Balancing the 750 crankshaft

For those interested, here is a story about balancing crankshafts, especially the old 750's. The numbers givn heer are valid for a 750 SF2 from 1975. They might be different for other models and triples.

I am not a mechanic, but this balancing thing was a nice theoretical exercise, which I could turn to reality when the crankshaft bearings gave up, somewhere in 1995.

There are two ways to balance a crankshaft: dynamic and static. With modern crankshafts, in one piece, only duynamic balancing is possible, but with the older types, both ways are possible. For dynamic balancing, you need a special testbench, which is no doubt expensive. Static balancing does not require much equipment.

The basic idea of the balancing is to compensate for the moving mass of the piston and the upper end of the connectng rod. The lower end of the rod and the big-end are rotating masses that can be compensated for fully in the webs. The problem is in the moving mass: if it is not compensated, there will be huge forces in the direction of the cilinders. If it is compensated fully, there will be a force orthogonal to the cilinders.

Generally, only a portion of the moving mass is compensated to minimize the resulting forces and to have them point in a certain direction. In order to find the percentage of compensation I played with MathCad and came up with these plots:

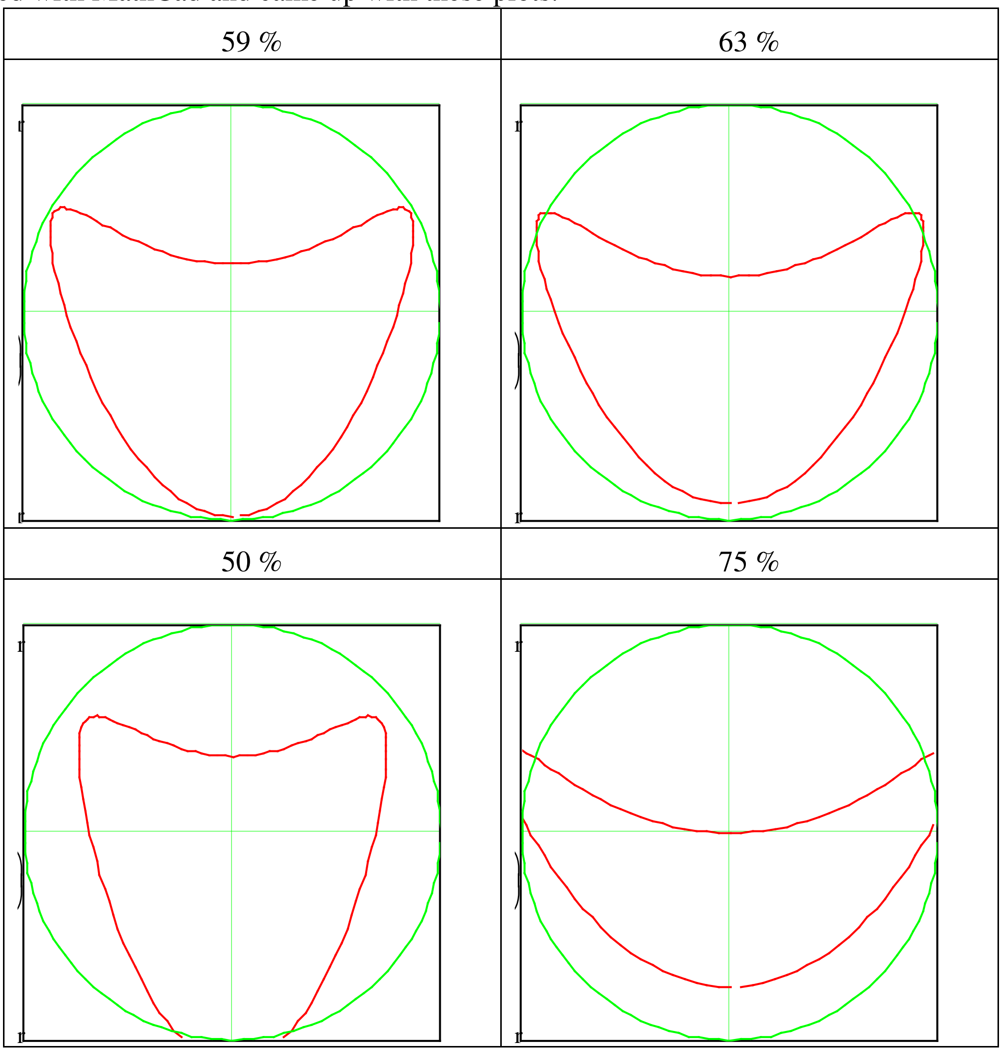
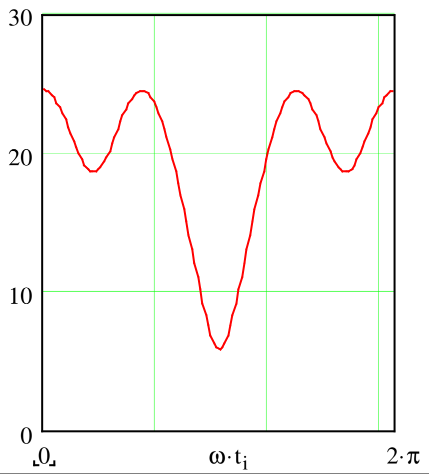


Figure 1. Polar diagrams of the forces in horizontal and vertical directions.

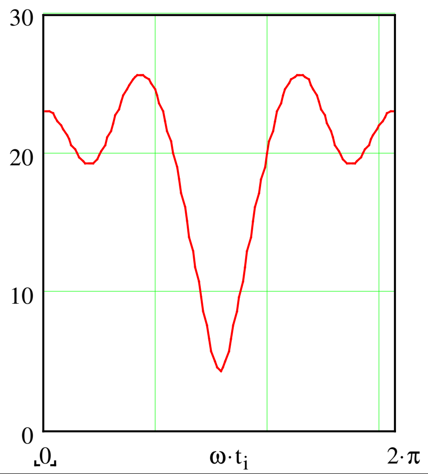
Horizontal are the forces orthogonal to the cilinders and vertical is parallel to the cilinders. If you want to fit the forces in the minimum circle, the factor is about 59 %. For a fit in the smallest square, 63 % is better.

The absolute value of the forces can also be plotted as a function of the angle:

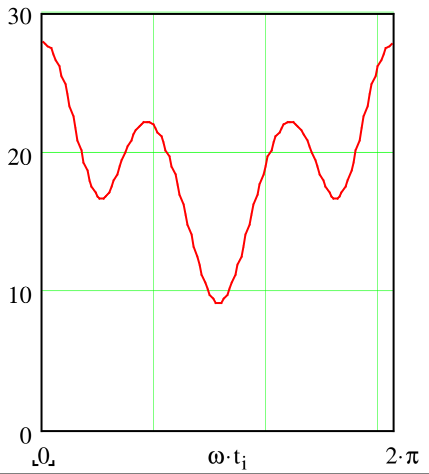
59 %



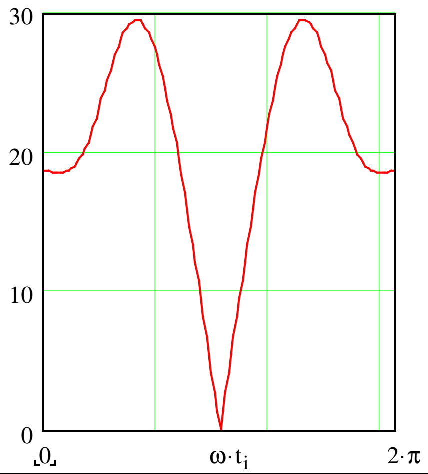
63 %



50 %



75 %



As you can see, 59 % seems better, but with 63 %, the forces in the direction of the steering head are slightly smaller and to me that seems better.

The data I used:

Length of connecting rod: 146 mm

Stroke: 74 mm

Mass of big-end pen: 540 gm (rotating mass)

Mass of two big-end bearings: 78 gm (rotating mass)

Mass of piston with rings and pen: 445 gm (moving mass) (Asso)

Mass of big end side of rod: 320 gm (rotating mass) (Carillo)

Mass of piston side of rod: 125 gm (moving mass)

The total compensating mass is then: 540+78+320+63%(445+125) = 1297.1 gm for two webs or 648.55 gm per web.

How to balance?

Simple: apply 648.55 gm to the hole in the web where the big end pen belongs and make sure it is balanced. If the big-end pen is still in the hole, add 108.55 gm to the pen and then balance it. Do this for all four webs. Find the heaviest spot on the web and drill a hole here to take off weight. Do this until there is no preferred position.

Checking this on my crank proved that the inner webs were reasonably well balance, but the outer webs had about 48 gm of unbalance in totla. At 6000 rpm that amounts to 700 kilo's!

The amount of broken bulbs and lost nust and bolts was considerably less after this exercise.

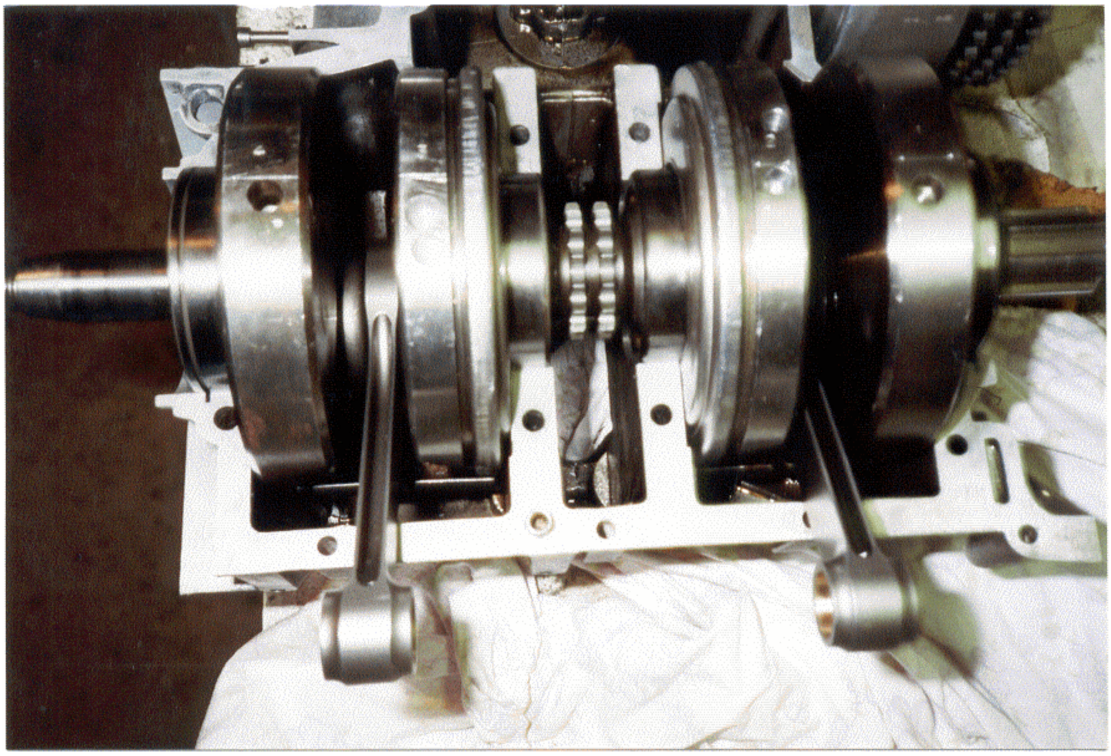


Figure 2. My 750 SF2 crankshaft with holes drilled in the outer webs.

Hope this is useful to anybody.

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