Federation of Model Engineering Societies

3-D CAD Design of a novel 5" locomotive

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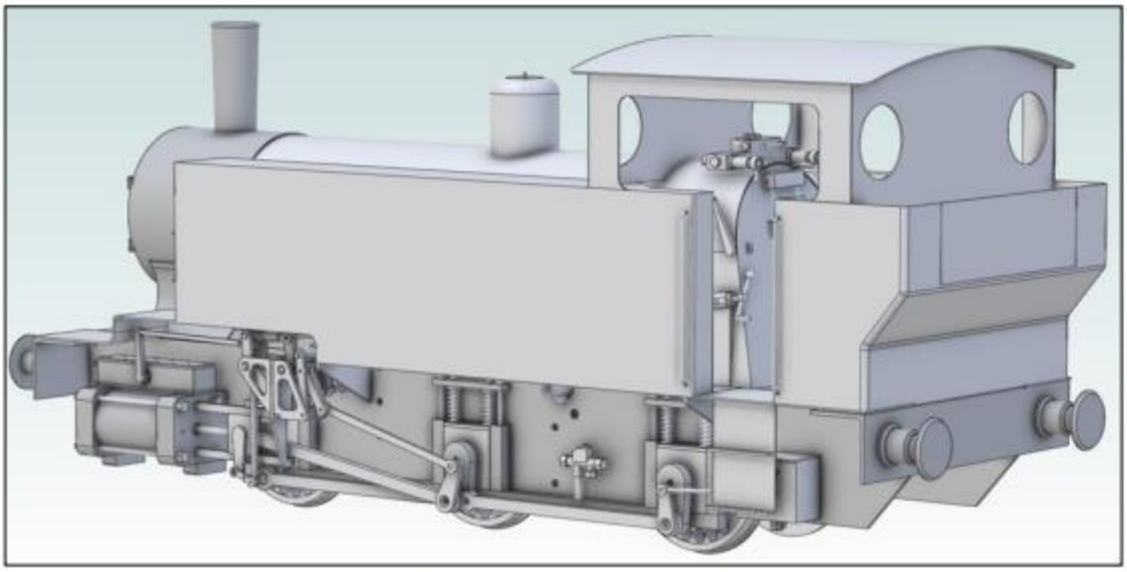
5" gauge freelance 0-6-0 loco project

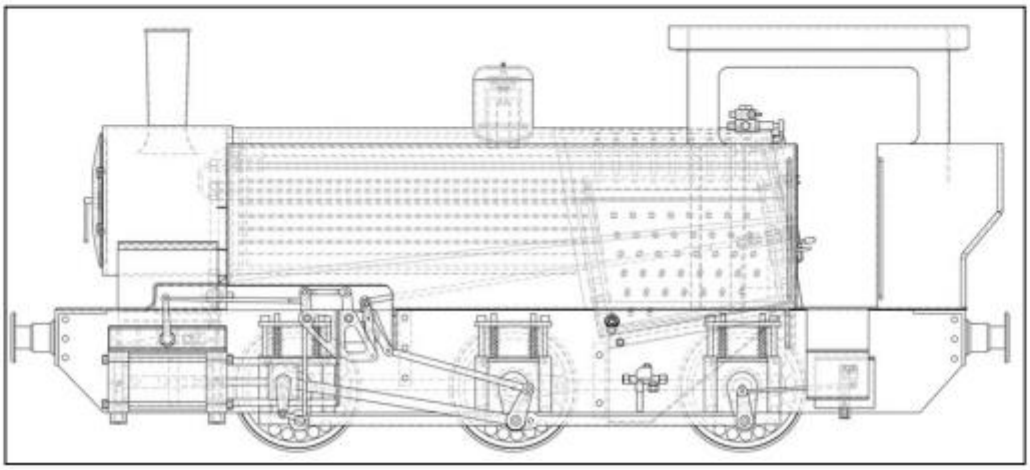
In response to the request for articles in the club's flyer I thought I would share a few notes on a freelance 0-6-0 tank loco I have been working on (and off) for the last 3 years or so. The loco design has relied heavily on the use of 3D CAD so that most of the functionality could be checked before committing to metal. This then is a brief description of the progress thus far.

The initial concept was for a loco with low maintenance, easy to service and where possible make use of materials lying around the workshop.

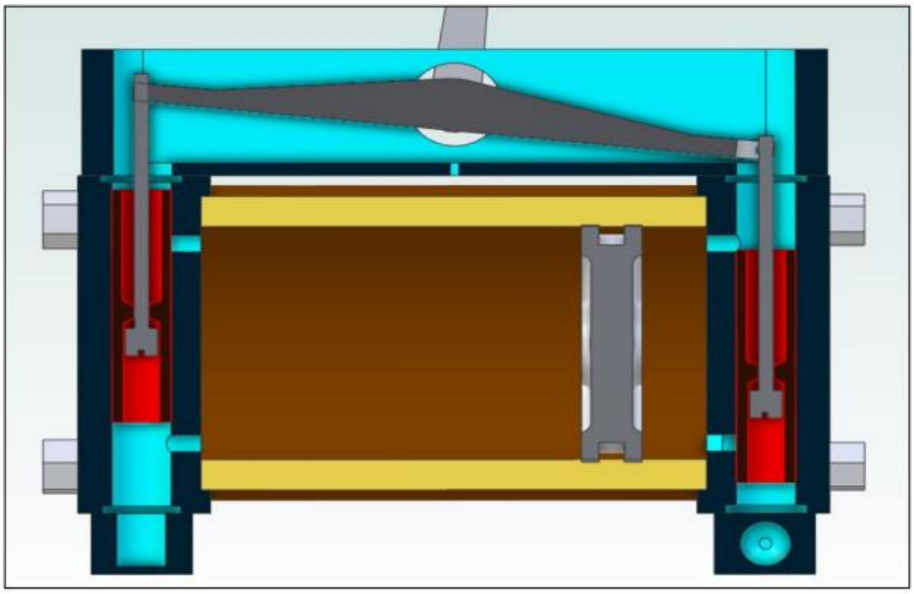
With this broad outline, I started on an 0-6-0 tank loco based around a pair of substantial coupling rods purchased in an earlier 'bring and buy' sale. This then was the starting point for the project. Initially I worked on a rotary valve gear design with poppet valves. The valve gear went through several iterations which eventually evolved into a single split cam common to both cylinders, the valve timing variation being achieved through the use of a differential epicyclic gearbox. This concept worked on CAD so was duly manufactured and tested. The valve gear worked but disappointingly I just couldn't get the poppet valves to seal reliably. After trying several mods without success, I gave up on this approach and opted for a more conventional valve gear. Ironically, I think the piston valves now used on the loco would have worked with the rotary gear, so I may re-visit this system in the future. To accommodate the now discarded rotary valve gear, an outside mainframe design was required. By the time I had dropped the rotary valve gear the mainframe and wheel sets had already been made, so I opted to stay with this design rather than starting over. This then became the current and hopefully final layout for the loco.



CAD 3D rendering of loco general arrangement.

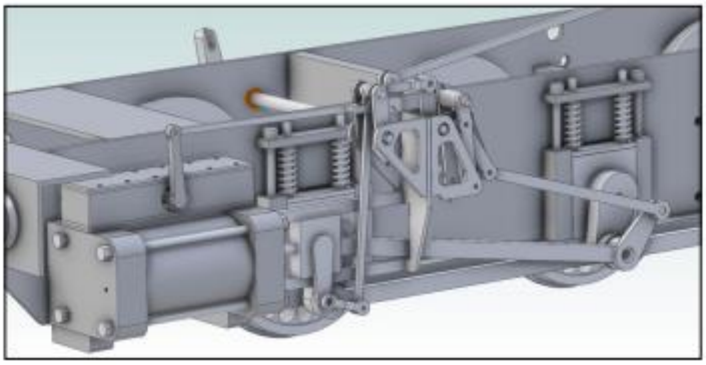


Being an outside frame design, the loco has taken on a narrow gauge style with overall dimensions of 40” over the buffers Wheels are 5” diameter solid steel. The mass of the cranks and rods is balanced by a combination of holes and weights on the wheels. The axles rotate in sealed ball bearings to reduce friction and will hopefully be maintenance free for the lifetime of the loco. The suspension is a set of floating coiled springs externally mounted above the axle boxes. The cylinders differ from conventional design, being more akin to pneumatic cylinders found in industrial machinery. The phosphor bronze cylinder barrel is sandwiched between a pair of thick end plates doubling as valve blocks, the whole assembly being held together by 4 longitudinal bolts. The steam chest houses a rocking lever linkage, actuating vertically mounted piston valves in the end plates.

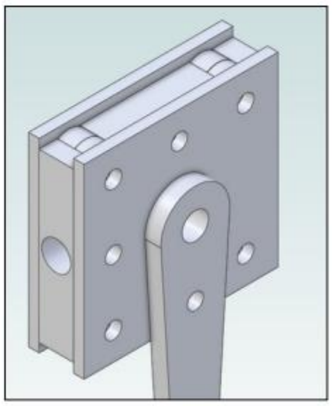


Cross-section of cylinder, steam chest and valves. The cylinder is 1.875” diameter by 2.6” stroke.

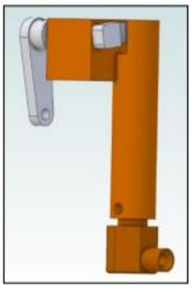
The cross section above shows the steam chest and passages (light blue), rocker arm, cylinder and the two vertically mounted valves (red). With the rocker in the position shown, live steam is admitted via the top of the RH valve whilst exhaust steam exits at the bottom of the LH valve. As the rocker rotates counterclockwise, the RH valve is lifted and LH valve drops under steam pressure causing flow reversal. As the exhaust ports are at the bottom of the cylinder, any condensate is expelled with the exhaust steam which can then be separated out and drained before hitting the blast pipe. Cylinder drain cocks are thus unnecessary. The valve gear is of a modified Baker type. Baker gear only uses rotating joints, there are no sliding components. By using sealed ball bearings throughout, there is minimal wear. And as a bonus, no oiling-round necessary!

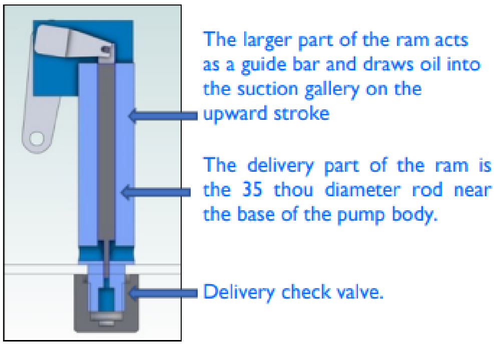


CAD 3D view of the mainframe showing the modified Baker valvegear and cylinder assembly



The crosshead sliding surface has been replaced with a set of 8 ball bearings to reduce friction. The outer race of the bearings rolls along the hardened guide bar surfaces. The oil pump has just two moving components, the ram and actuating arm. Because there is no ratchet system, the ram operates at the same speed as the wheels i.e., 1 stroke per rev. To overcome what would be a massive over-oiling with this setup, the ram is just 35 thou in diameter delivering approximately 4 microlitres per stroke. The oscillating cylinder is replaced with a fixed cylinder which is part of the pump body.





With this arrangement there is just one valve, the nonreturn valve at the delivery end of the pump. This valve must guarantee an absolute seal as the pump relies on generating a vacuum on the upward stroke of the ram. When the ram clears the wall of the cylinder, oil is drawn into the vacuum void ready for the next downward delivery stroke. I tried different size steel balls for the valve without much success, they just wouldn't seal well enough. The arrangement found to work was to replace the ball with a 2mm long section cut from a Viton 'O' ring which then acts as a resilient disc valve. With these component parts manufactured and assembled it was time to do a bench test on air. To my relief the chassis ran with less than 10psi but the motion was quite lumpy, the valve timing needed tweaking. This highlighted the Achilles heel of this design – the valve timing is impossible to view or even set up accurately prior to assembly. The solution was to drill a small tapped hole in each cylinder end plate which would then normally be plugged. By removing these plugs and connecting the cylinders to a low-pressure air supply, the onset of the steam admission can be observed as the wheels are rotated slowly by hand. Each valve height can then be adjusted as necessary to open at top and bottom dead centres.

This is as far as the construction has progressed, a concrete sectional workshop in the winter is not an inviting prospect anymore! The winter period has been spent mapping out the rest of the loco on CAD so I will try to get an update together for the next 'between the lines'.

Two views of the actual loco chassis during testing