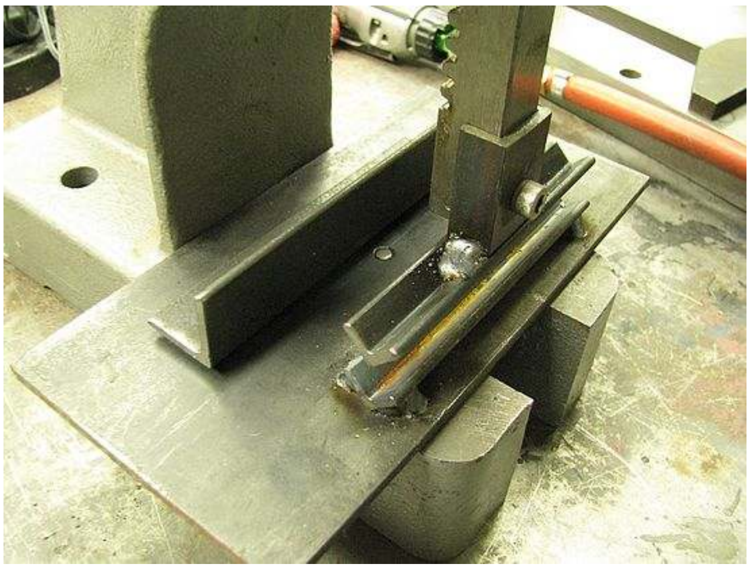
Bending Angles Greater than 90° version 1.2

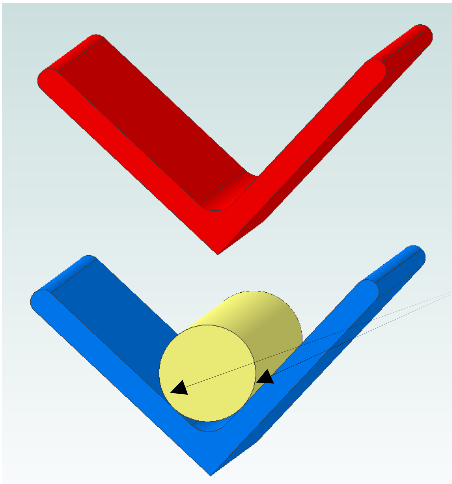
By Bill VanOrden as told to R. G. Sparber



On a recent visit to "Beevo's" shop, I was shown a modification to an arbor press that made bending thin strap easy. A length of ½" angle stock had been welded to a plate with a mating piece of angle attached to the arbor's ram. You can find more details of this machine at:

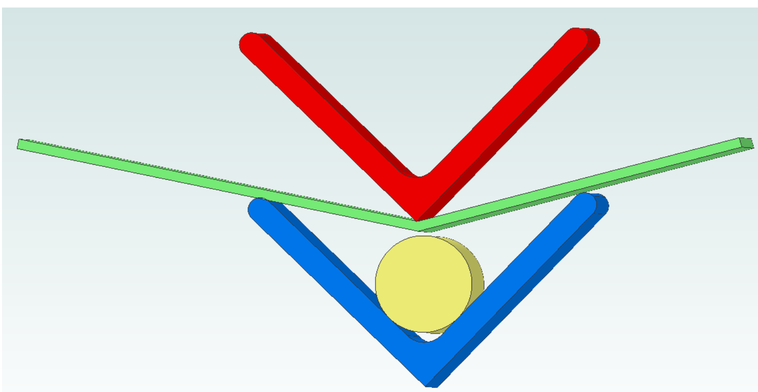
http://www.beevo.org/MetalWorking/Bench%20Press%20Brake/index.htm

What caught my attention was the box of drills next to the press. What was that for?



Beevo showed me how you could drop one of the drills into the lower piece of angle and bend strap to angles greater[2] than 90°. The bends are clean and repeatable. Pure elegance!

There is one minor word of warning. The drill must be in contact with the flats of the angle stock. Errors occur if it rests in the bottom of the V.



It is not hard to use a "cut and try" method to figure out the drill diameter needed for a given bend angle. But since I enjoy using math in my shop, I came up with a spreadsheet to do the job.

[2] I am talking about the "included angle" here. Without the rod, the angle is 90 °. By adding the rod, the angle is shallower so the number of degrees is larger.

Bending Greater Than 90° in a V Brake

direct calculation		
input desired angle:	145.7	degrees
needed diameter rod:	0.201	inches

One time calibration		
selected diameter rod	0.250	inches
resulting angle bent	158.8	degrees
	0.52503	

First you make a test bend with a known drill diameter and measure the resulting angle.

This data calibrates the system.
It lets me directly input a desired angle and be given the needed drill diameter.

general table

desired angle	rod diameter
90	0.000
91	0.005
92	0.011
93	0.016
94	0.021
95	0.026
96	0.030
97	0.035
98	0.040
99	0.044
100	0.049
101	0.053
102	0.058
103	0.062
104	0.066
105	0.070
106	0.074
107	0.078
108	0.082
109	0.086
110	0.090
111	0.094
112	0.097
113	0.101
114	0.105
115	0.108

It also lets me generate a table of desired angles versus needed drill diameters. I have arbitrarily set up the table to be in steps of 1°. This table will be printed out and placed with my brake.

Contact me directly at Rgsparber.ha@gmail.com for a copy of the spreadsheet.

Details of the math are in the appendix.

I welcome your comments and questions.

If you wish to be contacted each time I publish an article, email me with just "Article Alias" in the subject line.

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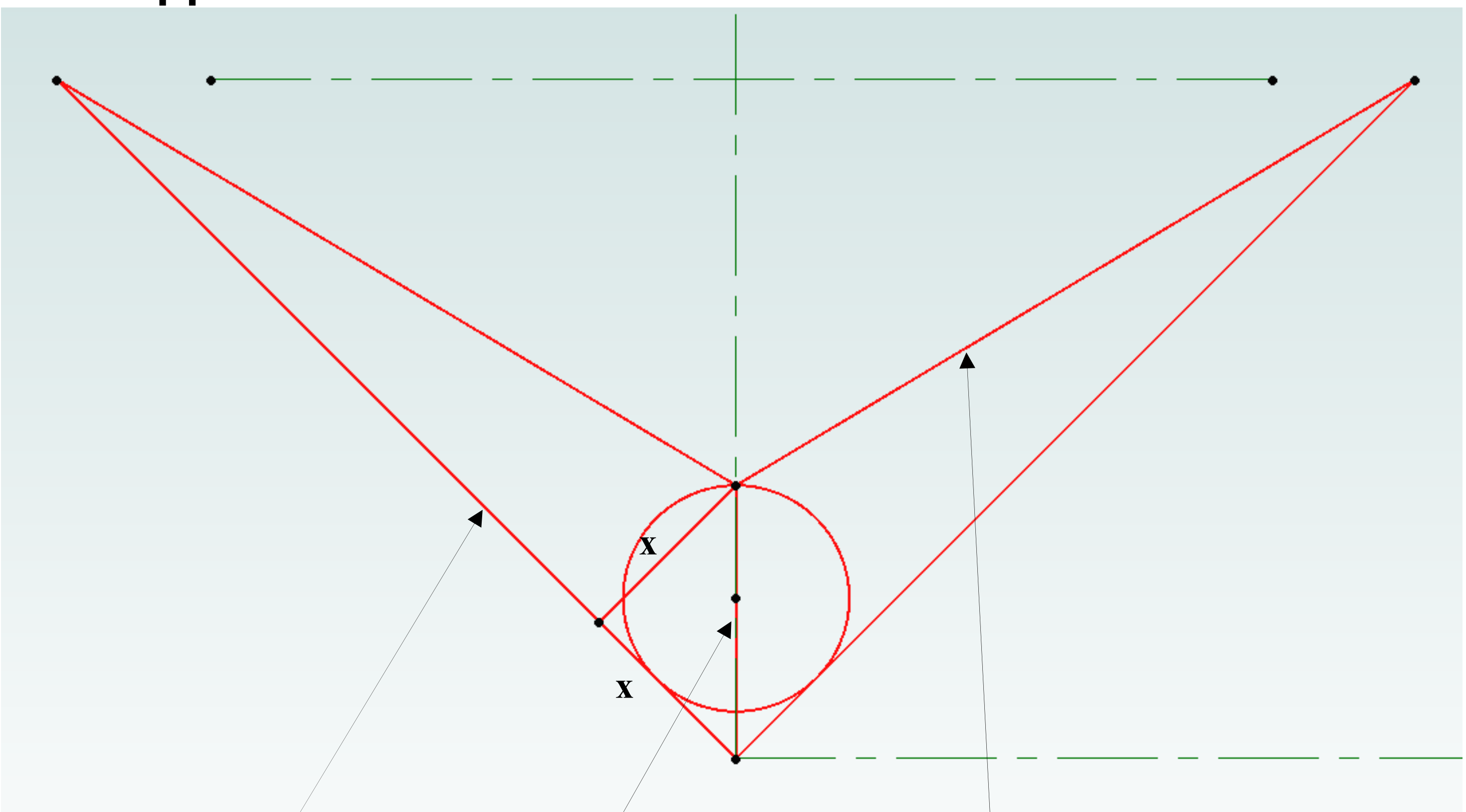
Appendix



The lower V is the angle stock. The upper V is the strap bent to the desired angle. The circle is our rod. The vertical line has a length equal to

$$\left(1 + \sqrt{2}\right) \times R$$

where R is the radius of the rod.

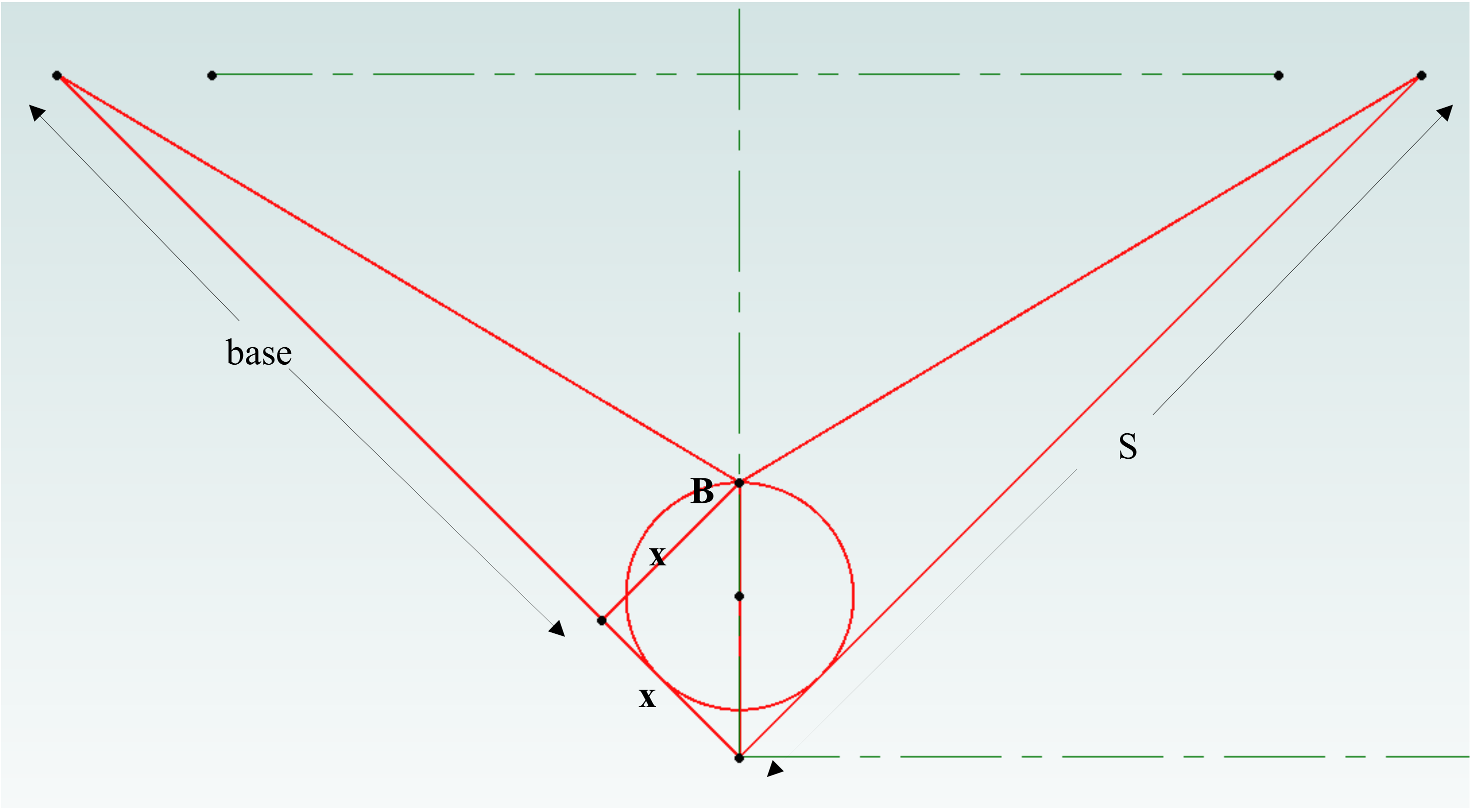
This vertical line bisects the bottom of the angle stock to form an isosceles right triangle. The hypotenuse is our vertical line. The sides are therefore equal to the hypotenuse divided by $\sqrt{2}$

$$x = \frac{1 + \sqrt{2}}{\sqrt{2}} \times R$$

Or

$$x = \frac{1+\sqrt{2}}{\sqrt{2}} \times \frac{D}{2} \qquad (1)$$

Which approximately equals 0.8536 D.



The length of one side of the angle stock is "S". We know that the side of our isosceles right triangle, x, is approximately 0.8536D long so have the base of our larger right triangle

$$base = S - 0.8536D \qquad (2)$$

This gives us the dimensions needed to calculate the angle opposite the base

$$B = \tan^{-1}\frac{base}{0.8536D} \qquad (3)$$

Note that angle B plus 45° gives us the angle between vertical and one side of the strap from the underside. By subtracting this result from 180° we get the angle from vertical to the top face of the strap. Double that number and we have the total included angle of the strap

$$strap\ angle = 2 \times \left(180 - \left[45 + \tan^{-1}\frac{base}{0.8536D}\right]\right) \qquad (4)$$

Which can be rearranged to

$$D = \frac{base}{0.8536 \times \tan\frac{270 - strap\ angle}{2}} \qquad (5)$$

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I don't want to try and measure the base but can use equation (5) to calculate it.

By rearranging terms, I get

$$base = 0.8536 \times D \times \tan\frac{270 - \, strap\ angle}{2} \qquad (6)$$

First I measure the diameter of a rod that fits correctly in the angle stock. Then I bend some strap and measure the resulting strap angle. Plug those values into (6) and solve for base. Plug base into (5) so any desired strap angle will determine the needed diameter of rod. Messy equations but once they are in the spreadsheet there is little fuss.