How to achieve the best possible results with a Rong Fu Mill-Drill

By
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How It Is

• Novice interested in “hands-on” machine tool work.
• Productivity not a high priority.
• More interested in getting it right the first time.
• Really hate having to remake parts because of avoidable errors... it depletes my motivation.
• Have an “old school” bias... CNC is just more computer programming.
What’s Up?

- Cut steel accurately.
- Put a good finish on steel parts.
- Learn new skills.
- Find or invent machine tool procedures that work for me.
- Don’t break expensive tools.
Today’s Agenda

• Mill Work Table
  – Old table made of angle iron and bolted together.
  – Old table kept giving away and loosing level.
  – This placed variable torque on the mill base and ruined the tramm.
  – The old table was junk.

• Tramming the mill

• DRO error correction

• Work Techniques
New Work Table for the Mill-Drill

• New table made from ½ inch steel plate from Rose Steel.
• Was going to make top 1 inch thick but, thank you all for talking me out of that.
• Gene Rowan did plasma cutting of table top.
• Legs made of 4 inch square mild steel tube from Rose Steel.
• Legs cut to specification by Rose Steel using a band saw.
• Shelf and leg supports made from angle iron.
• ½ inch steel foot pads from Rose Steel cut to size with reciprocating saw.
Work Table

- Design copied from YouTube.
- Table is over engineered and uses all welded construction.
- Legs welded to table top using a stick welder.
- Foot pads welded to table legs using stick welder.
- Angle iron welded to table legs using Mig welder with flux core wire.
- Edges and welds cleaned up with angle grinder.
Large Vernier Caliper

- Holes for bolting down mill-drill laid out with large vernier caliper.
- 24 inches long
- Both Imperial and Metric Scales
Same Large Vernier Caliper

- 1/128 inch precision
- 0.05 mm precision
- Made of aluminum so actual precision very much depends on temperature.
- Mill requires ½ inch bolts.
- Drilled 5/8 inch holes in table.
Leveling the Work Table

- Foot pads drilled and tapped to accept common machine leveling pads.
- Monroe pads.
Yes, the leveling pads work.
Near-Finished Work Table

• Note the four holes for bolting down the mill.
• Table weighs about 350 lbs.
• Table is
  – 24 inches wide
  – 32 inches deep
  – 27 inches tall (+ pads)
• Mill weighs about 650 lbs.
Lubricating the Mill-Drill

- X axis lead screw is easy to get to and lubricate.
- It is exposed on the underside of the T-slot work table.
Lubricating the Mill-Drill

• Back half of Y axis lead screw easily accessed by removing swarf shield.
• The front part of the Y axis lead screw is completely concealed by the mill base. There is no access to it.
Lubricating the Mill-Drill

- Used an acetylene torch cut a hole in the Work Table.
- This allows application of way oil to front part of Y axis lead screw.
Lifting the Mill-Drill

- Lifting accomplished with 2 ton engine hoist from Northern Tool.
- Had to make a special lifting jig to fit the Rong Fu Mill-Drill.
The Lifting Jig

• Top view
• From top to bottom:
  – Balance bar
  – 1.8 inch channel
  – ½ inch all thread
  – ½ * 3 mild steel
  – 5/8 inch all thread
  – ½ * 3 mild steel
The Lifting Jig

• Bottom View
• Lower plate sandwiched under mill column and above mill base.
The Lifting Jig

• Closer view of middle of jig.
• Note the heavy jaws.
• Cut to fit around the central column of the mill.
• Slot in top jaw fits around rack on column for raising mill head.
• Welding done with a stick welder.
Suspense!

- Mill-Drill is hanging from the engine hoist.
- Old table has been removed
- In the process of shoving the new table under the mill.
- The welds in the jig are holding!!!!
Too lazy or too ambitious?

- Mill was lifted and positioned with all attachments in place:
  - Milling Vise
  - DRO
  - Power Feed
Shelf and Cookie Sheets

- Shelf under table made of ¾ in. plywood cut and lacquered.
- Two steel cookie sheets hold commonly used tools and keep them from rolling off the shelf.
Lubricant Caddy

• I keep all my lubricants in a portable caddy.
• Here the caddy is in place for use with the mill-drill.
Tramming

- With the lifting jig and engine hoist in place, I had an opportunity to install new tramm rods between mill column and base. Lifted the mill again without the base.
- Rods made of O-1 tool steel (left annealed).
- 5/8 diameter.
- Nuts are L9 alloy cadmium plated and waxed.
- Lower threads are 5/8-11 tpi to fit the mill base.
- Upper threads are 5/8-18 tpi
- Theory: Fine threads will allow fine tramm adjustments.
Tramming Methodology

• With ½ inch drill rod in collet.
• Do rough tramm using machine square in both dimensions.
• Experience has revealed subsequent tramming steps will be difficult and time consuming without this initial step.
Tramming Methodology

• Tramming gage tool purchased from Edge Technology. $100
• Advertised regularly in The Home Shop Machinist magazine.
• Works sometimes. Other times it is a major source of frustration.
• Just followed the instructions that came with the tool.
You don’t want to see this

• After tramming the mill I mounted my milling vise on the mill.
• Put two factory made parallels into the vise and checked them with a dial indicator.
• Backs of parallels were 11 mils lower than the front.
• Concluded the vise was causing the trouble.
• Tried to fix problem by tampering with the tramm.
• BIG MISTAKE!!!
Fixing the Vise

• Sudden insight suggested possibility that there was swarf down in the bearing surfaces of the vise.
• Took the vise apart to clean it.
• No swarf... just a little preservative wax.
• Bottom of inside shown.
Fixing the Vise

• Top of vise inside was also clean with only a little preservative wax to remove.
Fixing the Vise

• Bottom side of vise also had only a little preservative wax to remove.
In a fix with the vise.

• Cleaning the vise bearing surfaces accomplished nothing.
Vise Problem Work Around.

- Adjustable Parallels to the rescue.
- Small set screw in the end of homemade parallels allows them to compensate for deficiencies in the vise.
Tramming Methodology

• Tramm rod adjustments made with 15/16 wrench and dead blow hammer.
• Adjustments made by gently tapping nuts through 10 degree rotations.
• Nuts turn very, very smoothly.
Tramming Methodology

• Decide which direction you are going to move (Up or Down).

• You have to make room for an adjustment before you can apply it.

• If UP, start by loosening the top nut.

• If DOWN, start by loosening the bottom nut.

• Every adjustment step ends with all nuts in fully tightened position.
Had to re-tramm the mill

- Could not get the dial gages to work.
- Had to settle for machinist square method.
- Push the square hard up against the drill rod.
- Slide a piece of wax paper between the square and rod and slide it up and down to determine which direction has no contact.
- Adjust the tramm accordingly.
- When the wax paper will no longer fit anywhere between the square and rod... call it a day.
- Advice: do not use a pen light to determine the gap. Your eyes will get tired and you will not be able to tell a large gap from a small one.
Re-tramming the Mill

• Tried tramming X direction by itself and then the Y direction.
• Changes for the sake of Y ruined the X tramm.
• This can lead to a situation rather like a dog chasing it’s own tail.
• Solution: both the X and Y tramm states must be taken into account simultaneously.
Re-tramming the Mill

• Here the four tramm bolts have been arbitrarily labeled A,B,C,D.
• Assuming that the machine square examination has revealed that the A corner needs to be raised.
• Begin by lowering the D corner by the prescribed 10 degrees.
• Raise C and B by 10 degrees.
• Raise A by 20 degrees.
• During each adjustment cycle make sure all 8 tramm nuts are loosened and tightened again at some point.
• Loosening and tightening each nut helps even out stresses in the column base.
• Uneven stresses in the column base will make the tramm process erratic and unpredictable.
Tramming Conclusions

• Long hours of work followed by an attempt to tram will make tramming especially difficult.
• Tramm when you are fresh.
• The dial device probably works but the tram must be nearly perfect to begin with.
DRO error correction (X – Axis)

• Clamped a large height gage to the mill-drill work table in the X direction.
• Pushed the height gage out 10 inches with the drill rod and X Axis lead screw. DRO followed along.
• Fed 10 inches into the DRO as an X Axis correction factor.
DRO error correction (Y – Axis)

• Clamped a small height gage to the mill-drill work table in the Y direction.
• Pushed the height gage out 5 inches with the drill rod and Y Axis lead screw. DRO followed along.
• Fed 5 inches into the DRO as a Y Axis correction factor.
Sanity Check

• Oops, this is too much work.
• Besides, the height gages may bend when the drill rod pushes on them.
• Only need a couple gage bars (for X and Y) to test or reset the DRO.
• Edge finders will then allow precise positioning WRT the gage bars.
• This gage bar is 10.020 inches long and is for the X Axis.
See, it wasn’t square

- Making a gage bar for setting the DRO error correction.
- Made first cut before I discovered vise was warped.
- Mill has been re-trammed.
- Depth of cut set to cover entire end of gage.
- End of gage painted with Dyken Blue.
- After first pass of end mill only part of gage has been cut.
- It was not square.
- I have adjustable parallels but not $1700 for a new Kurt vise... maybe try ebay?
Laying it all out

- Dyken Blue
- Granite surface plate 9x12
- Steel angle
- Height gage.
- Machinists squares
- Digital caliper
- Carbide Scriber
- Metal rule
- Sometimes use sewing needle in pin vise for scribing.
A Typical Quagmire

- Heavy lines made with height gage on surface plate.
- Circles and cross hairs drawn with sewing needle in pin vise.
Reciprocation is nice

- I like reciprocating saws.
- Carbide tipped blades allow me to cut off big pieces of mild steel and aluminum.
- Saves a lot of hard work with a hack saw.
Progressive Drilling Methodology

• Always use progressive drilling for large holes.
• To get a ½ inch hole:
  – Start by drilling a 1/8 inch hole.
  – Next re-drill with a ¼ inch drill bit.
  – Next re-drill with a 3/8 drill bit.
  – Finally drill with a ½ inch drill bit.
• Use stub length or screw machine drill bits whenever possible.
• Photograph compares Stub vs. Jobber length drill bits.
• Stub drills combined with the progressive technique will produce the straightest holes.
Positioning to drill a hole

- Given a layout mark where the hole is to go:
- Mount 1/8 carbide engraving bit in the drill chuck.
- Position as best I can over layout mark and use bit to put a small dimple in the work piece.
- Use magnifying glass and penlight to inspect dimple.
- If on center of layout mark: done.
- If not, adjust and make another dimple.
Positioning edges and holes

- Old school mechanical edge finders and center finders work best for me.
About End Mills

• Prefer ½ inch end mills for most cutting.
• Have 3/8, ¼ and 1/8 end mills.
• Prefer end mills that are HSS with some cobalt.
If you aren’t bored yet

- Always use the shortest possible end mill.
- Always set the mill head as close to the work piece as possible.
- Use 4 flute end mills on steel and 2 flute end mills on aluminum.
- Do all roughing work in steel with a fine tooth roughing end mill.
- Do near-finished work with smooth cut end mill.
About Carbide Burrs

• Do final cuts with a carbide burr.
• I like ½ inch diameter burrs.
• Beware of cheap burrs, they may contain runout.
Getting Stoned

• I don’t have a precision grinder.
• Make do with grinding stones and Mill-Drill
• Aluminum Oxide
• Best way to get finest finish.
• When the stone gets worn, I use a diamond dresser to straighten the edge of the stone.
Regressive Milling

- Never take more than a 0.030 cut with a Rong Fu Mill-Drill.
- When you get down to 0.030 remaining, proceed in half steps.
- Only cut away half of the remaining material on any pass.
- Re-measure after every pass.
- When you get to 0.004 of material still left, switch to carbide burr.
- Only cut 0.001 at a time with the carbide burr and make a climb milling pass each time.
- Re-measure.
- Leave 0.001 or 0.002 for polishing or finished grinding.
Depth of Cut Advice

- Frank Marlow, PE and P.J. Tallman wrote *Machine Shop Know-How*
- It contain all manner of excellent advice including guidelines for depth-of-cut.
  - Off the side of a mill < 0.1 D
  - Off full end of a mill 0.5 D Max
  - Off partial end of a mill < 0.90 D
Speed Advice

• Drilling mild steel
  – 1000 RPM for 1/8 bit
  – 700 RPM for ¼ bit
  – 300 RPM for 3/8 bit
  – 100 RPM for ½ bit.

• Milling mild steel
  – 700 RPM for ½ end mill
  – 1000 RPM for ½ carbide bit.
  – 1000 RPM for a 1 inch stone.
Getting Belted

• Set screw holds motor and rear belt in position.
• Loosing this set screw allows motor to swing towards front of mill.
• Allows rear belt to be removed.
Getting Belted

- Note the two bolts that hold the middle pulley in position.
- These have to be loosened to move the front belt.
- When both belts have been positioned for the new spindle speed:
  - Push the motor into position. This will re-tension all the belts. Re-tighten the motor retention screw.
  - Re-tighten the center pulley bolts.
- Belts should have equal tension and should deflect about 1 inch when wiggled from side to side.
- Too much belt tension will cause bearings to wear out prematurely.
Even a warped one will do

• Get a large heavy duty vise where the movable jaw is forced down onto the vise base when screw is tightened.

• Avoid light weight vises that are used on drill presses. Work piece will rotate and result in bad cut.

• Three arm turning wrench speeds things up.
Aluminum Vise Jaws

- Magnetic backs
- Top jaws have rubber face - won’t scratch work piece.
- 3x5 cards also will prevent work piece scratching.
- Lower jaws have V slots for holding round objects (e.g. steel rod)
- Used to hold Diamond Dresser when truing round stones.
Give me power

• Hand feeding of mill always results in irregular depth of cut.
• Power feed makes really consistent cuts possible.
• Essential for milling and especially grinding.
No smoking, please.

- I use Mike-O-Cut cutting fluid on steel.
  - Lard
  - Sulfur
- I use A-9 cutting fluid on aluminum.
- Little squeeze bottles with needle tube apply enough lubricant safely and help control mess.
- If it’s smoking, you’re going too fast or cutting too deep.
- My work pieces, drills and end mills are just mildly above body temperature when I finish a cut.
A little dab will do ya
Tapped Out

- I use Mike-O-Cut #7 fluid for tapping in steel.
- T-handle extension on tap wrench fits into drill chuck and keeps me from breaking so many taps.
What’s happening?

- I want to see what is going on.
- Swarf caught under an end mill forces extra cutting, eats up end mills and ruins finish.
- Don’t have a coolant system.
- Chip brushes get chewed up.
- Air bulb is nice for moving swarf out of the way.
Puff the Magic Dragon
Cleaning up the Swarf

• Often I use an old shop vacuum to pick up smaller swarf.
• I use paper towels for wiping down the mill.
• Often I use magnetic pickups on swarf.
Cleaning up the Swarf

- Trash can is a plastic bucket from Home Depot.
- Cheap trash can liners make cleanup much easier.
- Often use double thickness paper towels to pick up swarf by hand.
- Place a paper towel over a magnetic pickup, tap the pickup against the swarf.
- Then over the trash can, pull the magnet away from the paper and the swarf will drop off.
- One paper towel good for a half dozen passes.
Yes, but does it work?

• Project: make a dial gage holder for a quick change tool post... after Martin Kennedy’s article in January 2014 HMSC newsletter.

• This dovetail worked on an Aloris AXA tool post.
Better to Saw than End Mill

- Never use an end mill to remove metal that can more quickly be removed with a saw.
Better to Drill than End Mill

• Never use an end mill to remove metal that can more quickly be removed with a drill... and then a hack saw.
Strike One

- Depth of cut on the Rong Fu is very hard to control.
- Here the slot was cut too deep.
- Tried to compensate by cutting top surface deeper.
- Cut it too deep.
- Material is 1018 steel
KA-LUNK... KA-LUNK

- The vertical controls on this mill are junk.
- The coarse control limps along in 0.010 mil steps emitting an audible KA-LUNK sound with each step.
- The fine control emits additional sounds and is less precise than the coarse control.
In Desperation

- Tried to control the depth of cut with a height gage.
- With quill locked at depth of last cut, place small height gage on vise.
- Set scribe upside down and move up so it touches underside of quill.
- Back height gage down to level of next cut and lock.
- Rotate height gage out from under quill.
- Unlock quill and lower it.
- Rotate height gage back in to test if quill is low enough.
- Lock quill when height gage just touches bottom of quill.
- This works sometimes but often not!!!
In Greater Desperation

- Made a rudimentary screw jack from a coupling, all thread and a jamb nut.
- \( \frac{1}{2} \) diameter.
- With quill still locked in place from last cut, select next desired depth of cut on a feeler gage.
- Place feeler gage under quill and screw up jack to a snug fit.
- Set the jamb nut.
- Remove the feeler gage.
- Unlock, lower and relock the quill.
Depth of Cut Summary

• Existing quill controls are adequate for crude hogging cuts where precision is not a big problem.
• Fine precision is only possible with some external supplement to the mill vertical controls.
Strike Two

• Cheap taps do not threads make.
• Tap has reamed out top of hole and caused wall to bulge into dovetail.
• Had extreme difficulty getting the slightest bit of thread cut.
• This was a cheap tap that came from a set and the work piece was tool steel.
Strike Three

• Material was 1018 steel
• Never had trouble cutting the dovetail... it fits the tool post.
• Other dimensions were easily controlled.
• Quality of this part was good until I blundered.
• Can you guess what I did wrong?
In Summary

• The Rong Fu mill-drill is a marginally viable tool.
• It’s OK for hobby work but I wouldn’t want to try production work on one.
• The X & Y control is very good and easy to use.
• The vertical control is pathetic.
About the DRO

• Have only a little experience using the DRO.
• The DRO is very nice for incremental cutting.
• I am not yet confident enough to trust it with layout work.
• Even the Z axis readings seem fairly good... it’s the mill itself that has poor vertical control.
About the Power Feed

• Don’t leave home without one.
• The power feed is what makes this Rong Fu mill-drill a tolerable tool to work with.
Maybe Someday

• Edges around the new table will allow permanent placement of a better work light.
• May build a steel stand for the DRO readout and fix it to the table.
• May replace floppy screws on gibs with knurled knob screws.
• Would like ball screws for the lead screws but nothing substantive to be gained... not going to CNC.
The End