Shay Tender Frame Fabrication

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This page shows additional detail on the tender frame members and some of the processes used to make the parts.

Bolsters: The first frame member constructed was the bolster. The photos on the right and below show the details. The roller plates and the block between the channels were attached to the channels with screws and then the pieces were silver soldered together. The channels were cut about 1/16" long and the ends milled to the correct length after the bolster was soldered together. This insured that the ends were square. Two 1/4" thick plates were then attached to the ends first with screws and then silver soldered. The final step was to attach the four angle brackets. The faces of the end plates and angle brackets were positioned 0.020" to 0.030" back from the ends of the channels to make sure the the ends of the bolster are held firmly against the side channels.

Side Channels: The side channels were next. The photo below shows the completed channels. Sorry about the poor quality. The channels had just been cleaned and then sprayed with WD40. The brass colored splotches on the left end are the residue from brackets I'd soldered there and later removed because I didn't like them. The channel fabrication sequence was:

1. Cut the channels and mill the ends to make sure they were square.
2. Use a drilling template to drill the holes for the rivet detail by the bolster (used for screws to attach bolster to side channels).
3. Drill holes on ends to attach brackets to hold end channels.
4. Attach frame brackets (see detail on frame brackets below)
5. Attach sill bracket (see detail on end sill brackets below)

Triangle Frame Brackets: Considerable thought was given to a process to make the frame brackets. These brackets are merely decoration on the tender. However, they support the walkways on the main frame so a process to make uniform sturdy brackets was required. When making the corner brackets used between the channels it was learned that if those brackets were made to be a snug fit in the bottom of the channel U the the brackets keep the channels aligned. Similarly, if these triangle frame brackets are a tight fit in the channel U, they will be self aligning in the vertical position as well as being straight. So, that was a first requirement. The next requirement was that the upper surface be even with the top of the channel. The next requirement was that they look good with square ends, etc. The solution that worked was to make a fixture and use a carefully thought out process. The following shows the process that will also be used to make the main frame triangular brackets. (This process isn't ISO 900X certified yet, but it could be.)

The first step was to make the angles. The bending was done in a vise with the metal sandwiched between scrap angles with sharp corners. The actual forming was done with a hammer. The two legs of the angles were then cut to slightly over the correct width after the angle was formed. This was done with a saw. A piece of flat stock of the appropriate width was clamped into the angle as a saw guide. Each angle was then clamped into the mill and the edge finished to the proper leg width. You can see the edge of angle between the left vise jaw in the photo on the right. The flat stock to the right of the finished edge is a spacer to facilitate clamping in the milling vise.

The next step was to make the fixture shown on the right. The two pieces were screwed together with two flat head screws and machined together. The size is the size of the bracket inside the the angles as seen in the subsequent photos. This fixture is both a pattern for cutting the bracket shape and a jig to hold the parts together during the fabrication process.

To make a bracket, the four angles and triangle piece are all clamped between the two sides of the fixture. The angles are cut extra long and the sheet is cut extra large.

After the pieces are clamped in the fixture it is set in an angle iron as shown and each side of the fixture seated in the inside of the V of the angle iron using a hammer and punch.. This insures that the angles of the bracket are against the edges of the fixture.

The fixture was then used as a pattern to drill the five rivet holes. # 2 drive screws were used for the rivets. The hole size was the clearance hole for the #2 screw. After the holes were drilled, five #2 screws and nuts were used to hold everything together. (When I make the fixture for the main frame brackets I'm going to tap the one side of the fixture rather than using the nuts. Must have lost a dozen nuts when making the six brackets.)

The next step was to use the bench grinder to cut the ends of the angles and the outside edge of the sheet to close to the correct length. A file was then used to finish all edges down to the edge of the fixture. The photo on right shows a trimmed bracket still in the fixture.

One side of the fixture then removed and several screws set in the rivets holes to keep every thing aligned. The drive screws were driven home with hammer and punch. The upper part of the holes in the remaining fixture plate was drilled larger so that the part of the drive screw extending through the bracket wouldn't stick in the jig.

This is the bracket with all 5 drive screws installed.

The next step was to silver solder the angles to the sheet and the drive screws.

After everything was soldered together, the protruding end of the driver screws was cut to about 1/16" using a Dremel cutoff disk. The ends were then further dressed with a file.

It took about an hour to make the fixture, about an hour to make bend and the mill the angles. I got better and faster making the brackets as I repeated the process. The first bracket probably took an hour to make and the last about 10 minutes.

The final work on the brackets was to drill the six holes to attach the angles to the side channels. I couldn't think of an easy way to make a drilling jig. I ending up center punching the holes by visually aligning the punch with a rivet in one direction and in the center of the angle leg in the other. This worked well.

The brackets were a tight fit in the channel. The holes in the channels were drilled using the bracket as the drilling pattern. One hole was drilled and tapped first. A screw in that hole was then used to hold the bracket in place while the other five holes were drilled and tapped.

End Sill Brackets: The end sill brackets were made from a piece of angle iron and bent 1/8" X 1/2" cold formed stock as shown on the right. The angles were cut first and then the flat stock bent to the desired shape. Several bending attempts were required to get one that looked right. That one was then used as a pattern to bend the second one. A scrap bar was then drilled with the desired hole pattern. The two pieces were then clamped to pattern and the holes drilled in the pieces. The pattern was then used as jig to hold the pieces when they were silver soldered as shown on the right. The bar was also used as a pattern to drill the bracket mounting holes in the frame channels. The brackets were mounted using 4-40 button head screws (simulated rivets).

Testing Silver Solder Strength: Recall that I had made, installed and then removed 1/8" flat stock frame brackets. Before discarding them one was tested to get a handle on the silver solder joint strength. One of the unmolested brackets is shown in the upper part of the right photo. An attempt was made to break the joint by bending the bar stock. That was stronger than any joint I could weld! The joint was finally broken by beating on the pointed edge of the joint. There was a uniform layer of solder over the mating surfaces. Before soldering I'd cleaned the joints in pickling solution and placed a very thin flat strip of solder that had been fluxed on both sides between the pieces. The pieces were held in a jig that kept a small amount of pressure on the joint. A quick heat with the a propane burner completed the task.

Corner Brackets: The corner brackets were formed in my little brake (vise & hammer). The legs were then milled so each leg was the same width and the edge was uniform using a setup similar to that shown above for the frame bracket angles. Each piece of angle was long enough to make three brackets

Next, the angle was sawed into three pieces for three brackets. The ends of each bracket were then finished in the mill as shown on the right. Care was taken to make the length such that each bracket is a snug fit in the channel.

A collection of brackets. These are for the internal channels. The ones for the outside corners were made the same way. The two brackets with holes only on one side go between the forward internal channels and the front channel. A five hole pattern is used in the front channel. Those holes were drilled in the front channel first, the internal channel clamped into the correct position and the front channel use as a pattern to drill the holes in the bracket.

The holes for the corner brackets were drilled in the channels first. Everything was then clamped together as shown and the channels used as patterns to drill the holes in the bracket. A 0.25" shim was placed between each bracket and the channel when the holes were drilled. The shims were removed when the brackets were installed making a very tight joint. I usually drilled one hole in each side, tapped the hole and screw the joint together and verified everything was straight before drilling the remaining holes.

End Channels: The machining on the end channels shown in the next photo was fairly straightforward. The tender coupler was a bit of a challenge. While doing that machining I figured out a better sequence that I plan to use on the mating engine coupler. I'll document that when I do the main frame ---- if I remember. Recall that I'm mounting the rear channel level with the side channels. A 3/16" thick plate was attached to the channel and will be used to attach the coupler pocket. This plate was screwed and then welded to the channel. If I did it again, I'd use the screws and silver solder.

Internal Channels: The internal channels were made after the outside channels and the bolster were all temporarily screwed together. Care was taken to make the length a few thousands less than the distance between the end channels and the bolster to make the internal channels hold the end channels tight. The brackets were mounted to the internal channels first, then the internal channels placed inside the frame and the correct position of the channels marked on the bolster and end channels. The frame was then disassembled and the holes in the bolster and end channels were were drilled and tapped.

On to the main frame.....

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