DIY make your own weeding hoe (using scrap steel with high carbon content)

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1. Introduction:

Three types of hand held weeding hoes were made from scrap steel with medium or high carbon content: L-hoe, T- hoe and chopping hoe (Figure 1 and 2). L-hoes are light weight with small blade surface area; less area for wet soil to stick on to blade. T-hoes provide larger cutting edge. Chopping hoes are heavy; provide greater momentum to cut through thick weeds. A cursory view of garden hoes in tool catalogs was helpful in designing weeding hoes (Branch, 1978 and Mulvany, 1985)

Figure 1 From left to right: 4 inch L-hoe made from bed frame angle; 2 ½ inch L-hoe from rebar; 7 inch T-hoe from shovel; 6 inch T-hoe from coulter blade; 8 inch T-hoe from coulter blade; and 4 ½ inch chopping hoe from notched disk.

Figure 2 Close-up of L-hoe, T- hoe and chopping hoe

Source of medium or high carbon steel include bed frame angle, concrete reinforcement bar (rebar), coil harrow tine (also called field cultivator tine or spring tooth tine), shovel head, coulter disk blade and notch disk blade. Compared to mild steel, high carbon steel is harder, higher tensile strength, hold sharpness of blade edge better, does not wear as quickly and must be heat treated to reduce brittleness (tempering).

High carbon steel bar or rod is cut, heat until red hot, hammer to desired shape with beveled cutting edge, drill bolt holes for handle attachment, and bend to form handle attachment stub. Then the steel is heated to 1550-1800F (840-980C) until orange-red hot and the steel changes from magnetic to non-magnetic (use magnet to confirm); then cool in forced-air with a fan; then reheat to 400F (200C) for 1 hour to reduce the brittleness (tempering), otherwise the harden steel would crack, break or shatter. If the steel blade does not attain sufficient hardness, reheat to ~1550 F (840C) until non-magnetic; quench in oil; reheat to 400F (200C) for 1 hour to reduce brittleness. If oil quenched steel does not attain sufficient hardness, reheat the steel blade to ~1550F (840C) until non-magnetic; quench in water; and reheat to 400F (200C) for 1 hour to reduce brittleness. Test steel hardness by scratching the surface with sharp awl, drilling or filing the surface. Harden steel is more difficult to scratch, cut, drill or file compared to softer mild steel. This is trial-and-error heat treatment of steel with unknown carbon content; start with forced-air cool, before using oil quench, and last choice is water quench. Doing water quench last minimizes the number of broken blades before a suitable heat treatment is discovered when using steel with unknown alloy content. If the steel blade is too brittle, increase the time of heat treatment to 2 hours at 400F

(200C) and repeat tempering treatment a second time (heat to 400F for 2 hour, cool steel then heat again to 400F for 2 hours).

Tempering treatment depends on alloy content of steel (which is unknown) and end use of steel. Use lower temperature if greater hardness is desired; higher temperature if toughness is desired: temper at 300-400F (149-200C), at least ½ hour preferably 1-2 hours (Digges et al); see additional notes on tempering below; see references for additional information on heat treatment of steel.

2.0 L-hoe

L-hoes were made from steel bed frame angle, concrete reinforcement bar (rebar) and coil harrow tines (Figure 3). They have 2 ½ to 4 inch (63-102 mm) cutting edge and 4 inch (102 mm) handle attachment stub. The 4 inch (102 mm) handle attachment stub provides extra clearance for soil to flow away from the 90 degree bend and reduce soil accumulating at the bend.

Figure 3 L-hoe made from 1 1/4 x 1 1/4 inch bed frame angle, 3/8 inch diameter rebar and 3/8 inch coil harrow tine

Advantage and disadvantage of L-hoes are

a. Light weight, easier to carry and maneuver around crops with less effort; the weight difference is noticeable when weeding for extended time. However, light weight hoes do not provide sufficient momentum for chopping thick weeds. For thick or dense weeds, use a heavy chopping hoe, described below, or use commercially available rectangular hoe or eye hoe.

b. L-blade has small surface area for moist soil to stick on to metal blade, consequently less need to scrap off wet soil from blade. If soil is loose, dry, and does not stick to blade then the need to scrap off soil diminishes.
c. The small surface area has less frictional resistance when gliding below soil surface. However, blades with small surface area are not suited for furrowing, digging holes or moving soil.
d. L-hoes have narrow blade suitable for weeding closely spaced crops.
e. The optimal length of the L blade cutting edge is 2 to 4 inches (51-102 mm); at greater than 4 inches (102 mm) the blade flexes excessively the 90 degree bend. For longer cutting edge make T-hoe, described below, or use commercially available rectangular hoe.

2.1 The bed frame steel used here is 0.11 inch thick 1 ¼ x 1 ¼ inch angle, (2.8 x 32 x 32 x mm) (Figure 4). Cut the bed frame corner with a hack saw or oxy-acetylene torch to make flat steel bars.

Figure 4 From left to right: cutting torch used to cut bed frame at corner; section of bed frame; two 7 1/2 inch flat bar; flat bar with half of its length hammered and beveled for cutting edge; and two L-hoe blades made from bed frame.

Make cutting edge by reducing the thickness of the bed frame flat bar to 0.8 inch (2 mm) on half of the length; heat steel to red hot (Figure 5) and flatten with hammer (Figure 6). After flattening, the flat bar will be wider, longer and slightly curved, but does not affect the cutting ability.

Figure 5 Heat flat bar to red hot

Figure 6 Flatten half of length to make cutting edge 0.08 inch thick

Figure 7 Heat and bend 90 degrees

Sharpen the cutting edge with grinder. Drill 2 bolt holes for handle attachment. Heat and bend steel 90 degrees at ½ inch (13 mm) behind cutting edge to form 4 inch (102 mm) cutting blade and 4 inch (102 mm) handle attachment stub (Figure 7 and 8).

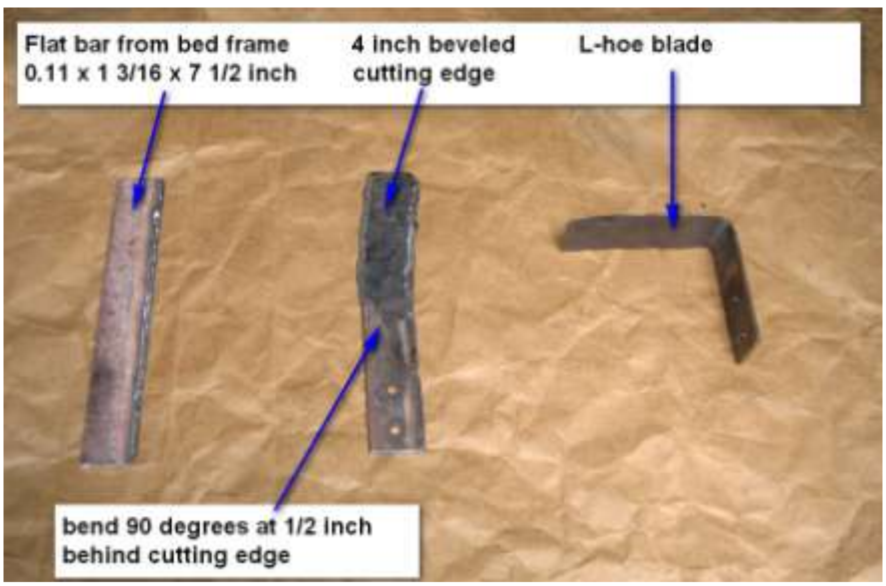

Figure 8 Left to right: blank flat bar from bed frame angle, 0.11 inch thick; flat bar with hammered and beveled cutting edge, 0.08 inch thick and drill 2 bolt holes for handle attachment; L-hoe blade after heat treatment

After shaping the L-hoe blade, heat steel to red hot, until it changes from magnetic to non-magnetic; then cool in forced-air with a fan; then temper by heating in oven at 400F (200C) for 1 hour (Figure 9). If the blade is not sufficiently hard, re-heat steel to red hot until non-magnet; quench in oil; then temper by heating in oven at 400F (200C) for 1 hour. If the blade is still not sufficiently hard, re-heat to red hot until non-magnetic; quench in water; then temper by heating in oven at 400F (200C) for 1 hour. If blade is too brittle, increase the duration of temper treatment to 2 hours and do a second tempering treatment. Make wood handle, described below, and attach blade. Completed L-hoe shown in Figure 1 and 2.

Figure 9 Hoe blades are baked in oven at 400F for 1 hour to temper steel to reduce brittleness.

2.2 L-hoe made from concrete reinforcement bar (rebar) 3/8 diameter x 7 inch (9.5 x 178 mm). For the cutting edge, heat rebar to red hot (Figure 10) and flatten a 2 to 3 inch (51-76 mm) section of rebar to 0.08 inch (2 mm) thick (Figure 11). Bend rebar 90 degrees at ½ inch (13 mm) behind the cutting edge to form handle attachment stub (Figure 12). Attach L-hoe blade to hoe handle.

 **Figure 10 Heat rebar to red hot**	 **Figure 11 Flatten 3 inch of rebar to make cutting edge**	 **Figure 12 Heat and bend 90 degrees**

2.3 L-hoe made from 3/8 inch (9.5 mm) diameter coil harrow tine is same as for 3/8 inch rebar (Figure 13). Cut a 7 inch (178 mm) length of coil harrow tine. Heat tine to red hot and flatten a 2-3 inch (51-76 mm) section of the 3/8 inch (9.5 mm) diameter tine to 0.08 inch (2 mm) thick for a cutting edge (Figure 14). Drill hole at shank for handle attachment. Bend tine 90 degrees at ½ inch (13 mm) behind the cutting edge to form handle attachment stub (Figure 15). Attach L-hoe blade to hoe handle. (The coiled section of tine can be uncoiled by heating to red hot and straighten on vice.)

 **Figure 13 Left to right: 3/8 inch diameter coil harrow tine; tine hammered to form cutting edge; tine bent 90 degrees**	 **Figure 14 Heat tine to red hot and flatten to 0.08 inch thick for cutting edge**	 **Figure 15 Heat tine to bend 90 degrees at ½ inch behind cutting edge**

3.0 T-hoe made from shovel

Steel from a discarded shovel head with cracked midrib was used to make a T-hoe for weeding (Figure 16 and 17). The side of a shovel head was cut to T-shape using an oxy-acetylene torch; then heated until the steel is red hot to flatten lip and arch of the shovel steel; drill 2 holes on leg of T for handle attachment; bend leg of T 90 degrees for handle attachment stub; heat to red hot until steel changes from magnetic to non-magnetic then cool in forced-air with a fan; and baked in oven at 400 F (200C) for 1 hour to temper the steel. The dimension of cutting edge of blade was 0.065 x 2 ½ x 7 inches (1.6 x 63 x 178 mm). The slight shovel curvature on blade was retained, the blade is not flat. Attach T-hoe blade to hoe handle.

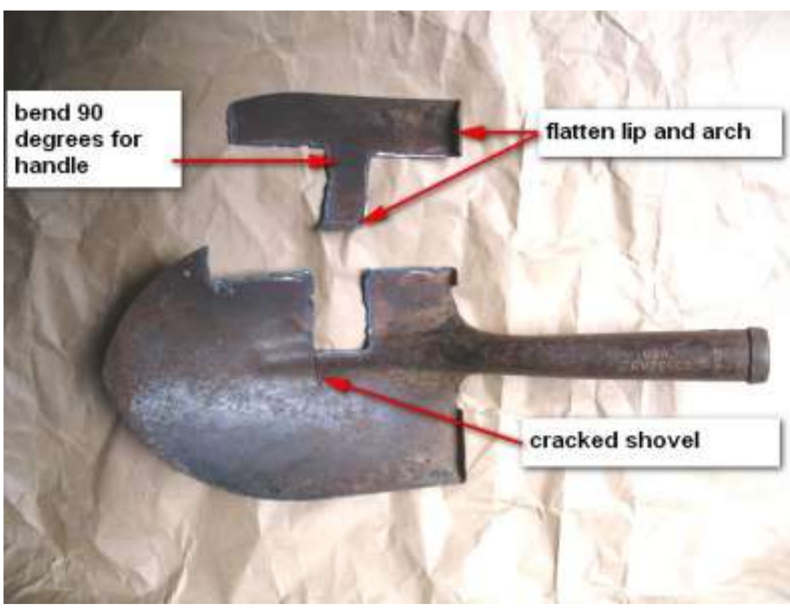

Figure 16 T-shaped steel, version 1, cut from shovel with oxy-acetylene torch

T-hoe, version 1 had a straight and narrow handle attachment stub. Small cracks developed at corner of the 90 degree bend, probably the result of improper heat treatment.

Figure 17 T-hoe, version 2 with wide shoulder handle attachment stub

Wide shoulder T-hoe, version 2 (Figure 2 and 17), provides more strength at the 90 degree bend, compared to version 1. T-hoe made from the point of the shovel FAILED to develop sufficient hardness even when quenched in water. The handle attachment stub bent. Cause for failure unknown, but excessive heating and reheating thin steel may have boiled off too much carbon resulting in low carbon steel instead of high carbon steel; insufficient carbon in the original shovel; or steel was too thin.

3.1 T-hoe made from a broken coulter disk blade

A 0.072 inch thick x 13 ½ inch (1.8 mm x 343 mm) diameter coulter disk blade, with cracked hub, was repurposed into a T-hoe (Case-IH #603013R2 grain drill disk; later version of 603020R2 is 0.10 x 14 inch diameter; a John Deere equivalent is K202M, 0.082 x 13 ½ inch diameter). A section of the coulter blade was cut into T shape using an oxy-acetylene torch (Figure 18); drill two holes on leg of T for handle attachment; heated to red hot and bend leg of T 90 degree for handle attachment stub; heated to red hot until steel changes from magnetic to non-magnetic; then forced-air cooled; and baked in oven at 400F (200C) for 1 hour to temper the steel. Attach T-hoe blade to hoe handle.

Figure 18 Coulter disk blade and T-hoe, version 1 blades with narrow handle attachment stub

4.0 Chopping hoe made from notched disk blade

A notched disk blade, originally 18 inch (457 mm) diameter and wore down to 16 inches (406 mm). It was repurposed to a heavy chopping hoe with 0.15 inch thick 4 ½ inch (3.8 x 114 mm) cutting edge and weighed 0.85 pounds (0.385 kg) (Figure 19 and 20). Its heavy weight provides momentum for cutting dense weed and shrubs but too heavy for general weeding.

Figure 19 Worn notched disk blade, section of notched disk blade and chopping hoe made from notched disk blade

Figure 20 Section of notched disk blade, heated and bent to form hoe attachment stub

Cut a section of the notched disk blade with oxy-acetylene torch; drill 2 bolt hoes for handle attachment; heat and bend 90 to make handle attachment stub; and temper in oven at 400F (200C) for 1 hour. Attach chopping blade to hoe handle.

5.0 Hoe handles

Use suitable lumber such as maple or ash to make hoe handles. Cut lumber into 1 1/16 inch square x 6 feet long (27 x 1830 mm) with a table saw (Figure 21). Cut the square into an octagon with 45 degree cuts at 1/3 of the height for each of the 4 corners (Figure 22). Use hand plane and sand paper to smooth out edges (Figure 23).

		
Figure 21 Cut lumber to 1 1/16 inch square with table saw	**Figure 22 Make octagon with 45 degree cut at 4 corner using table saw**	**Figure 23 Use hand plane and sand paper to smooth out octagon handle**

6.0 Additional notes

1. Tempering
    a. "*The tempering temperature depends upon the desired properties and the purpose for which the steel is to be used. If considerable hardness is necessary, the tempering temperature should be low; if considerable toughness is required, the tempering temperature should be high…Good practice requires at least ½ hr (or, preferably, 1 to 2 hr) at tempering temperature for any hardened steel… Thin sections need not be soaked as long as thick sections, but if different thickness exist in the same piece, the period required to heat the thickest section uniformly governs the time at temperature. A rule frequently used is to soak ½ hr/in. of thickness.*" (Digges et al, page 13-14, 9)
    b. "*Tempering quenched-steel … from 148 to 205 C (298 to 401F) will produce a slight reduction in hardness, but will primarily relieve much of the internal stress. In some steels with low alloy content, tempering in the range of 260 and 340C (500 and 644F) causes a decrease in ductility and an increase in brittleness, and is referred to as the 'tempered martensite embrittlement' (TME) range. Except in the case of blacksmithing, this range is usually avoided. Steel requiring more strength than toughness, such as tools, are usually not tempered above 205C (401F). Instead, a variation in hardness is usually produced by varying only the tempering time. When increased toughness is desired at the expense of strength, higher tempering temperature, from 370 to 540C (698 to 1004F) are used.*" (2022 entry in Wikipedia: Tempering (metallurgy)).
    c. *"Note that the impact energy drops significantly in the tempering range of 500-550F. It is now customary to call this loss of toughness, tempered martensite embrittlement, TME (An old name for it is 500F embrittlement.) Because of this problem steels intended for use at high strength levels are not tempered above around 400F (205C). For applications requiring high*

toughness with less strength required, tempering is done at temperatures above around 700F (370C). Notice that at temperatures of 1000-1200F excellent toughness is obtained. Of course the hardness goes way down… tempered martensite embrittlement (TME) occurs for tempering in the range of 500 to 650F, and this range is to be avoided in tempering." (Verhoeven page 96-96, 101)

2. Below is a steel test strip, spot heated at blue area, showing gradation of oxide colors corresponding to decreasing temperatures away from blue spot-heated area (Figure 24). Oxide surface color can be used as temperature guide when tempering steel.

Figure 24 Gradation of surface oxide color on steel test strip that was polished and spot heated at blue area with hand held propane torch.

Pale yellow	430F	220C
Gold yellow	470F	240C
Brown	490F	255C
Purple	530F	280C
Dark blue	600F	315C

(from Verhoeven, 2005)

3. Forced-air cool using a fan provided sufficient hardness for steel used in the above examples, with unknown alloy content.
4. Water quenched blades require more control of temperature and duration of tempering; otherwise they crack, usually at the 90 degree bend.
5. Quenching in water did not provide sufficient hardness for T-hoe made from point of shovel head; the handle attachment stub bent.
6. Slow cooling to room temperature in sand bath did not provide sufficient hardness for T-hoe blade using the "IH" coulter blade steel; handle attachment stub bent.
7. AgriSupply (www.agrisupply.com) in a 2019 web page listed disk blades made from 1070 steel (0.70% C) made in India; 1080 steel (0.80%C) made in Brazil and 65Mn steel = 1065 manganese steel (0.65% C) made in China. Jersey Shore Steel (www.jssteel.com) makes bed frame steel from railroad tracks with 0.65% carbon plus 0.85% manganese. Knowing the alloy content of steel allows

proper heat treatment; see Heat Treater's Guide: Practices and Procedures for Irons and Steels. ASM International, 2nd edition (1995)

8. Shoup parts(www.shoupparts.com), Herschel parts (www.herschelparts.com) , and John Deere (www.johndeere.com) sell disk blades, coulter blades, and coil harrow tines (also called spring tooth tine, field cultivator tine, and harrow tine).

7.0 References

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8.0 Acknowledgment

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Mention of manufacture's name is for reader's benefit and does not imply endorsement from I-Tech.