Boiler Smoke Box Fittings

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The machining of the smoke box related castings and fabrication of the smoke box fittings were done while waiting for the boiler to arrive. The smoke box castings are the smokestack, smokestack base, smoke box front and smoke box door. The other smoke box fittings fabricated from stock are the petticoat, the blower and the engine exhaust fittings.

Smokestack Base: The first casting to machine was the smokestack base. This is the base for Cass No 10. Kenneth's casting is similar except he provided only four attachment bolts between the smokestack and the base. Maybe Kenneth has the right idea since it appears only four nuts were used on Cass 10.

The machining of the base is straightforward except for the radius on the underside to match the smoke box radius. The first step was to mount the casting in the 4- jaw chuck and center the points between the little smokestack attachment bosses. The upper surface was then turned to the correct height and the inside drilled and bored. The chuck was then transferred to the rotary table and the 4 smokestack attachment holes and the 6 base attachment holes marked with a center drill as shown on the right.

There were two obvious ways to cut that 3.315" radius on the underside; mount it to the lathe faceplate or to use a boring bar/ fly cutter type tool in the mill. Friend Dan Staron said he used a fly cutter.

A holder for a boring bore as shown on the right was made and mounted in the mill. The base was mounted in the milling vise with the finished side resting on a couple parallel spacers. The vise and milling head were oriented such that the axis of the cut was centered over the front and back mounting holes. This turned out to be easy to setup.

The little Maximat V10 mill head originally had four speeds but only two were working so care was take to make very small cuts on the slowest speed --- that 3.3" lever produces a lot of shock. After the job was about 80% done the last two speeds on the mill disappeared. I'd been thinking that the mill was just too light for live steam work .....

So, had to use the lathe to finish the job. The base was mounted to a scrap piece of 1/4" thick angle using the smokestack mounting holes as shown on the right. Care was taken when mounting the base to the angle so that the axis of the cut was perpendicular to the base of the angle. A centerline was scribed on the base. The angle was then mounted to the faceplate on the bench and aligned so that the centerline was in line with the center of the faceplate and the position of the finished cut in the base would be 3.315" from the center. This was much easier than expected --- of course, this is not a precision cut and an error of a few thousands or more will be undetectable.

The finish cuts on the lathe went well --- again using low speeds and a fine cuts. The angle and base were light enough and speed slow enough that counterweights were not required.

The underside of the fished base is shown on the right.

The Mill: *Now back to the zero speed milling head. The gear box was opened and three sets of gears found Each set (shaft) has two gears, one steel and one fiber. Only one gear on each shaft is used at a time and the arrangement is such that the meshing gears are always steel - fiber, never steel-steel or fiber-fiber. The steel-fiber interface may be to reduce noise. In any case, it's not a very robust design. Two of the the fiber gears were toothless.*

A call to the only know parts distributor brought the expected news that replacement parts are no longer available. Further study revealed that the damaged gears were 24 tooth and within a few thousands of 16DP 14.5 degree spur gears. Replacements arrived in two days and three hours later after boring, cutting off the boss, trimming the width and filing the teeth a bit the mill was back online with all four speeds. It's now a bit noisier, but these gears were always noisy anyway.

There is one fiber gear remaining but it's much larger and probably less likely to fail. On further reflection, failure was at least partially due to not fully engaging the gears so that the load was carried by only part of the width of the teeth. Must be more careful.

Smokestack : The Cass 10 smokestack is very close to the design that Kenneth used.

The challenge with the smokestack is to find a way to mount it with the casting centered --- there are no true edges. Also, the lathe doesn't have a stead rest, but not sure how one word work on the rough casting.

The thing that worked was to mount the large end on the 4-jaw chuck and then adjust the chuck so that surfaces of the hub midway between the little tabs (see photo on right) was as close to centered as possible. Next, the inside of the end was bored to a depth of about 3/8" using very small cuts. This was continued until a smooth surface was obtained.

Next, a brass disk was turned to match the bored inner surface of the previous step. The disk was center drilled for the lathe tailstock center. The setup is shown on the right. Next, the 4-jaw chuck was adjusted so that the end closest to the chuck was as centered as possible --- see photo.

Once this was done, it was a simple matter to turn the base end and then mount the base in the 3-jaw chuck to turn the taper on the upper end.

Friend Dan Staron had warned me that the outer crust of the castings were very tough and hard to machine and it was best to grind the surface. That turned out to be the case with the tapered part. If one takes an initial cut of 0.020" or more, there's not much trouble with the surface. However, very small cuts sometimes dulls the tool nearly immediately. The tapered part was lightly faced on the bench grinder which cured the tool dulling.

Some voids were found in the base of the smokestack as shown on the right. It almost looks like termite damage. The only area of concern was under the ring and a small area above the ring. Those areas were filled with 550 degree solder and filed smooth ---- almost like lead body work.

The base was then aligned on the stack and used as a drilling fixture to drill the mounting holes in the stack. The two pieces were joined and an air die grinder used to match the ring and tabs on the stack with the mating surfaces on the base.

Petticoat: I have many photos on the smoke box interiors of shays where the tubes are being replaced. However, the petticoat had been removed from those to provide access to the boiler. This photo I think is of parts from the smoke box of a large Shay or maybe a 100 ton Heisler. The parts were covered with black soot so I'm pretty sure it came from the smoke box --- hope I'm not embarrassed by someone pointing out that the parts are from a Chevy pickup. I think the exhaust enters the closest piece and the furthest piece connects to the smokestack.

Update: Mike Green of Ontario came to the rescue with this photo taken by Gordon Carlson that shows the petticoat on Shay #3345, that I'm told was the last narrow gauge shay built by Lima. Note that the parts are similar to the previous photo.

Kenneth suggests steel or brass for the petticoat. The large end is 2.75" diameter and that size brass round bar sells for ~ $9/inch. Didn't like the thought of boring a huge hole in a big hunk of steel either. So off to the hardware store and came back with the 2" to 1.5" reducer and 1.5" to 1" bushing shown on the right for $6. Got out the big pipe wrenches and tightened the joint.

Next step was to turn and bore the bushing end so that it would mate with the base end of the smokestack. This setup is shown on the right.

Next, the excess length on the reducer end was cut off in the abrasive saw. The upper small end was then chucked in the lathe and the lower bigger end turned on both the inside and outside.

The finished petticoat after an acid bath and shot of WD40. The inside shape is not quite like that shown on Kenneth's drawings. Hope it works.

Smoke Box Front: Cass 5 front is nearly identical to Kenneth's castings. One difference is that the front is secured with 24 studs rather than the 20 Kenneth specifies.

Cass No 10 front: Note the hinges are on the right. Most if not all the other Cass Shays have the hinges on the left as does Kenneth's drawings.

This is also Cass 10 with the door open. It was taken on an earlier visit than the previous photo. Suspect the heavily rusted piece is part of the exhaust or blower fittings.

The inside surface of the door must be skimmed so that it will seal. The challenge was to find a way to chuck it in the lathe. The problem was that the steps on the chucks are such that the jaws have to grip the rounded edge of the door casting as shown on the right. Believe it or not, the grip was firm.

Skimming the inside of the door.

The front casting was mounted and centered on the 4-jaw chuck. The inside was then bored to create a smooth reference. The surface that mates with the door was then skimmed. The little bosses where the clips mount couldn't be skimmed because the tool would hit the hinges.

Note: Kenneth's Drawing # 24 shows the front OD as 6.562". The boiler and smoke box is made from 6" schedule 40 pipe that has an

OD of 6.625". The 6.562" is an error and should be 6.625". The drawing shows the lip that mates with the pipe ID at 6.030". The pipe ID is 6.065" so maybe that margin is excess too. Maybe 6.050" diameter for the lip is more appropriate.

The front was then mounted on the 3-jaw chuck and the outer edge and inside surface finished.

Next, the front was reversed on the chuck, the chuck moved to the rotary table mounted on the mill and the location of all the holes marked with a center drill.

The clips were made from a piece of 1/8" angle. The legs were milled to the correct length and the leg that goes over the door thinned. Each clip was then sliced off with the slitting saw as shown on the right. **(Update 4/15/04:** I was unhappy with these clips --- they were too large and out of scale. I later replaced the clips with cast dogs. There is more information at the end of this page.)

Slots were milled in the cover hinges and the hinges on the door filed to fit. The door was then positioned and retained with the clips and the hinge pin holes drilled through the front and the cover in the same operation.

The holes in the front were tapped with a starting tap leaving tapered threads. Screws with nuts were screwed tight into the tapered threads, the nuts tightened and the excess screw cut off with the Dremel cutoff disk leaving the stud with nut.

Four holes don't have studs installed. The studs for these will be in the smoke box. These four studs will hold the door and front to the smoke box. The four nuts will be removed to remove the front and door to gain access to the smoke box for maintenance.

Blower & Exhaust: The most difficult part of the blower-exhaust system is the flange that attaches to the bottom of the smoke box. Kenneth suggests that the flange be made from the cutout for the boiler steam dome. I'm having my boiler built by someone else so I didn't have the cutout. A short piece of the 6" schedule 40 pipe was obtained from the local machine shop. The 0.28" thickness seemed excess so I turned the thickness down to about 3/16" I then drilled a

1/2" hole in the middle of what was to be the flange. This was done before cutting out the flange to make sure the hole was perpendicular to the flange. The flange was then rough cut from the section of pipe. A piece of 1/2" rod was center drilled on one end and the other end silver soldered into the flange, making sure the rod was perpendicular. The rod was then chucked in the lathe and the outside turned to 2.5"

The photo shows the piece of pipe and the flange with rod after the OD was turned.

Next, the flange was chucked in the 4-jaw chuck. The end of the rod centered with the tailstock center and the chuck adjusted so that the rod close to the flange was also centered. The chuck was then tightened and the rod cut off next to the flange (hacksaw). The flange was then drilled/bored to ~ 0.975" to match with the OD of a 3/4" copper elbow.

These are the components of the exhaust and blower system. The brass blower ring and exhaust were machined as per Kenneth's drawings. The flange hole positions were changed from the drawing; the two mounting holes closest to the exhaust pipe were located away from the equal spacing position slightly to give easier access to the screw

heads. **Update5/14/04:** Kenneth had specified four 1/32" (0.032") holes for the blower working with his propane burner. These holes plugged up several time using my oil burner. Bob Reedy's design for his oil burning Three Truck Climax (July/August 2003 Live Steam) uses four #55 drill (0.052") holes. Reedy's design was copied and the blower holes were enlarged to 0.052" which fixed the problem **End update**.

The finished blower and exhaust system after the parts were silver soldered together. The 3/16" nipple is to show the position of the blower input and will be replaced with fittings connecting to the blower line.

This finishes the smoke box fittings. The installation of these fittings will be presented in a separate page.

Update 4/15/04 - New Dogs: I was unhappy with the clips that held the smoke box door closed--- they seemed too large and

way out of scale. I replaced the clips with cast brass dogs from Railroad Warehouse (the smaller dogs, part # DOG-01). The photo on right shows the installed dogs on the freshly powder coated smoke box front and door. The four shiny screws hold the front to the smoke box --- these screws will be painted black at some point. The powder coating sealed the door to the front casting --- there are no plans to open the door; smoke box access is by removing the door and front castings as a unit.

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