MODELLING THE PHYSICS OF HIGH SPEED PRODUCT-WEIGHING

Compac Sorting Equipment Ltd, Auckland

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Compac Sorting Equipment Auckland (Compac) manufactures and exports high-speed, accurate sorting systems for fruit and vegetables. Their sizers operate at between 10-15 pieces of fruit per second per lane. They weigh each piece of fruit individually, using a pair of cantilever loadcells, in less than 1/10 of a second. Compac wanted a mathematical model of the weighing process, that will help them to accurately weigh heavier fruit (more than 250g) at higher speeds (in less than a tenth of a second). They also asked for help with easing back on the size and stability of the weighing assembly, which would reduce the physical size and manufacturing cost of the overall system.

The signal from each loadcell is amplified and low-pass filtered. The tail end of the signal is averaged, to obtain a mass that is required to be accurate to less than 1g.

The MISG group studied the frequency components present in the output of loadcells, for various sized fruit running at various speeds. Apart from a high frequency which is of no concern to Compac, we typically observed two lower frequencies, which reduce as fruit mass increases, causing difficulties with oscillations getting past the analogue filter. An option is to reduce the cutoff frequency of the lowpass filter. However, this might not help at higher operating speeds, as there may not be enough time for the filtered signal to level off.

We developed models for simple harmonic motion in the vertical direction, as well as a side to side rocking motion between the two loadcells. Our modelling suggests that the reduction in the low frequency is generally to be expected as mass increases.

The key parameters are mass (and its distribution), effective spring constant, and effective damping. An option is to stiffen and reduce the effective mass of the loadcells, thereby increasing oscillation frequency and damping. However, stiffer loadcells require greater amplification of the signal from the loadcell and are more vulnerable to drift, thus potentially reducing the overall accuracy of weighing.

A possible strategy is to use the understandings from the modelling, rather than just filtering out the oscillations. We showed that it is feasible to infer key parameter values from the oscillation frequency, damping rate and oscillation amplitude. A joint approach, digitally combining this information with filtered output, might be faster and more accurate than the present setup. In order to do this, a model that takes into account the structure of the loadcells and attached plates has been proposed. This model is more complex than a damped oscillator and involves a few time-dependent frequencies but is a promising direction for continued work.

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