Modeling Track Component Life

In recent years, there has been a growing use of computer models to calculate the life of key track components under a variety of simulated service conditions. This trend has been spurred in part by the increasing availability of computers. It is also driven by an increasing need to understand the complex relationships between many of the key track and traffic parameters affecting the lives of track components. In many cases, these component life models can be used as maintenance planning tools. One case would be in conjunction with a computerized data base (see *Tracking R&D,* November 1986), to permit more effective planning and allocation of resources.

In other cases, these models can be used in cost-benefit analysis for different track designs or maintenance practices. Such has been the case, for example, in strategic planning for rail replacement.[1] Here, the economics of different rail replacement strategies is evaluated, using a rail-life prediction model. Consequently, issues like the effects of rail lubrication, rail hardness, and their relative costs can be examined.

The meaning of 'life'

Track component life models can be either 'failure' models or 'degradation' models, depending on the component in question and the corresponding maintenance activity it requires. Component failure is usually defined as the point at which component removal is necessary. It must be borne in mind, however, that component failure here may be an actual physical failure as when the tie is completely decayed, or it can be an *economic failure.* An economic failure is the point at which it is cost effective to replace the component, for instance rail with fatigue defects.

Component degradation models, on the other hand, are directed at those components that do not necessarily 'fail.' Rather, they focus on deterioration in performance, which requires some form of maintenance activity. Variations in track geometry characteristics like surface or cross level are examples of degradation behavior. However, the ballast is not ordinarily replaced. Instead, corrective maintenance is undertaken when the geometry exceeds the defined limits.

Track component life models can range from the very complex to the very simple. The proper model to be used would depend directly on the specific application involved. In many cases, the results of a complex model are tabulated as functions of or are simply graphed against key parameters, and are therefore of direct engineering utility. Such an output is illustrated in Figure 1, for an empirical rail wear model.[2] In other applications, for example an integrated database and maintenance planning system, the actual model, appropriate to the specific application, is required.

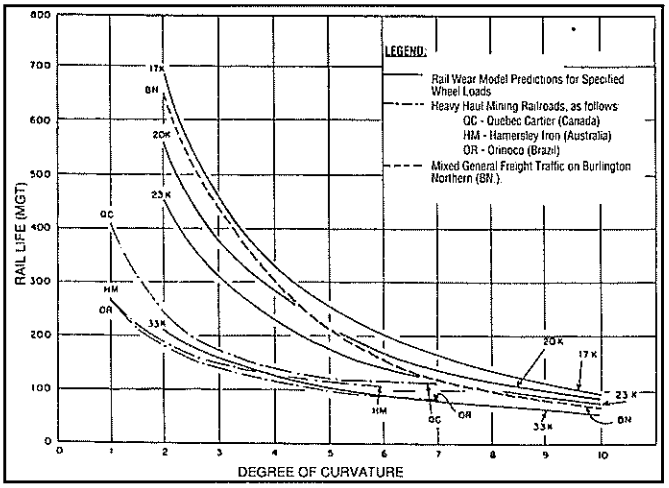

Figure 1 — Actual and Theoretical 132RE Standard Carbon Rail Life as Functions of Curvature and Wheel Load. A Rail Head Area Loss of 25% Represents the Condemning Wear Limit.

In general, there are two other classifications for track component models: *mechanistic* and *empirical.* Mechanistic models are mathematical and attempt to simulate the failure mechanisms. Their use is also referred to as an "engineering approach," and attempts to define the physical properties of the component and its complete loading environment along with the interaction between the loads and the materials. As a result, mechanistic models tend to be relatively sophisticated, often requiring complex computer algorithms and a significant amount of computer time. Nevertheless, they usually provide a good understanding of the behavior of the components under various conditions, as well as determining which of the component properties are the most important in improving performance. Examples of this type of model include the *AAR RFLAP* and *Phoenix Rail Life* models.[3]

Simpler models

Empirical models are relatively simple models in comparison to the mechanistic types. They do not attempt to employ any specific failure theory, but are based on experimental or observational data. This type of modeling often uses statistics, by which large volumes of experimental or observational data are correlated. And from this information, relationships are developed between important track and traffic factors. However, empirical models tend to be highly dependent on the data used in their development. As such, they cannot be readily extended beyond the range of behavior defined by that data.

Still, since empirical models can be relatively simple in their final form, they can often be used with simple hand calculations, or with simple computer programs requiring much less machine time than would a mechanistic model. The Empirical Rail Wear Model, which is compared with actual field data in Figure 1, is an example of this type of model.

With the increasing use of computer systems at the local office level and the emergence of sophisticated maintenance planning and analysis techniques, the need grows for effective and reliable track component life models. But regardless of their sophistication, these models are, in the final analysis, simply another tool for M/W officers to use in their ongoing track maintenance activities.

References:

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