Discussion on Paper II (iii) by W.E. ten Napel, R. Bosma and M. Akker: "Lubrication of the small-end bearings in heavily loaded two-stroke diesel engines"

made on purely economic grounds.

Ir. H.J. van Leeuwen (Eindhoven University of Technology, The Netherlands). I would like to commend the authors for their paper. It shows that the optimization of an existing design by using mathematical analysis does not yield a valuable improvement. A real breakthrough can only be attained by re-design, as the authors show, followed by new calculations. Their comprehensive summary of topological theorems enlarges the insight into bearing dynamics in a simple manner, thus giving a very handy tool for the designer. Their continuing work in applications of the mobility and impedence methods is very much appreciated.

Some questions remain:

(a) Can the authors comment on elasticity effects at minimum film thicknesses as low as 0.1μm, which is really worrying compared to the bearing radius?

(b) Have the authors considered elliptically shaped geometries, like the one investigated by Goenka and Booker and shown in the paper by Martin (II(i)) earlier in this Session?

(c) Has the proposal with Belleville washers been tried already? If so, I assume that the support of these washers has been re-designed, because Hertzian pressures go up as high as 5 GPa (50,000 bar).

(d) The mobility method needs a symmetric bearing surface relative to the load vector or a non-rotating load. To what extent is this condition fulfilled - viz; what does the polar load diagram look like?

Reply by Ir. W.E. Ten Napel (Twente University of Technology, The Netherlands).

(a) We did not take into account elasticity effects, but we are aware of the fact that they do play an important role in explaining why the bearings under consideration at the lower power conditions worked quite satisfactorily. Investigation of these effects, however, was beyond the scope of this project.

(b) The answer to this question is 'no'.

(c) To our knowledge the use of Belleville washers in this application has not been tried as yet. According to the manufacturer's catalogue Belleville washers can adequately support the applied pre-load. With respect to the support, a simple calculation shows that a rim of about 0.5 mm is necessary to carry the load. This can either be achieved by plastic deformation of by pre-grinding.

(d) The authors agree with the discussor. However, as mentioned in the paper, the load can be regarded as directed vertically downwards when inertia effects, due to the mass of the connecting rod, can be neglected. We investigated the influence of this effect by constructing some different mobility maps for different load directions. Constructions of journal paths using these maps showed no significant difference with the results presented.