General Statistical Design of Experimental Problem for Harmonics

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Tires are subjected to a variety of force measurements that are stored as periodic waveforms. Harmonic components of these waveforms are related to tire performance characteristics such as noise and comfort and hence the control and reduction of the amplitudes of these harmonics is an important activity of manufacturing. Technicians may choose to perform designed experiments on their production processes to understand better their impact on the resulting force harmonics. It could be advantageous to have a general design of experiment methodology which allows technicians to choose optimal designs for their studies.

To make this more concrete consider two types of forces (F and G). F is characterized by 5 harmonics F1-F5 and G is characterized by 10 harmonics (G1-G10). Practically the technician might have 20 different process elements (P1-20) that can be rotated within the construction of the tire and which can affect the force measurements. It is assumed that rotation of a production process will result in the equivalent rotation of the force measurement and that superposition of P1 and P2 will result in a corresponding superposition of resulting F1s. In general the movement of any process element such as P1 may affect all harmonics and forces (F1-F5 and G1-G10).

The general problem is to choose the angles of rotation for a set of Ps so that the harmonic effects are well estimated and the cost of experimentation is minimized. Note that the variance of the estimates is related to the angles chosen (for example choosing 180 degrees prevents the estimation of the even harmonics) and that the cost of a study is proportional to the number of angles that are used in the design. Other features of interest include the reparability/extensibility of designs, identifying sets of competitors/surrogates and allowing different precision for different harmonics.