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Discussion

Notes on the Paper "Conventional Versus Self-Steering Radial Trucks for High-Speed Passenger Trains"[1]

M. G. Pollard.[2] The conclusion drawn by G. R. Doyle at the end of his paper, that secondary yaw damping is the most beneficial of the three methods examined to stabilize a high-speed passenger bogie after modifications to assure reasonable curving, should come as no surprise. It has been European practice for over a decade to do just this. The majority of railway business experience with high-speed passenger train operation has been accumulated in Western Europe and so it is unfortunate that Mr. Doyle does not refer to the designs which have been developed. In the UK and France in particular new train sets have been developed, HST [1], TGV [2] and APT [3], all of which rely on secondary yaw damping for their stability. The latter in particular has a very soft primary longitudinal suspension to facilitate curving.

The use of cross-bracing, or cross-anchors, was first suggested by Wickens [4]. The technique followed from mathematical analyses being carried out in support of the APT development. It was realized at that early stage, however, that the application to high-speed passenger bogies was not appropriate, particularly under conditions of high cant deficiency. The development of cross-bracing, a resilient shear connection between wheelsets, has since proceeded in a number of countries and in particular it has been applied to the 3-piece bogie where it is particularly efficacious. It is not appropriate to read across from freight to passenger stock because of the very different requirements.

Although I have written that the APT has been designed with a soft primary suspension this is unusual when one surveys the inter-city scene. Most bogies have a relatively stiff primary suspension but do not suffer severe wheel wear. It is European experience that a low percentage of passenger vehicle wheels need turning because of wheel wear. The French TGV is an exception and a special case. Usually the wheel has been damaged by other causes and these require remedial attention. The conclusion is that for high-speed passenger bogies the typical route is such that wheel wear is not significant.

The optimization exercise that Mr. Doyle has carried out is incomplete on a number of grounds and although the conclusion reached is a proper one the analyses is not sufficiently thorough to prove the case. The single bogie model for examining stability is usually only used when the bogie hunting problem is being examined and there are a number of assumptions which need to be made in order that the model results can be properly interpreted. When one uses secondary yaw restraint to stabilise the bogie the body/bogie relationship is very important and I suggest that a full vehicle model is necessary even for a preliminary analysis.

It is not satisfactory to do optimizations with only one value of effective conicity. The chosen value of 0.2 is, in European terms, excluding the French, low. In the UK a lightly worn wheel gives an average value of 0.23 and a range of 0.05 to 0.5. If one is using single bogie theoretical model then clearly the highest value is the most appropriate but I submit that a proper optimization should recognize the variability of the effective conicity and cover the range properly so as to include the low conicity area also since body to bogie interaction under these conditions may be a problem.

Similarly the creepage coefficient is an uncontrolled variable and current practice relates the coefficient to the value of the coefficient of friction between the wheel and the rail. The value of 0.15 taken by Doyle for this parameter is low for bogie stability studies, a range of value from 0.2 to 0.5 is more appropriate. A range of coefficient of friction and, therefore, creepage coefficient should be taken to cover all aspects of performance and environmental conditions; a single value is liable to lead to wrong conclusions. The combination of creepage coefficient and conicity taken by Doyle will give optimistic answers to the stability problem. Further, the effects on the 3 types of bogie of increasing the values will be different, so there is no guarantee that the ranking will remain the same.

In the curving analysis the low coefficient of friction will again distort the results. At low values of friction steering bogies steer less well but all bogies have less wear. With realistic values of friction coefficients it may be possible in shallower curves for the tread to react the lateral forces generated without gross slip and under these conditions the wear will be very small. With a worn wheel profile it is essential to take account of the gauge spreading forces which are generated between the wheelset and the rails and which are very significant. These forces push the wheelset into the flange root area such that the "normal" force is amplified and inclined. This effect will significantly affect the "wear index" and the value will be sensitive to the angle of attack of the wheelset even though the flange is not in rail contact.

Doyle comments that the inter-axle lateral stiffness spoils the curving performance if its value is too high. This is only true on shallower curves. On very tight curves the higher stiffness is beneficial and this underlines my basic thesis that simplified optimizations are dangerous. The curving study should properly be carried out for a distribution of curves, a distribution based on route statistics, such that a correct ranking of the candidate bogie designs can be achieved.

There are, of course, other methods of stabilizing bogies while allowing for adequate curving. For example, yaw relaxation on the primary longitudinal suspension is extremely effective in giving good stability combined with excellent curving. A different method altogether is to reduce

[1] By G. R. Doyle, published in the December, 1982 issue of the JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT, AND CONTROL, Vol. 104, No. 4, pp. 290–296.

[2] Railway Technical Centre, Derby, England.

the mass of the bogie. This is a very stabilizing effect which can be employed very effectively to give improved stability and curving.

I hope that I have indicated 3 major points.

(i) Secondary yaw relaxation is a technique which is being used extensively already to stabilize railway vehicles.

(ii) A simplistic optimization routine will not necessarily give the right answers.

(iii) With railway equipment there are many parameters which vary outside the designers control and proper cognizance must be taken of these at all stages of the design. Only by doing this will the designer be able to select an optimum value for those parameters which can be fixed.

References

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