

The Chopper Builders Handbook Tube Bender

The CBH Tube bender is a low cost and simplified version of a typical compression type bender such as the JD² model III, the Pro-Tools model 105 or the ones made by JMR or Shop Outfitters.

The term 'low cost' doesn't mean that it's necessarily cheap to build, just less expensive than a comparable store-bought unit. How much less depends upon the fabricators resources.

The design shown herein was developed over a long period of time and was a collaborative creation between several of us who post at the various discussion boards. It borrows bits and pieces from several different contributors and manufacturers. This is a proven design that does what it's supposed to do unlike many of the other bender 'plans' on the Internet which might look good at first glance but end up either costing more than a pre-made bender or producing less than satisfactory results.

Dollar for dollar and pound for pound there is no way a person can build a less expensive or simpler bender that produces professional results than what we'll outline in this article.

The reason that we don't see cheap 'imported' compression benders is that you can only downgrade a bender so far and then it simply won't work no matter what you do and most domestic benders are already built at the raw edge of providing satisfactory performance. Even the overseas copycats can't cut them back much more to reduce costs than the American makers have already done. The bender outlined herein is less expensive than most because it's designed for a very specific purpose that has well defined limits dictated by the product it's supposed to produce. That product is a motorcycle frame. This bender is not designed to build 1.75" diameter heavy wall DOM roll cages for dragsters or 4-inch diameter bumpers for an off road 4x4. If you need a more general-purpose bender for a wide variety of general fabrication purposes you'll be time and money ahead to just buy one from any of several different manufacturers. On the other hand if you're just building Chopper frames the unit described herein may be the low-buck solution you've been looking for.

This particular bender is designed to use dies (formers) purchased from JD Squared but you can also buy dies from independent makers or modify the bender slightly to use dies from Pro-Tools. If you have the equipment it is also possible to make your own die sets. Some builders have even used wooden or plastic dies with excellent results. In order to simplify the design this bender is specifically set up to use dies having a 4.5" centerline radius. It will bend tubing ranging from 0.75" up to 1.5" in diameter so long as the wall thickness does not exceed .188 inches for the larger tube sizes.

This bender can be installed to operate in either the horizontal or vertical position and it can be adapted to hydraulic operation very easily.

Cost for the raw materials to make this unit average \$70 (excluding the die and follower) but creative scrounging can bring this figure down significantly. Even at the high end this is a significant savings over the \$295 average cost of a pre-manufactured bender frame from JD², Pro-Tools or other suppliers. You also save on shipping costs and of course there is the 'satisfaction' factor of doing it yourself which is priceless. You can spend far more than this trying to build the popular 'bottle jack' benders that seem to permeate the Internet chopper sites as being 'low cost' but believe me they are far from cheap to build and the results are sometimes questionable.

I'm a big fan of this particular type or style of bender for one reason and that is because the classic horizontal compression bender is used in about 90% of all car and bike fabrication shops in business today. The reason this is so is because these units work so well. They are pure workhorses that produce consistent, accurate and repeatable bends time after time, which is something you just can't say for the various varieties of bottle jack benders being pimped on the Internet today.

This bender design is perfect for a collaborative group effort as you can easily build two or three assemblies in a single day in your garage and by sharing the cost of materials and tools the unit costs come way down compared to doing a single one-off. A group of friends, each with their own bender frame, can share single purchased dies so that overall expenses of owning a good bender is spread around among several fabricators.

For the first time Chopper builder this bender is a perfect starting project since you can't begin a cycle frame without a bender and if you can't build this unit then you probably can't build a frame. Starting here on a project can save you a lot of money and also test your abilities before you get committed to something you may or may not be able to accomplish.

Materials

The steel strap stock can be purchased in almost any large building supply outlet, or hardware store. Here on the west coast typical sources are Ace hardware, Lowes, Home Depot and Orchard Supply hardware. The smaller steel supply and fabrication shops can also be a good provider, usually at a lesser price. Scrap yard scrounging will yield even lower material costs. As a last resort you can buy the materials from an on-line source but you'll be paying a big premium. Even then however the cost for the finished bender frame should be under one hundred dollars.

The bender doesn't have to be made from flat stock. You can easily substitute 1"x2"x.120 wall rectangular tubing for the plates by making some minor modifications in the dimensions. You can also weld together thinner plate stock to build up thickness if you can't easily find the half-inch plate specified on the plans. In other words the plans provide a generic design concept that can be altered or modified to reduce cost, make fabrication easier or even improve the operation of the unit. In fact we expect that each maker will modify the basic design concept to suit their own unique ideas and then pass those improvements along to others.

Construction

Building the bender is a relatively quick and easy process. The only special tool needed is a half way decent drill press so the holes are straight. Start by cutting the plates to the overall lengths noted on the plans. This should give you two pieces 16.5” long and two pieces 16.25” long. The strap stock can be cut with a chop saw, saws-all, saber saw, cut-off wheel on a mini-grinder or even a hacksaw if necessary. Where there’s a will, there’s a way.

Next I usually start out by drilling the half-inch holes in the control arm plates per the dimensions on the plan. Clamp the two plates together making sure the edges and ends are lined up and square and then drill the two holes in the two plates in a single pass.

Do likewise for the two three quarter inch holes in the frame plates.

Once these holes are drilled I’ll temporarily bolt the pieces together to make sure they don’t shift when we move on to the larger holes.

One inch and seven-eighths inch drill bits may be hard to find in smaller towns and when you do find a local retailer that stocks these large sizes the price may be a little high. As an alternative you can use regular bi-metal hole-saws that are available almost everywhere for less than ten bucks each. These hole-saw bits will last long enough to make about four benders before they start to get dull. The key to using hole saws is to drill a quarter inch pilot hole with a good drill bit (not the hole saw pilot bit) prior to using the hole saw with it’s cheap pilot bit serving only as a guide.



Figure 1

Figure 1 shows what we’ve got up to this point. In the upper area of the snapshot is a piece of the raw stock we bought from a local hardware store. The bars in the middle of

the picture are the bender frame plates bolted together so we could drill the larger pivot pin holes. The plates at the bottom of the shot are the bender control arms; sometimes call 'drive-links'. You can see we didn't waste any money buying special hole-saws from the higher quality manufacturers. These cheapies are still as sharp as when we first started using them.

Unfortunately the only material we could find on short notice for this particular project was Hot Rolled steel so to make the plates at least half way suitable for use we had to sand them down a little. At the same time we de-burred all the bored holes and lightly rounded the ends of the plates so we didn't get gouged later down the road.



Figure 2

At this stage we have four prepped pieces of strap stock with the major pin and boltholes drilled in place per the drawings.

You don't have to kill yourself with extreme precision measuring to build one of these units. The only truly critical dimensions are the 6.5" space between the die pivot pin and the die follower and the .75" offset from the edge of the arm to the follower hole. These have to be exact. The other holes can be within a sixteenth or so and everything will still work properly.

It should go without saying however that all of the upper holes have to align with all the lower holes or the frames won't be plump and square. This is why it's important to stack the plates and drill all coincidental holes at the same time.

Functioning of the unit can be improved if you have the tooling to bore all of the holes slightly undersize and then ream them for a tight fit to the various pins and bolts.



Figure 3

The two upper plates are for the frame of the bender and the two lower plates are for the control arms (drive links).

Total investment so far \$52, which includes the steel, temporary bolts, sandpaper, hole saws and one good 3/4" drill bit. I used an old 1/2" bit already in the toolbox for the control arm spacer holes so this needs to be factored in if you're starting with nothing.

Pin Hole Elongation

I've seen posts at various web sites from people who claim that the pivot-pin holes in the plates of their JD2 benders (1/2" thick stock) become elongated over time. My model III is almost twenty years old and has made, at a very conservative estimate, well over three thousand bends. About 75% of these bends were in thick wall 1.625" DOM roll cage material and the holes in my machine have no signs of distortion. I'm not sure what caused other units to have this problem but it sounds to me more like a misalignment situation where the pins weren't equally loaded top to bottom so they tended to 'wobble' in the holes over a long period of time. The maximum load on any pin in a typical bender is far below the tensile strength of mild steel so theoretically it's impossible that the pins can put enough pressure on any particular hole to actually distort the steel surrounding the hole unless something is binding over a long period of time and the elongation is due to wear and not stress. For this reason I personally suspect that the guys with elongation problems didn't know how to set up their benders in the first place so it's an operator error situation, not a basic bender design flaw.

On the other hand if you do intend on bending a lot of large diameter/thick-walled tubes in your bender you can reinforce the pinholes at this stage of construction by welding on 'doublers' or even DOM extension sleeves so the load at the pin penetrations have more bearing area.

Spacers

Next in the schedule is the fabrication of the spacers made from ERW or DOM tubing that serves to hold the bender frame and the control arms spaced apart.



Figure 4

Figure 4 illustrates the tubing spacers for this project. The spacers also serve as bolt sleeves and bearing support for the ratchet arm and bending handle so they need to be made from thick walled (.120) tubing. This is where many tube bender projects get bogged down, as finding small sections of tubing can be a big problem if you don't live in a large city. There are improvisational workarounds that we'll discuss later but for now let's just say you have the tubing and you've made the spacers (sleeves) per the plans. The cut ends of the spacers need to be perfectly square to the tube body so take care to dress these ends as true as possible.

The bolts I've always used in all of my benders over the years have been just regular old el-cheapo hardware store material and none have ever bent. If you want to go overkill for some Mongo type bender you can usually find grade 8 at almost all auto parts stores and some of the better hardware stores. The gold anodized grade 8 bolts do add a touch of class to a bender if you want some flash but polished stainless is maybe even better if you've got a little extra cash. All of the parts can be upgraded over time. Most well built benders last for a couple of generations at least. I've had the privilege of working with several home-built benders that were made over sixty years ago.

Basic Assembly

I get more feedback on both the discussion board and in emails about tube benders than any other subject. I've also seen it's a high priority discussion point on almost all chassis

fabrication sites. A huge portion of the overall general discussion about benders involves the complexity and building expense of the various options available to independent builders.

The more or less standard compression type benders like the JD², Pro-Tools, JMR and Shop Outfitters models are usually seen by most people as being far too complicated to build as compared to the bottle jack type of vertical benders but nothing could be further from the truth. The reality is that compression benders are by far the easiest to build for the average small operator or homebuilder. To put it mildly, they are elemental compared to the gyrations one has to go through to successfully build a 'good' properly aligned bottle jack bender.

I personally think a large part of the problem is that compression benders 'look' complicated in comparison but they are actually very simple once you understand how they're built.

A typical compression bender has a 'frame' and a control arm; sometimes called the drive arm or drive links. The frame is mounted to a bench, a stand, or some other relative stable object. I've seen some clamped into a portable 'workmate' or even a bench vice. The 'frame' is the stationary part of the bender. The frame doesn't move. It just sits there acting as a base for the control arm or drive link that actually does the bending.



Figure 5

Figure 5 illustrates the basic assembled 'frame' of a compression bender, which is the object in the lower portion of the picture. It consists of two arms spaced apart with some tubing sleeves. Inside these sleeves are bolts that serve to not only hold the frame together but also anchor it to some kind of stable base structure or holding fixture which is normally a workbench or steel tube stand bolted to the floor of the shop or garage.

I personally don't know how it's possible to make anything less complicated or less expensive than this type of assembly.

Control Arms (Drive Links)

The next unit is the control arms. Some builders call these the 'drive links'. This is the assembly that actually moves the bending die (die former) as you're making a bend.



Figure 6

The 'frame' is in the background in this snapshot and the control arm assembly is shown propped up on a roll of tape. Like the frame this is an elementary fabrication only slightly narrower than the frame. Nothing can get much simpler than this.



Figure 7

Figure 7 shows the control arms in their relative position within the frame. Note that the frame is wider than the control arms and that the control arms (drive links) nest partially inside the frame assembly. This is a little loosey-goosey picture since we don't have the various washers and spacer installed or the bolts tightened yet but I think it gives an indication of how these benders fit together.

Taking another gander at all of this I have to admit that it does look complicated but the keyword here is 'look' as it's really a very simple concept once you get your head around it.

So far we've never had to worry about squaring planes of various angle iron legs or even having to worry about the axial relationship of pivot-pin holes since these benders are more or less 'self aligning' once they're assembled. I've built a couple of vertical bottle jack benders in the past and compared to those exercises building one of these units is a piece of cake.

If you've been following along with us so far and this is your first attempt at building a bender you've probably spent less than four hours getting these parts ready for the next stage. I hate to harp, but believe me you'd still be trying to square and tack the frame legs on the typical bottle jack bender by this point in time assuming you could scrounge up all the channel stock, hardened drive pins and other special parts such benders require.

Ratchet Arm

Some makers call this object an Indexing Arm or Indexing link. It looks like a piece of a ratchet assembly so most folks call it a 'Ratchet Arm' even though it doesn't really ratchet in the real sense of the word.

Many people who look at the plans immediately drop the idea of building one of these benders simply because the ratchet arm itself looks to complicated to make at home but believe me this is not a complicated fabrication for the home-builder. Even using just a cheap hand drill and saber saw you can make one of these arms in less than an hour and a half from start to finish which includes several beer breaks while the bits cool off.

I originally though about making the arm from a section of 1"x2"x.120 wall rectangular tubing since I thought it would be quicker and easier to cut not to mention much stronger than the flat bar stock. In the end I decided to use the flat plate just to see exactly how long it would take to hack one of these out with typical garage tools. It actually wasn't all that bad, just very boring.

With better quality bits, a good drill press and a small band saw I imagine one of these can be made in less than an hour. Compared to the cost of having one plasma or water jet cut the idea of making one the hard way has considerable appeal.



Figure 8

Figure 8 illustrates the ratchet arm with the pilot holes drilled for the ‘tooth’ spacing.



Figure 9

Figure 9 shows the ratchet arm bar with the 7/8” diameter holes drilled for the ‘teeth’ that we’ll be cutting into the bar a little later. We’re still using the same cheap 7/8” hole saw we started with. It took just under forty minutes to drill those eight holes, which is the worse part of building one of these benders.

I noticed that some places in this particular steel plate were much ‘softer’ than other spots, which is a little scary. At a couple of spots the hole-saw went through the material like a hot knife through butter. Kind of makes you wonder about the quality control in the plants where this stuff was made.

As a result I don’t have a huge amount of confidence in the overall bending strength of this particular ratchet arm but time will tell if it’s up to the task.



Figure 10

Figure 10 is the finished product. I started cutting the notches with a an abrasive disc but found it didn't give me much control so I switched over to using a saber saw with a metal cutting blade with was much easier. It certainly won't win any beauty awards but it should work just as well as some fancy water-jet cut version. The standard JD Squared ratchet is shown in the upper portion of the snapshot for comparison.

Control Handle (Bending lever)

The last thing we need to make is some kind of handle or bending lever to control the movement of the ratchet bar. In the old days this style of bender didn't have a ratchet bar and all you did was wedge a long bar in between the drive link bolts and bend away using brute strength. This method actually works very well for the smaller diameter of tubing but once you get past 1"x.120 wall material it helps to have some leverage and that's exactly what the ratchet bar provides.

Almost all compression benders use a rather short ratchet control handle that's actually just a stub-out for a long removable extension lever, usually 1"x2"x.120 wall rectangular tubing. The advantage of this system is that you can match the length of the lever to suit the force required to bend a particular specification of tubing. About 90% of the time a 30" long extension lever is all that's needed for most tubing encountered on cycle frames.

Building a cheap and easy stub-handle isn't as easy as it might first appear due to the rather unique movement of the ratchet arm itself.

The standard handle on the mass produced benders are to complicated to simply copy for quick and easy fabrication in the average garage environment so we have to do some shade tree improvisation.



Figure 11

Figure 11 shows the basic bender without the die installed. The drive link and ratchet arm are in the normal position for starting to make an initial bend.

The control 'stub-handle' shown here extending to the right of the ratchet arm is just a section of 2" wide material built for illustrative purposes. This simple arrangement works just fine up to a point.

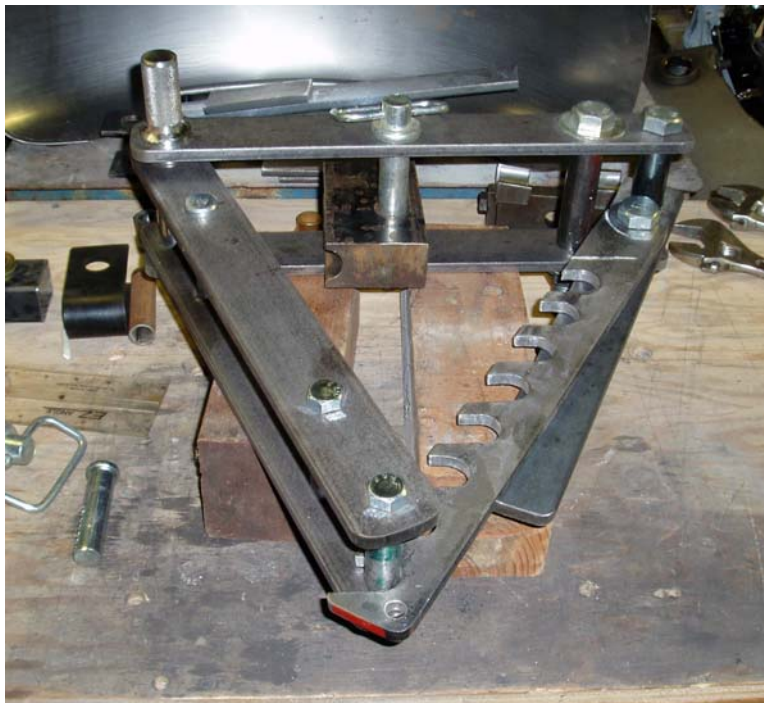


Figure 12

Figure 12 shows the bender in the fully extended position at the completion of a bend. Note how our simple handle is now almost parallel with the ratchet arm and would be a good place to lose a few fingers if we were bending without an extension handle, which I do quite often.

There's still enough exposed material where we could weld on a stub for an extension handle but a better solution is to build a stub-handle that has no potential interference problem with the ratchet arm to begin with.

The simplest way to do this is to use two pieces of material. One short piece with the ratchet arm and pivot-pin holes and one long piece with only the pivot pin hole. Weld the two pieces together with a forty five-degree angle between them as shown in Figure 13.

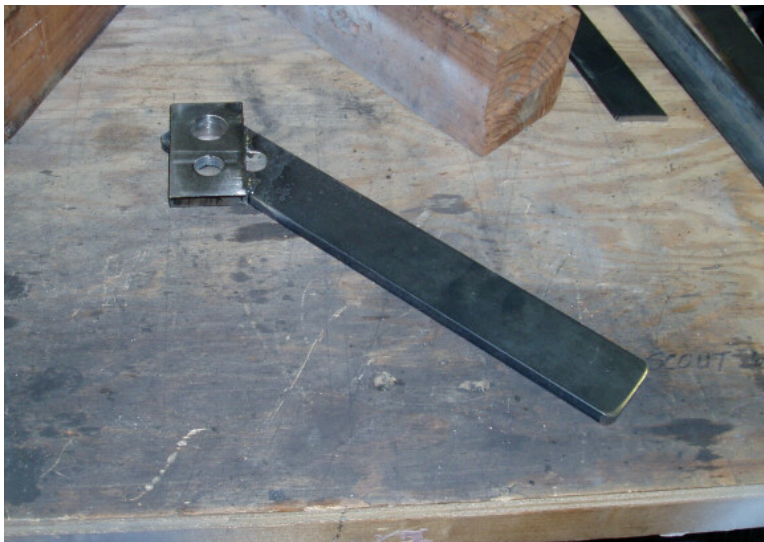


Figure 13

That 'extra' hole in the long arm shown here is not part of the design. It's just the ratchet arm pivot-pin hole left over from recycling the original straight handle shown in earlier snapshots.

If you have patience you can make a fancy handle from some 3" wide plate stock as shown in Figure 14. I cut this with a saber saw. The dimensions and geometry are the same as on the el-cheapo handle but this took a long time to make.



Figure 14

An even better, high-tech handle was invented by John Stewart, (Hose Dragger) in his bender write-up on the discussion board. This consists of a 1.25"x.120 DOM sleeve that slips down over the 1" sleeve in the frame arms. You weld tabs for the ratchet arm pivot to the sleeve and a weld-on handle made from almost anything on hand.

The parts for this type of handle are shown in Figure 15 below.



Figure 15

This idea is so good that I'm going to make a handle like this for my regular JD² Model III bender. This scheme is an infinitely superior design concept and stronger than the factory handle.

Figure 16 shows the handle assembly welded up and ready to install. When I built this particular handle all I had handy was some .120 wall tube and for a production model I

would prefer to use at least .188 or even .25 wall DOM for the sleeve, as you can get better welds into the thicker material.



Figure 16

There is literally no limit as to what one can do to build a truly customized tubing bender for specific applications and with each new design concept somebody comes up with the basic design only becomes more practical in execution. This is the huge advantage us home based builders have over manufacturing companies. We can afford to experiment and improvise over long periods of time since we're not trying to make a buck on any particular product or idea. Virtually everything we build is an experimental one-off prototype. Some of what we come up with works and some doesn't but that's just the breaks of doing things on your own. The good stuff, the stuff that's cheaper to build or does a better job than store-bought items is passed along largely by word of mouth or posted at the various discussion boards.

Figure 17 shows our bender up to this point in its construction with the fancy new ratchet handle installed. The reason it looks like it's 'drooping' is because the frame itself still isn't bolted down to a solid mount and the spacer washers between the links aren't installed so the entire assembly is tilting towards the drive links in all of these snapshots.

In reality one of the biggest problems with this particular project from the outset has been in figuring out how take pictures that actually describe the building process since I'm a one-man operation. If I'm cutting something for example I can't take a picture of that particular work since both hands are usually occupied. I trust that the reader can read between the lines so to speak and figure out how some of the actual cutting and drilling operations were done.



Figure 17

To be honest I didn't really spend all that much time building this particular bender since it was basically an experiment and a backup for my old Model III that I use more or less on a daily basis. What you see pictured in this article was fabricated over the course of four days working in my spare time so it's not perfect by far. I expect that another fabricator would take far more care and spend more time in putting this type of assembly together. From start to finish I have less than six hours of actual work invested into this particular set of parts. Most of those hours were spent in simply drilling holes which is the only really time consuming part of the building process. A two-man team should be able to build at least three of these units in a single day as there is a considerable conservation in time by doing more than one unit at a single setting.

Now that I know what to do I could very probably build one of these units in less than four hours, which is kind of how it goes with doing fabrication work of any kind. The first one's always a bitch and then the second and subsequent versions are cakewalks.

Pivot Pins and Bolts

Bolts used in this type of bender can be regular un-graded hardware store items, as they are not subjected to much stress. If you're building a heavy-duty model you might opt for grade 5 or grade 8 bolts to be on the safe side.

Pivot pins for this bender can be regular grade 5 or better clevis pins purchased from McMaster-Carr or the builder can make their own pins from bar stock with a simple washer welded to the top. There is no need to use special hardened steel pins as you might need for a vertical bottle jack bender. In fact thick wall tubing can be substituted for solid pins to save some money.



Figure 18

Figure 18 illustrates two types of pins. The one installed in the drive link is a standard hardware store clevis pin. The pin in the foreground is made from 7/8"x.188 wall tubing with a washer welded on one end. Note that both of these pins have shallow heads.

The big fancy one-inch diameter die pivot pin with the knurled handle at the upper left is actually a dumbbell handle I bought at a garage sale for \$2 and sawed in half.

On the plans we show where you might have to grind two clearance notches for the die drive pin and the die follower pin in both the drive links and frame assembly.

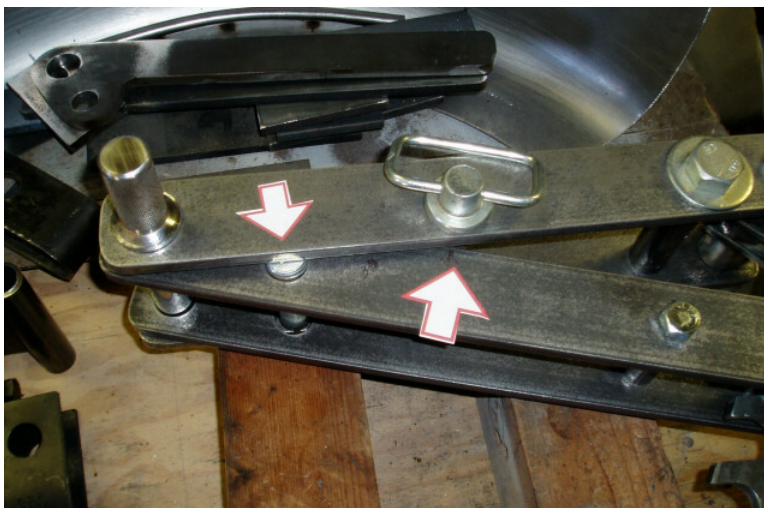


Figure 19

The arrows indicate these two areas as shown in Figure 19.

The die drive pin is the small clevis pin to the left in the picture. You can easily see that if you use a pin having a shallow head it actually will slide under the bender frame so no notch will be necessary. This is the preferred arrangement and requires that you deliberately make the frame about one quarter inch wider than the drive links. The extra space between the two plates should be filled with a spacing washer.

The follow bar pin is the larger object with a bail in the end of the pin situated in the middle of the snapshot. Note that if the drive links are bought up extremely close to the bender frame they will actually hit the shaft of this pin.

A slight clearance notch may be required in the drive links at this point but it depends on the particular die set you happen to purchase. With the JD Squared dies no notch is required at this point.

Bender Die Sets

Over the past forty years I used several different types of benders and perhaps several dozens of dies from various suppliers and when it comes down to a bender die you usually get exactly what you pay for.

Ironically the difference in cost between a very high quality die from a well-established top of the line manufacturer and a lesser substitute from an independent or upstart machine shop is around \$30 or so.

Dies are expensive. Even cheap second tier dies cost a lot of money but when you're spending a hundred or better on a die why not spend the extra thirty and get something that's really top notch quality? Trying to save money on a die is perhaps the worse possible place to cut corners if you're in the fabrication business.

Most of the good dies I have are over twenty years old and to be honest they look almost brand new. Some have bent literally thousands of feet of tubing. The 1.25" die I have used the most cost about \$157 back in 84. That works out to about \$8 per year for the privilege of owning it. It'll last at least another twenty years and I imagine that particular die, a JD², will be handed down for several generations.

Almost all of the lesser quality dies I have bought gave up the ghost years ago. Some were so poor that they never actually went into service in the first place so I ended up paying twice; once for the bargain die, and then again for a better die to actually do the work at a level of quality I was satisfied with.

This isn't to say that all dies made by other sources are inferior but rather a warning that you should do your homework and ask around to get input on the die sets you plan to purchase no matter where they come from. Some of the cheaper after market dies are actually extremely well made but they're not easy to find.

In some ways our little site is responsible for the rash of cheap die sets that started to appear on the market a few years ago as some companies saw a way to make a quick buck on the suddenly huge number of homebuilders wanting to buy economy dies and/or cheap benders. Thankfully most of these outfits finally went out of business but some of their excess inventory is still be pimped out over the Internet, especially on eBay so let the buyer beware.

Limitations

Please keep in mind that the design shown herein is a greatly simplified and scaled down version of a typical multi-purpose compression bender. It's not designed to bend 1.75" thick walled tubing for roll cages or other heavy-duty applications. This unit is intended to be used on typical 1.25"-1.375" diameter tube Chopper frame applications which includes smaller sized tubes for handle bars and other accessories.

The design however can be beefed up if you need to have a bender for more robust applications and you have a larger building budget.

For those on an extremely tight budget the bender can be built with thinner steel for the arms. In fact the version we built for this article is actually made from 2"x.375" steel instead of half-inch material as the plans call for. It could probably be made from quarter inch steel if you welded a small 3/4" wide flange or angle iron on the sides of the arms to make them stiffer. Alternatively, thin channel sections can be used for both the frame and drive links for an immensely strong assembly. Simply using thicker plates is not a cost effective way to add strength though it's less labor intensive, which is why manufacturers resort to this method.

Customizing

Just like building a Chopper, putting together a tube bender can be an extremely personal thing and almost every home built unit I've seen is tailored to the user and customized in many ways. I've even seen one where the frame arms were cut so they appeared to be flames coming out of the back edge.

Some people use stainless or chrome fasteners and pins. Some custom cut their pivot-pin heads with fancy knobs or even spikes. Others prefer to add bronze bushing and bearing washers to their designs. Fancy paint jobs are also a common touch to a unique bender.

Several months ago one of the discussion board visitors likened me to Ron Popeil, the television guy who sold the cheap gadgets on television for several decades. Some of you probably remember some of his inventions like the Popeil Pocket Fisherman. My Mom bought one his gizmos back in the sixties. I think she paid about six dollars. It was called the 'Veg-O-Matic' and it worked incredibly well and lasted about thirty years. So in

honor of Ron, who was perhaps the first guy to promote that 'cheap' can sometimes be a good thing, I've decided to call our bender the CBH 'Bend-O-Matic'.

Contributors

As I originally mentioned this particular bender design has been a collaborative effort with design details, tech-tips, and other types of fabrication information contributed by several of the visitors to the Chopper Builders Handbook discussion forum.

Several individuals stand out in this effort and I'd like to acknowledge John Stewart (Hose Dragger) and John Scott (Johnno) just to mention two people out of scores who provided a ton of development effort in bender design and setup information.

Summation

This isn't the end of this article. We'll be preparing a second part that deals with calibrating the bender, die setup, die set comparisons and other technical info needed to get the most from these low cost benders.