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Adjustments to Stephenson's Valve-gear

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Introduction

The late Charlie Dockstader was a remarkable American model engineer who, not content with producing some fine models, also produced user-friendly simulations of every type of steam engine valve gear known to man, or so it seems.

The simulations were written in the early days of Windows with the result that the software is remarkably efficient and economic by today's standards and has proved to be compatible with all the later versions. I was using Windows 3.1 when I discovered his software and the only discrepancy, I have found with late versions is that the optional sound effects when running have changed from a "chuff" to a "ping".

The simulations were originally available as freeware and since his death several clubs in the USA continue to make the software available. The simulations cover both locomotive and boat gears and are scaled for 1:8 and use imperial units. The layouts shown are predominantly aimed at American locomotive practice, but the editing facilities provide ready means to adapt to English practice. For example, a linear die-block guide for Stephenson's gear can be approximated by the use of a very long suspension link. All component dimensions and positions are editable.

As you might expect some of the terms for components have to be translated from USA to UK.

What I find very reassuring with this simulation is that it is based on pure geometry (rather than mathematics) and that adjustments can be made one element at a time and the consequences immediately observed. This allows for the sensitivity to tolerances and settings to be appreciated as well as design optimisation.

I have one warning; playing with the simulation can be mesmerising and addictive to the point where it can be a time waster. On the other hand, it was the hours of watching and thinking that has led me to the subject of this paper.

Using the Charlie Dockstader Simulation

Assuming that all of the files available have been downloaded, double clicking on the valve-gear of choice will present you with a default version of the simulation running. There are running adjustments readily apparent such as reverser position and speed and the ability to pan and zoom the image and add visual and sound effects of the exhaust. There are buttons which when clicked give options to edit "Frame" and "Cylinder" dimensions. The "Frame" is essentially the valve gear. To the right of the task bar are four buttons that give access to presentations of the overall performance. Being a simple-minded soul, I primarily make use of the cut-off diagrams and occasionally the sine diagrams. This is where the arguments can start with regard to what are the best criteria for success. When a locomotive is running, the by-stander may listen for evenly spaced exhaust beats, and this is essentially a measure of exhaust timing. Alternatively, one might

reasonably look for equal work to be done by the front and back of the cylinder, which is mainly determined by the inlet cut-off. Unfortunately, with some valve gears, optimum cut-off and exhaust events are not available together so you have to make a choice. This may be why early designers, particularly in America, sometimes made use of separate cut-off and exhaust valves. My preference is to equalise cut-off for front and rear end of the cylinders as this leads to nearly equal work done by the forward and rearward stroke.

In the simulation image, the front and rear cut-offs are shown dynamically as the simulation runs; it was watching this dynamic simulation and observing that cut-off as the reverser is adjusted that suggested to me that there may be a way to improve the performance of some versions of Stephenson's valve gear. The effect is most marked for gear with short rods.

The first time that I made serious use of the simulation was for the design and construction of a North East Railway T1 0-8-0 (for which I was delighted to be awarded a silver medal at the ME show in 2002) The T1 uses loco link gear with relatively long rods and short travel valves. Apart from adjusting the lifting links to represent an approximation to linear drive to the link die block gave very good events without the need to depart from conventional gear dimensions.

My next use of the simulation was for the valve-gear of a 7 ¼ "G LNER B1 which uses Walschaerts valve gear. Having examined Martin Evans' design, the only departure that I made was to reduce the link back-set to scale of the full size as this improved the valve events at short cut-off though at the expense of long cut-off.

The next occasion I had to simulate Stephenson's gear was in the design of a 7 ¼ "G Baldwin 2-6-0. Compared to the T1 this has relatively short rods and Launch links. Playing around with this simulation on my lap-top in front of the television it was apparent that if front and back cut-offs were equalised in full gear then they diverged badly at short cut-off, and vice versa. The usually recommended fudge is to set for 50% cut-off and put up with the results elsewhere. I found that if cut-off was equalised in full gear (75% say) then in mid gear the front cut-off becomes very short or negative whilst the rear cut-off remains longer. Bearing in mind that the valves operate through a rocking lever, it occurred to me that if the radius of the link was decreased, this would affect the mid gear cut-off whilst leaving the full gear events unaltered. This proved to be the case and the link radius was reduced to 6 inches as against the 7 inches radius that would have been applied conventionally. Whilst it seems to be self-evident that the radius of a Stephenson's link should be equal to the rod centres length plus the offset, in fact link radius is not very critical and can be changed to compensate for errors that are much more difficult to deduce.

Having satisfied myself of the correctness of my deduction both by simulation and in practice by completing the Baldwin in 2016, I thought it would be interesting to apply the approach to some other popular design.

Holmside, potential modifications.

A very large number of locomotives to the Martin Evans "Holmside" design have been built and shown to be successful. We have two in our society, the Frimley and Ascot Locomotive Club, one of which has been modified to improve the support of the expansion link by lifting from both sides to reduce wear but otherwise they are to drawing. The proportions are not dissimilar to my Baldwin Mogul except for the use of direct drive to the valves for Holmside as against a rocking lever for the Baldwin. A similar discrepancy of front and back cut-off is found using simulation but, because of the direct drive, an improvement is achieved by increasing the radius of the link rather than reducing it. As increasing link radius is a slower function than reducing it with regard to valve position, the required increase in link radius is very large, more than double the original, but the improvement in performance at short cut-off very significant leading to smoother performance. The downside is that the exhaust timing suffers a little so an uninformed line-side observer may be critical. The builder may also find it more difficult to machine the link slot to the increased radius

due to the difficulty of achieving sufficient rigidity when mounted on a small model engineer's rotary table. I have experience of this whilst machining the link for my latest project, a 7 1/4" G Stirling 8 ft Single.

Notes on using Dockstader Simulation added by Peter Gardner

1. When you select a valve gear a running simulation will be presented on the screen. It will be typical American lay-out at 1 1/2 inch scale and will not have been optimised in any way. It will show the gear running forward but in mid gear and will show the cut off at the front and rear of the cylinder. The speed is set by the step angle slider, the reverser angle slider controls forward/reverse and you will see cut-off change as you adjust.
2. In order to fit the dimensions to your valve gear, you need to call up either "edit dimensions" or click on the third icon from the left for the valve gear (called frame in USA speak) or the fourth from the left for the cylinder and drive dimensions. The tables that pop up have a button to the left of each item which are used to highlight the feature concerned thus translating from American. You can then edit the numbers to match your design.
3. A little creativity is needed to convert the rocking lever design of American Stevenson gear to many British layouts by changing the sign of one end of the lever to be negative. A linear guide can be emulated by very long levers and a very remote suspension point. The eccentric position will have to be changed too of course.
4. Whilst it is possible to examine the workings of the valve gear point by point using the driver angle control, my preference is to use the graphical output options; of those I find the one on the furthest right the most useful showing the cut-off at each end of the cylinder with reverser setting. A good aim is to achieve equal front and back cut-off over as wide a range of reverser setting as possible e.g. from 20% to 75%. (American practice is for much longer cut-offs). This may not give equal exhaust cut off but will make the energy input to each end of the cylinder as near the same as possible.
5. The two features that I have found useful in tweaking small errors are the link radius in Stevenson's gear and the link back-set and combination lever ratio in Walschaerts.
6. An entertaining feature of the simulation is the visualisation and sound by clicking the blast symbol. Unfortunately, the "chuff" sound obtained with very early Windows systems is replaced by a "ping" with current operating systems, but you can still judge what the beat will sound like.