Injector design and operation

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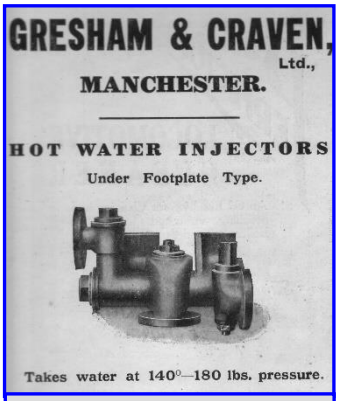
GETTING OUT OF HOT WATER

There once was a man called Giffard
Who found pumps were too heavy by far
So he came up with a wheeze
To feed water with ease
But some folk find it quite hard.

It seems as though about half of the conversations round a model steam locomotive involve injectors, these essentially quite simple gadgets produce a disproportionate amount of hassle to their users. Locomotive owners seem to fall into two categories, those involved in public running and other events who seem to be virtually unaware of their injectors and others who fiddle with valves and waggle hand pump handles at every opportunity. Why do injectors "play up" so much?

First a bit about them: about 1850 Henri Giffard was involved in the development of balloon flight using the only form of power then available, the steam engine, a fairly risky business you may think considering the proximity of the hydrogen filled envelope. As in all aviation work the weight of the power unit was critical and in his effort to reduce it he found a way of replacing the feed pump with a more compact device – the injector. The idea was quickly adapted for locomotive use as the only water feed until then had been by engine driven pumps, the injector allowed water to be put into the boiler with the locomotive stationary thereby relieving drivers from the chore of running up and down a short stretch to fill up, or even worse spin the wheels against a braked tender or buffer stops. I have yet to see this in 5" gauge.



Editor's note: Our able research staff turned up this century-old ad. How about pipe flanges in our sizes? 14 BA taps anyone?

To most people the injector seems to be a contradiction in itself, how can steam taken from a boiler at 80psi shove water past a clack valve held closed by 80psi? I have at hand a book with the equations applicable to the thermodynamics, believe me, you don't want to know. It can be described in general terms as the conversion of the heat and pressure energy of the steam into the kinetic energy of a fast-moving stream of water. Imagine an 8 oz hammer resting on a partially driven nail: no movement, now let it speed up and fall on to the nail: it moves. Several firms were involved in the supply of injectors and names such as Gresham & Craven and Metcalf & Davies, spring to mind. As usual the big boys like the LNWR, GWR, etc. designed and made their own but other companies with smaller engineering facilities found it more convenient to buy them in. In a similar way, some model engineers have the expertise, skill and interest to make their own injectors but the majority use those supplied by the trade. From this point the specialists can skip to the end as my only experience has been with bought-in items. My first two engines were constructed following "words and music" from the Isle of Wight and as befits designs for beginners they had the usual combination of axle pump and one injector: I relied on the former! At the same time the designer, Don Young, was pushing the "two injectors only" policy in his magazine LLAS. My next engine the 'Hunslet was to my own design but although I followed DYD principles where ever possible, when it came to water supply, I stuck to the pump + injector arrangement. I am not sure if it was the ease of plumbing a larger locomotive or what I had gleaned from reading but the injector performed reliably from day one. As sure as eggs the pumps eventually needed maintenance and being buried down within the frames, they didn't get any, they were disconnected and an identical injector was fitted on the other

side. At the next big maintenance, the pumps were stripped out and an improvement in running was noted, two axle pumps certainly soak up power. So, for several years now I have used only injectors and have begun to understand the sneaky little beasts.

The injector is a simple device with no working parts to go wrong and virtually no maintenance requirements so why are we not totally in love with them? Well, like other things in life, they react to the world around them and have their own dislikes so it is essential to get things right. There are four items to look at: the injector itself and the three pipework systems that connect on to them. The injector shouldn't be a problem as all we need is to get a good one. This is not difficult I have three locomotives each equipped with pairs from different well-known suppliers, the oldest having been in constant use with Sussex water for about 12 years with no more maintenance than the odd soak in vinegar. Some pick up more cleanly than others but they all put water in when required. Be careful about fitting an old injector with no history or with a limited pressure range, it might well work but if not, chasing red herrings can be very frustrating.

About the only way to damage an injector is to jam it up with something so remember that our cone diameters are scaled down but the bits in the water are from the full-size world: good filters are imperative! Most available injectors pick up over quite a range of pressures (50 to 100+ psi), it is always a good idea to ask before purchase if it will work at your pressure and at least one supplier numbers each injector and provides test data of pressures and delivery.
It is worth mentioning that some makes of injector are "lifting injectors", i.e they are designed to act a bit like an ejector and if the steam is put on first air is sucked out of the water line providing useful pull on the water. They will also pick up again if a slug of water comes along in the steam.
Now to the plumbing: steam-in, water-in, water-out. Needless to say, make sure the pipe connections are properly silver soldered, after preparing a section of pipe put a finger over one end and suck the other until you can maintain the vacuum by the tip of your tongue, do this after cleaning off the congealed flux. Let's look at the connecting systems:

Steam-in is a cinch, plenty of oomph to push it around, a pipe one size less than for water is fine and sufficient steam gets past quite a small aperture in the valve, bends not important. The only thing to watch is making sure that the steam is supplied from a high point such as a manifold, injectors need dry steam to work.

Water-out (delivery) is pretty painless, the injector will easily force the water round curves and past the clack. This latter has to be reliable, if it fails to seat properly the dribble of steam not only heats the injector but tends to push water back up the supply pipe making pick-up impossible. If additional reliability is sought an additional clack can be plumbed into the line after the output union of the injector. Do limit the ball lift of the clack, ¼ ball diameter is sufficient, I recall an injector that seemed to pick up only to go into full overflow an instant later because the water was forcing the ball into the output hole in the clack.

Water-in is the most usual cause of failure to pick up as the pressure available to move the water through the filter, water valve and pipe is effectively the partial vacuum created in the injector, at best a few psi. This is the line that has to be easy flowing but I have found elbows are not an impediment if the way through is a bit bigger than the pipe ID. The real bugbear is ingress of air since even small amounts in the feed line will seriously affect performance. This means that all connections must be tight and the water valve must seal against air, give it the suck test if unsure. Filters must be easily accessible for cleaning and water should be fed to the front of the tender via a large diameter pipe so that there is negligible pressure drop and less chance of sucking air at the valve. Side tank engines can have simple homemade screw down valves in the tank floor operated by spindles passing through the tank tops and being submerged no air can enter. Flexible connections must be rigid enough not to collapse under the suck.

So, what to do if the dratted thing refuses to work? It is a bit of a bind but each element at a time must be tested so as to eliminate possible causes. Start with the water feed; fit a temporary rubber pipe fed from a raised funnel or tank, if this cures the problem then you know where the fault lies. Now for the delivery side: slacken the pipe at the injector and see if you can squirt hot water everywhere, if you can then the clack has an obstruction or possibly it is too small. The final resort is to test the injector itself on another engine or ideally a test rig. Our clubs are always doing new things and making improvements: what about a club injector test rig that members could borrow?

The good news is that once an injector works well it is unlikely to play up unless blocked by debris (expensive) or a water valve becomes leaky (cheap to fix). Happy boiler filling!