
15. Refer to the Drawing for machining Details. The measurements on the individual drawings take precedence over the instructions detail measurements if there is a discrepancy. Notify your instructor if one is found. Always mark Progress Chart after each total completion of a machined part.

## LATHE - Facing the Hydraulic Piston Blank

16. Stock needed for machining the Cylinder is one piece of 4" O.D. $\times 21 / 2 "$ long aluminum round rough stock.
17. FACING OFF A PART 1st End -
18. Place part in 3-jaw chuck leaving only 1.375 " of part to overhang jaws.
19. With machine stopped, make the following adjustments on the lathe:
20. Set Chuck RPM's to 654.
21. Set the ABC Knob and the Quick-Change Tumbler \#'s 1 through 8, to achieve a Surface Speed of .0036" per revolution of the chuck.
22. Set Chuck RPM's to 654 and oscillate chuck to red and back to neutral.
23. Place the reverse lever in the down position for cross feeding.
24. Start lathe \& with 3-jaw chuck spinning (to prevent over cutting this part because it is large \& wobbles a lot), very lightly touch the 35-degree cutting tool moving left on the outer end of the part about $3 / 16$ " with the point of the insert. Set the red needle only on the outer dial of the Travel Dial to 0 . Travel Dial tracks tool movement from right to left.
25. Set the cutting tool to take a facing cut by first rotating the Cross-Feed Dial counterclockwise to move the cutting tool toward the operator. Then move the cutting tool to the left $\mathbf{. 0 2 0}$ " with the Carriage Handwheel. Never cut more than .020 " on a facing cut in a single pass so as not to break the insert on this operation (it can be less).
26. You may have to take several repetitive cuts to clean off all saw marks from the end. Do not re-zero.
27. When you are ready to begin machining, pull the feed control lever to the right \& down to begin facing off the part. Put light left pressure on the carriage hand wheel with left hand to remove backlash \& keep carriage from moving right when making facing cuts. The Travel Dial Red Needle should not move.
28. Start by facing off on one end just enough to remove all saw marks. Several cuts may be necessary. After the last cut is made on the face, pull the cutting tool to the right instead of straight back.
29. Upon completion of the Facing operation \& filing on the first end, remove part; flip end-to-end \& rechuck.
30. Face Off the opposite end until all saw marks are removed at .020 max depth of cut at a time with a 35degree cutting tool.
31. Next, measure part while still in chuck with a caliper. Do not remove part. Continue facing off . 020 " at a time until part measures the proper length of 2.375 " as shown in the drawing. There is a tolerance of plus or minus . 010 "

## 32. DRILLING A CENTER HOLE IN THE CYLINDER -

33. AT 654 RPM'S, Centerdrill a short-tapered hole $3 / 4$ the length of the taper of the Centerdrill.
34. Next, at 351 RPM'S, using the $37 / 64$ drill bit thru part at about $3 / 4$ " at a time, backup, continue drilling.
35. Reaming with the $5 / 8$ " Reamer. Add oil in the hole to avoid clogging or galling. At 351 RPM'S, using a $5 / 8$ " Reamer for accuracy, ream the part halfway thru, back out and stop machine. Add oil a second time in the hole and start machine \& feed the reamer all of the way thru past the part. Feed the reamer in slowly with the Tailstock Handwheel to produce a smooth cut and back out slowly. Stop \& pull out reamer if it gets very tight to avoid breaking the reamer. Reamer will clog or gall if not enough oil is
used. Be generous with the oil. Be sure to look for reamer exiting the hole on the left side of part. Reamer must go all the way through.
36. Chamfer hole on back side slightly with gold colored hole chamfering tool (see instructor if needed) with chamfer visually appearing to be at about a $1 / 16$ " in width. Very little chamfer is need to remove burrs
37. Remove the part from the three-jaw chuck.

## 38. CUTTING THE DIAMETER OF THE PISTON -

39. Locate a $5 / 8$ " Mandrel and place in vise vertically. Slide a 1.0 " long aluminum spacer first, then the 4 " O.D. Cylinder part, just machined and a metal washer and nut in this exact order. Be sure to tighten nut with an adjustable wrench tight in the vise.
40. At the Lathe, set Chuck speed to 654 RPM's. Chuck on round steel portion of mandrel only.
41. Insert a Live Center from the lathe cutting tools cabinet in the Tailstock of the lathe and lock in place. Tailstock Spindle should first be positioned at $1 / 2 "$ on the graduated scale.
42. Continue using the 35 -degree lathe-cutting tool.
43. Move 35-degree tool in position $1 / 16$ " past right end of part.
44. Slide Tailstock in position by proceeding in this order:
45. Slide Tailstock until the base of it touches the carriage.
46. Rotate the Tailstock circular handwheel until the Live Center lightly touches the mandrel.
47. Rotate circular handwheel on Tailstock clockwise to the right until the Knob reaches the one o'clock positions.
48. Tighten straight lever on tailstock to prevent tailstock from moving.
49. Lightly with thumb \& index finger tips slowly \& very lightly tighten the circular Tailstock handwheel. The knob of the Tailstock handwheel should be positioned between 1 and 5 o'clock. Do Not Over Tighten. It can cause damage to the Chuck Bearing.
50. Touch the end of the part with the 35-degree cutting tool and zero out both needles on the travel dial.
51. Move the cutting tool toward the operator and to the left $\mathbf{2 . 4 2 5}$ " and ZERO the travel dial a second time to mark the End Position that the Distance the O.S. diameter will be cut. The cutting tool will move passed the left end of the part by about .050 ".
52. Next, first move the cutting tool even with the right end of the part \& then move left $3 / 16$ " from the end. Lightly touch the diameter of the part by turning the Cross-Feed Handle clockwise. Loosen the small locking knob on the Cross-Feed Handle. Hold the Cross-Feed Handle with left hand and reposition graduated scale with right hand until it is zeroed out. Do not permit the Cross-Feed Handle to move or rotate during this process so that the cutting tool remains in position on the outer diameter of the part. The tool should NEVER touch at the corner of the part. Move cutting tool about $1 / 16$ " past the right of the part to clear it.
53. Position the reversing lever in the upward position in the top hole. Set the Lathe Start Switch to on. The chuck should begin rotating. Carefully position the Feed Control Lever to the left and Up to begin cutting the diameter of the part. The cutting tool should begin moving to the left. When the cutting tool reaches the end of the part and the travel dial is within one revolution before zero, move the Feed Control Lever Down to the Neutral or Center Position to stop the movement of the cutting tool. Slowly, at first, manually rotate the Carriage Handwheel Clockwise to the right to return the cutting tool to the right end of the part. Be careful to move right \& AWAY from the chuck.
54. You will only make one cut of $.025^{\prime \prime}$ if the diameter appears to have been cut around the entire part. Only make a second cut if needed \& to a lesser amount. The diameter will be approximately 3.980 " as shown in the drawing. This diameter is not critical. Only after the final cut is made should you move the cutting tool toward the operator or away from the part in a counterclockwise direction. Do not allow cutting tool to touch diameter when moving back to the right to avoid making unwanted spiral cuts on the part when making the one \& only final cut. Make sure the diameter has been cut completely around the part.

## 55. File the $\mathbf{1}^{\text {st }}$ Outer Corners of the Piston -

56. See the Instructor if help is needed to file the outer corner edges of the Piston at 256 rpm 's.
57. Do not remove part from $5 / 8$ " Mandrel if you are going to proceed with the next step of grooving the piston. Do NOT place mandrel in your locker when finished. Other students will need them.
58. Orientation - TOP End of Piston Face: CUTTING TWO GROOVES IN THE DIAMETER OF THE CYLINDER -
59. A $5 / 8$ " Mandrel should already be in place in the 3-jaw chuck in Lathe along with the 1.0 " long aluminum spacer, then the 4" O.D. Cylinder part, just machined and a metal washer and nut in this exact order. The nut should already be tightened with an adjustable wrench from the previous step.
60. A Groove lathe-cutting tool should be locked on the tool post. The insert should be a .125 " width.
61. Set Chuck speed to $\mathbf{2 5 6}$ RPM's. The Live Center should also be supporting the part.
62. Touch the face of the part with the Groove cutting tool and zero out both needles on the Travel Dial.
63. Move the cutting tool back toward the operator with the Cross-Feed Handle and to the left .225" (shown on drawing) as shown on the Travel Dial.
64. Next, lightly touch the diameter of the part with the Groove Tool by turning the Cross-Feed Handle clockwise. Loosen the small locking knob on the Cross-Feed Handle. Hold the Cross-Feed Handle with left hand and reposition graduated scale with right hand until it is zeroed out on the Standard $.001 "$ scale (not the metric scale). Do not permit the Cross-Feed Handle to move or rotate during this process so that the cutting tool remains in position on the outer diameter of the part. The tool should NEVER touch at the corner at the end of the part.
65. Turn on the Lathe $\&$ begin cutting the two grooves that will be done by manually turning the CrossFeed Handle clockwise until the Groove Tool has reached a depth of $\mathbf{. 1 8 0}$ on the Cross-Feed Handle. Do not use the auto feed operation.
66. Once complete, REMOVE THE PART, place mandrel in vise and remove it from the part. Never place the mandrel in your locker. The mandrel will be needed by other students in the next lab class.
Orientation - TOP End of Piston Face: Counterboring: Warning: Proper Depth is Critical
Set Chuck speed to 179 RPM's. Place an Endmill with a $15 / 16$ or 1.0: OD \& lock it in by shoving it hard into the Tailstock Spindle. Turn the Tailstock Round Handle until the spindle shows 1.0 ". Slide the Tailstock forward toward the chuck until the Endmill touches the face of the part \& turn the locking handle or lever to lock the Tailstock in position. Start the Lathe and drill to a depth of $\mathbf{. 2 0 0 "}$ deep as shown on the Tailstock Spindle or slightly less than the $1 / 4$ " mark or $4^{\text {th }}$ line on the $1 / 16^{"}$ scale. This would amount to about $31 / 2$ lines on the tailstock spindle graduated scale.
67. Return the endmill and get a $13 / 8$ " endmill and repeat the previous cut to the same depth as before.
68. Repeat drilling the counterbore larger with a $17 / 8^{\prime \prime}$ endmill to the same depth of .200 ".
69. Return the $17 / 8^{\prime \prime}$ endmill.
70. BORING THE HOLE LARGER with a Boring Bar -
71. See the Instructor on how to bore the hole to $\mathbf{2 . 0 0 5 "}$ OD to a depth of $\mathbf{. 2 0 0 \prime}$. Set RPM's to $\mathbf{3 5 1}$ RPM's. Maximum cut is $.025^{\prime \prime}$ with the larger boring bar. .130 divided by .025 per cut $=$ about 5 cuts approximately.
72. CHAMFER PART -
73. With RPM's at 351 RPM's, chamfer OD corner edge with the Boring Bar . 065 . See Instructor
74. Once Complete:
75. Change Orientation - BOTTOM End of Piston Face: Counterboring - See Instructor
76. Place part in Chuck with a $\mathbf{1 . 0}$ " overhang. Set Chuck speed to $\mathbf{1 7 9}$ RPM's. Place an Endmill with a $\mathbf{1 5 / 1 6}$ or $\mathbf{1 . 0}$ " OD \& lock it in by shoving it hard into the Tailstock Spindle. Turn the Tailstock Round Handle until the spindle shows 1.0 ". Slide the Tailstock forward toward the chuck until the Endmill touches the face of the part \& turn the locking handle or lever to lock the Tailstock in position.
77. Start the Lathe and drill to a depth of $\mathbf{1 . 0}$ " deep as shown on the Tailstock Spindle.
78. Return the endmill and get a $\mathbf{1 3 / 8}$ " endmill \& repeat the previous cut to the same depth as before.
79. Return the endmill and get a $17 / \mathbf{8}^{\prime \prime}$ endmill \& repeat the previous cut to the same depth as before.
80. Return the $17 / 8^{\prime \prime}$ endmill.
81. BORING THE HOLE LARGER with a Boring Bar - O.D. is 2.975"
82. See the Instructor on how to bore the hole to $2.975^{\prime \prime}$ OD to a depth of 1.0 ". Set RPM's to 351 RPM's. Maximum cut is $.025^{\prime \prime}$. Make 40 cuts of $.025^{\prime \prime}$. Use caliper to measure after this to cut proper diameter.
83. CHAMFER PART - before removing from 3 jaw chuck
84. With RPM's at $\mathbf{3 5 1}$ RPM's, chamfer OD corner edge with the Boring Bar . 075.

## LATHE - Drilling \& Turning the Base \& Rounding

85. Turning the Diameter - Place the Base in a Mandrel with a larger aluminum spacer.
86. With machine stopped, set chuck RPM's to 654 with a Surface Speed of .0036 ". Place the reverse lever in the up position \& slide the power feed level to the right for cutting a diameter.
87. "You Must See the Instructor before Proceeding to avoid damage to part \& tooling".

Extra notes if needed: You will only make one cut of .025 ". The diameter will be approximately 3.980 " as shown in the drawing. This diameter is not critical. Remember to leave .015 to .018 of material for the final cut on the diameter. When making additional cuts on the diameter, always turn the Cross-Feed Dial Clockwise only to insure accuracy. This means the cutting tool moves only forward and never backwards until the final cut to eliminate backlash in the gears. Only after the final cut is made should you move the cutting tool toward the operator or away from the part in a counterclockwise direction.

## Milling Machine Operations - Milling 8 Top Cylinder Holes

88. Place the previously machined top cylinder in the index head with the Bevel Side Up. You may need to use a rag to clean off any metal shavings to ensure that the part will be flat against the surface of the index head. Use the palm of your hand to put pressure on the part while using the chuck key to lock the cylinder in place. Note that, since space is limited, you should not use parallels.

## 89. CENTERDRILLING-

90. Remove the edge finder and place the Centerdrill into position. Be sure that the tool will not fall out by following the instructions listed in the "edge finding" section.
91. Since you will be drilling your holes a specified distance from the center, shown in your drawing, unlock the x -axis and use move the table until the digital readout shows $\mathbf{1 . 5 0 0}$. Lock the x -axis before drilling.
92. With the high/low lever on "hi," turn the machine on and adjust the speed to $\mathbf{8 0 0}$ RPM's.
93. Before drilling, be sure that the graduated cylinder on the index head is set to 0 . Using the quill feed handle, steadily begin drilling into the part until the Centerdrill is approximately $2 / 3$ of the length of the taper of the Centerdrill. Before bringing the tool up to drill the other five holes, set your stop using the quill lock and micrometer stop collars so that every hole will be a uniform depth.
94. Bring the Centerdrill up using the quill feed handle and rotate the index head $\mathbf{4 5}^{\circ}$. You do not need to turn the machine off between drilling each hole as long as you are cautious and comfortable while rotating the index head. Drill until you reach the stop and repeat with the remaining holes.

## 95. DRILLING THE HOLES ON THE TOP SURFACE-

96. Place the drill chuck into position and locate the $1 / 2$ " drill bit. Loosen the chuck by hand and insert the drill bit all the way up into the chuck. Tighten by hand then use the chuck key to lock the bit in place. You may use a rag with both hands on the chuck key to fully tighten the chuck. If the drill bit is not tightly locked in place, it may spin loosely inside of the chuck and get stuck in your part. It may also wobble wildly while drilling if not properly centered inside of the drill chuck.
97. Because space is limited, make sure that you use the elevation handle to lower the mill table as much as possible before setting your micrometer stop collar. Now, use the quill feed handle to lower the tool until the drill bit point is even with the top surface of the part, with right hand still applying a bit of pressure on the quill feed handle, tighten the quill lock with your left hand. Bring the micrometer stop collar up until both are touching. Tighten further by turning it clockwise with your thumb. Unlock the quill feed handle and raise it completely. Zero the graduated scale on the elevation handle by holding the graduated scale firmly with your left hand and loosening the black knob with the other. Rotate the graduated scale until it reaches zero then tighten the black knob. Use the elevation handle to raise the table to the depth of the hole marked on the drawing. One full rotation of the elevation handle is equivalent to $.100^{\prime \prime}$. In this case, you are drilling to a depth of $\mathbf{1 . 2 5 0 \prime}$. This means that you will need to go $\mathbf{1 2}$ full rotations of the elevation handle plus $\mathbf{. 0 5 0}$ ".
98. With the high/low lever in "Hi", turn the machine on also toward Hi Range and adjust the speed to $\mathbf{5 0 0}$ RPM's or less. Use a paintbrush to apply a small amount of oil to the drill bit then begin drilling. As you are drilling, be sure that you bring the drill bit up a couple of times to clear the metal chips and reapply oil. Otherwise, the chips may compact at the bottom or within the drill bit flutes, which will prevent the drill bit from drilling deeper.
99. Drill completely to the stop then raise the quill feed handle and rotate the index head $\mathbf{4 5}^{\circ}$. Drill the remaining 7 holes.
100. Use the hole-chamfering tool to create a small .015 " chamfer in each of the four holes. The high/low lever should be placed in "lo", the start switch on the machine should be turned to "lo", and the speed
should be adjusted to $\mathbf{1 0 0}$ RPM's. If the machine is instead turn on to high, the tool will spin backward.
101. DRILLING THE BOTTOM PISTON THREADED HOLES FOR A $1 / 4 "$ O.D. CAP BOLT -
102. Centerdrill $\mathbf{2}$ holes $\mathbf{1 8 0}^{\circ}$ apart with a \#7 drill bit to a depth of $\mathbf{1 . 0}$ " at a center distance $\mathbf{o f} \mathbf{1 . 7 3 7}$ ".
103. Using a $1 / 4-\mathbf{2 0}$ Tap, thread the 2 holes to a depth of $\mathbf{8 7 5 "}$ (7/8") by hand, see instructor.
104. DRILLING \& COUNTERBORING THE METAL BASE
105. Centerdrill $\mathbf{2}$ holes $\mathbf{1 8 0}^{\circ}$ apart with a $\mathbf{1 7 / 6 4}$ drill bit through at a center distance of $\mathbf{1 . 7 3 7}$.
106. Counterbore $\mathbf{2}$ holes with a $\mathbf{3 / 8}$ " O.D. Endmill $\mathbf{2 6 0}$ deep in the previously drilled holes for the rounded cap bolt head.
107. MILLIING THE RECESSED PISTON PIN HOLES \& 2 LARGER SIDE HOLES-
108. SEE YOUR INSTRUCTOR for instructions on milling these holes.
109. 

## Final Steps to Completing Your Project - See Instructor

110. See the Instructor before proceeding with the following steps for the proper procedure and materials needed to finish and assemble all of the parts.
111. Wash your hands before proceeding and remove any oil with cloth and triangular file in all holes of Large Cylinder Gear before Bead Blasting all aluminum parts. Oil will clog blasting media. Keep your project clean by wrapping the finished blasted parts with paper towels. Use compressed air to blast away all blasting media out of the holes before assembly. Dirty parts from hand prints can result in a lost of points in the final grading of your project. Do not blast the 3D printed part.
112. Acquire parts needed from the instructor to mount the Piston \& the Metal Base with $1 / 4$ " $\mathrm{x} 3 / 4$ " length Cap Bolt Screws.
113. A nametag will need to be filled out and placed under the wood base before turning in to the instructor.

Extra notes if needed: You will only make one cut of .025 ". The diameter will be approximately 3.980 " as shown in the drawing. This diameter is not critical. Remember to leave .015 to .018 of material for the final cut on the diameter. When making additional cuts on the diameter, always turn the Cross-Feed Dial Clockwise only to insure accuracy. This means the cutting tool moves only forward and never backwards until the final cut to eliminate backlash in the gears. Only after the final cut is made should you move the cutting tool toward the operator or away from the part in a counterclockwise direction.

