Injectors

By Chris Leggo

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SUMMARY OF TECHNICAL TALK GIVEN NOVEMBER 8, 2002

BUILDING COPPER BOILERS

Our Boiler Series touched on steel boiler construction, but not too much on copper boilers. John Lisherness had a good suggestion on how to correct that. Rather than try to redo and present what has been written already, we should simply refer prospective copper boiler builders to the key writers in the field. The British view on the subject is exemplified by Martin Evans through his many articles in Model Engineer and by Alec Farmer in his book *Model Boilers and Boilermaking*. In the USA, Kozo Hiraoka's articles in *Live Steam* are the things to study.

Interestingly enough, the technique of copying the masters is not new. The October 2002 issue of *Smithsonian* magazine had an article on page 76 called Master Class. It describes how young artists copy existing paintings by noted artists as a way to develop their own skills. The impressionist painter Degas said,"--- and it's only after having proved yourself as a good copyist that you can reasonably try to do a still life of a radish." It should not be hard to extend that concept to the world of model engineering. Study the construction techniques of the authors noted above and try your hand at constructing a boiler from one of their designs.

INJECTORS

Operation

Chris Leggo's talk for the November meeting was about injectors. He started by showing a ten-to-one photographic blow-up of an injector cross-section. It was a startling photograph because Chris made it by actually sectioning a working injector to see how the various components were arranged. He did the sectioning by filling the injector with clear epoxy then sawing the injector apart lengthwise. That's enough to bring tears to one's eyes!

The first nozzle encountered in the injector converts the incoming steam pressure to a steam jet of very high velocity. The second cone, made in either one or two pieces, combines the steam jet from the steam cone with the incoming water. The water condenses the steam and the mixture exits the combining cone at a high velocity. Chris pointed out that a properly made and functioning steam and combining cone can shoot a stream of water 25 to 30 feet before hitting the ground. The third cone is where the "magic" is performed. The delivery cone is actually a reversed nozzle, called a diffuser. Here the incoming low pressure, high-speed jet of water is discharged at a higher pressure and lower speed. The outlet pressure can be many times the inlet steam pressure and therein is the injector's secret on how it delivers water at a pressure higher than its inlet steam pressure.

Testing

Although there is now quite a bit of literature on how to build an injector, Chris cautioned that there are enough uncertainties to warrant building a test bench. Besides, testing is

half the fun. Figure 1 shows the arrangement Chris used to test injectors he built and repaired.

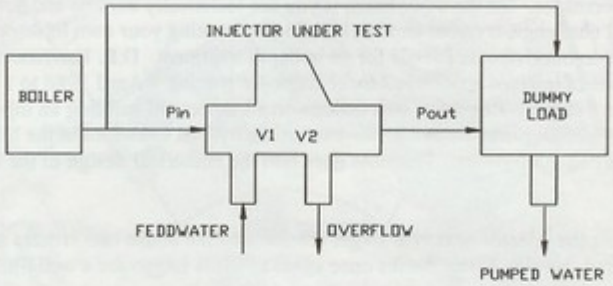

FIGURE 1 SCHEMATIC OF INJECTOR TEST SET-UP

The dummy load avoids loading the boiler with excess water, while providing the same boiler load to the injector. Chris monitored starting range, pumping range, and dry range. Typical values obtained were 60 to 135, 135 to 20 and 110 to 70 PSI. Notice the pumping range is larger than the dry range. The output pressure was typically 150% of the inlet steam pressure. V1 and V2 refer to spots in the injector where Chris measured the vacuum when diagnosing defective injectors.

Injector Water Supply

If an injector can lift its own feedwater, say several feet in full size practice, it's termed a lifting injector. On the other hand, if the water supply must be at the same level as the injector, it's called non-lifting. The ability of an injector to lift its own feedwater depends on the steam jet being able to exhaust all air from the water line. Thus, the injector must also be an ejector until the feedwater reaches the combining cone. Then it functions as an injector forcing the feedwater into the boiler.

Exhaust Steam Injector

If the operation of the live steam injector seems magical, consider an injector that operates on exhaust steam and can force feedwater into a boiler. The secret here is that the velocity of a steam jet issuing from an orifice is only slightly dependent upon the inlet steam pressure. For example, the velocity at 100PSI is 1420 FPS and at 15PSI it's 1340FPS. If the orifice size is adjusted for the density of the steam in each case, the exhaust injector is equal in performance to the live steam one. In practice, the ideal is not realized and one solution is to introduce a bit of live steam to improve the performance of the exhaust injector.

Conclusion

If you are plumbing a steam locomotive and are in a hurry, buy an injector and install it. However, do remember the points discussed here (and in the references) to enjoy the best possible performance. On the other hand, is you are technically curious and get a kick out of a technical challenge, try your hand at building and testing your own injector. Once again we turn to our overseas friends for an in-depth treatment. D.E. Lawrence published a 13 part series of injector articles in *Model Engineer* starting 4 April 1986 to 17 October 1986. This is a step-by-step set of instructions on all aspects of building an injector. *Australian Model Engineer* carried a two-part article by Ted Crawford in the Nov/Dec 1999 and Jan/Feb 2000 issues. This note goes into the numerical design of the injector components.

We will revisit the injector next year so get cracking on the above two articles and the references cited therein. Many thanks once again to Chris Leggo for a well illustrated talk.

WELCOME TO THE NEW GGLS MAINTENANCE SHOP

The new maintenance shop is now essentially complete. The only things remaining are to complete the air system plumbing and finish organizing. Although the shop is primarily for maintaining the club engines, we anticipate that it will be available a good deal of the time for individual member's use. Two transfer carts are available, each five feet long. They will support the club Pacific and tender together or the Pacific alone and another engine. Club engines will have priority, but it is anticipated that scheduling conflicts will be minimal. Before using a cart, check with the Rich Lundberg (shop foreman) or Kirk Lindstedt (club locomotive chairman).

The shop is intended to be a mechanic's facility, not a machine shop. A small drill press, grinder and abrasive cutoff saw will be available to start. Other power tools may be added later if there is a need. We are currently sorting out available hand tools and will slowly improve the collection, but users are encouraged to bring their own tools. We will have an inexpensive set of drills for the drill press.

Donations of tools or equipment are welcomed. However, any donated equipment must be in good working order and be pre-approved by the shop foreman, Rich Lundberg (415 924-2167 or www.luckylundy@attbi.com). Any unapproved item left in the shop is subject to removal and disposal without notification. As needs develop, we will advertise for donations in the Call Boy. Something we would like is a rolling mechanics tool chest. If anyone has an old one or is closing out a shop, please give us consideration.