Got it Together Part II by Henry Sibenaller

(Editor's note: Part I of Henry's interesting article can be read in the September 2009 newsletter or can be seen on the PAABA web site! Henry took a class by Jerry Darnell, an expert blacksmith who specializes in 18th century hardware. This article continues to focus on forge welding, a goal of many students.)

Fire Building and Fire Maintenance – So how do you know if welding temperature is achieved and how do you get welding temperature or welding heat? In a gas forge it all depends on the forge design and the proper combination of fuel and air supply. Some gas forges may not be able to achieve welding heat, it depends on the forge.

In a coal forge there are several factors to consider:
The quality of the coal
The design of the forge and forge blower system
Proper fire building and management, including proper coal/coke arrangement on the forge table
Experience in knowing what welding heat looks like in the forge.

Coal Info - Metallurgical coal has a heat content of about 12,000 BTUs per pound, and when burned the resulting coke ideally has a sticky or spongy consistency in the vicinity of the heated forging chamber. It will also be slow to produce clinkers in the bottom of the fire pot. If the coal does produce clinkers quickly it will be necessary to remove them often, possibly before each forge weld, in order to maintain a suitable fire. You know you have a clinker when you look into the fire and see dark spots that will not burn. In addition to not burning clinkers restrict the flow of air through the fire and will eventually prevent welding heat from being achieved.

Fire Pot Info – The forge and forge pot needs to be well designed. The forge pot needs to be deep enough to allow the fire to burn in a way that consumes all of the oxygen in the air before it reaches the level of the parts to be welded. It is also desirable to be able to shake down clinkers and dump them through the bottom of the fire pot. Good fire pots like this are available from a number of sources, but you can purchase a CENTARVULCANDP from Centar Forge for $ 180. If the parts to be welded are placed too low in the fire they will be exposed to oxygen at a high temperature and will scale up and become unweldable.

The forge table also needs to be big enough to allow you to build a big enough fire so that a welding chamber can be constructed over the fire pot by building an overhead coal structure. This is done by piling up burning coke in the fire pot and then raw coal is piled up over it. As the fire heats the unburned coal it starts to be converted into coke and to cause it to stick together in a way the supports the coal over the fire pot. The smith then pokes a hole in the side of the mound of coal, on the side facing the smith, opening up a chamber in which the forging temperature can be achieved and also providing access for placing the parts to be welded into the fire. The finished fire chamber shape looks something like an igloo or coke oven. The parts should be located on or just above the white hot part of the fire in the part of the fire where there is a reducing atmosphere, not pushed down into the coke where the oxidizing fire is located. A "deep fire pot" that provides sufficient space and time for all of the oxygen to be burned up before the flame reaches the rim of the pot works best. It is often necessary to stick a poker into and under the coke at the bottom of the fire and then gently pry or lift the coke slightly off the inside bottom of the fire pot to allow air to flow through the coke and promote intense burning. It is the flow of air through the coke with sufficient flow and pressure that produces the welding heat.

Blower Info – One reason that smiths are often unsuccessful at achieving welding heat in a coal forge is that they just don't have a sufficiently powerful blower. Squirrel cage blowers can produce a lot of air flow but only at low discharge pressure. In a coal forge it is necessary to have sufficient pressure to force the air through the clinkers, if they are there, and then through the burning coke at a high enough flow-rate to efficiently burn the coke. To do this it takes pressure, more pressure than a squirrel cage blower can produce. If there is insufficient pressure, as is often the case when a squirrel cage blower is used, welding heat can't be achieved. The blower needs to be able to produce enough air pressure to force the air through the burning coke in the fire pot. To do this a paddle type blower is ideal, like the old time hand cranked Champipn 400 that smiths used to use, before they had electric motors and motor controllers. A good alternative and very handy modern day motor driven forging blower with a variable speed drive is the PB50VS, available from Centar Forge for $ 400.

Jerry says, "Having a good fire pot and proper blower is critical to having forge welding success, so if you want to be able to forge weld, you can look at it this way, the fire pot and blower together will not cost you more than a good set of golf clubs, a hunting rifle, or even a good self propelled lawn mower, and they will last a lifetime."

Identification of Forging Temperature – So how do you know if you have achieved a fire with adequate welding heat? What does it look like? Welding heat is a local area inside the fire chamber that you built that is at least as hot as lemon yellow and is approaching white hot color. If you look at a white hot fire too long you will see spots before your eyes, which is definitely not recommended. It is also the heat at which an unfluxed steel rod will just start to spark and start to burn up, however a fluxed rod or part will just glow white hot. It is also the heat that will cause the flux to more than just melt, it will shimmer. You should be able to recognize it when you see it.

Weld Joint Design – The last thing that I want to discuss is the design of the parts to be welded. The critical thing is to provide a way for the melted flux, with the oxidized impurities in it, to escape from the joint to be welded. This is done by having at least one, but generally both, of the parts shaped to be convex relative to each other, as shown in the picture below. Then as you forge the parts together, using quick successive blows, the flux is smoothly squeezed out of the joint as the parts are progressively welded together. Because the parts are being hammered together they will squeeze out and become thinner, so it is often necessary to upset the parts before shaping and welding to provide the added material needed to end up with a properly shaped finished welded assembly. So you need to provide the additional material to be forged out before starting the weld, the parts need to have convex surfaces, and you don't want to hit the parts so hard that they squish out of shape. After you have successfully welded parts together you will not want to forge or work them while they are less than red hot, because doing so will often cause them to separate.

Properly shaped cylindrical rod end – ready for forge welding to a similarly shaped part.

Summary follows on page 8!

Got it Together (continued)

Summary:

1. Coal forges are generally better for forge welding than gas forges, but it is possible to forge weld certain assemblies in a gas forge.
2. For coal forge welding you need a deep fire pot and a blower with enough pressure to blow enough air through the clinkers and efficiently burn the coke.
3. The inside of the forge fire, at the location of the parts to be welded, needs to be in a reducing atmosphere condition.
4. Flux is applied to the heated parts to clean the steel surfaces, prevent oxidation, lower the welding temperature, and protect the surface adjacent to the weld from melting.
5. The parts to be welded need to be properly shaped and will generally be convex in shape where they are to be joined.
6. Heat parts up to welding temperature, just below white hot.
7. You need to make the weld quickly, before the parts to be welded cool down below welding temperature.
8. You need to use quick blows that are applied in a way that smoothly and progressively squeezes the flux out of the joint and at the same time welds the parts together.
9. You will need to practice forge welding, because it takes more skill and coordination than might be expected.

Having a skilled and patient teacher, like Jerry Darnell, helps tremendously.