Predicting Machine Setup Time: Suggesting a Limit Determiner with Transposition of Equation

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IN this article, it is suggested that machine setup time is predictable. It is understood that the setup time varies in each setup activity because this activity is dependent on the skills of the workers that are performing the job. As it is different in every activity, this fluctuation uncertainty affects the performance of the machine at peak time.

As far as long setups are concerned, it changes the flexibility of the machine as time increases. Thus, regardless of whether the setup time is fluctuating, having long setup time, or observing an unknown random pattern, this article suggests that by utilising a limit determiner, and transposing an equation from an existing recorded setup study to suit the new condition, the limit time or minimum time limit can be known and determined.

UTILISING A LIMIT DETERMINER?

A limit determiner is an equation that will determine the minimum time of a setup activity. It is a representation of an actual trend, which trends downwards, showing that a reduction exists [1]. This reduction trend is observed and it is similar to an exponential decay curve, with finite counts. Thus, the exponential equation is fitted best into this recorded time trend as described here. The coefficients of the equation are then derived from it, which represent the behaviour of the curve/ each machine.

A limit determiner is a method that is derived from a series of observations, which can then be used to transpose to other behaviour, by moving the curve to two points or more in a new condition to best fit into another machine setup behaviour. This is called the transposition of an equation. The limit determiner here suggests that, in every setup activity, there is a minimum limit regardless of its behaviour.

The curve behaves exponentially. It trends downwards towards a minimum limit. Based on this, one can depict that it is a reduction curve. Note that a minimum limit is valid for all setup activities. The purpose of this limit determiner is to ensure that the operation is firmly planned, with a minimum limit calculated to ensure that the estimated hours are based on equation. The next section describes the characteristics of this curve.

AN EXPONENTIAL REDUCTION CURVE

The characteristic of this curve is a reduction of finite incremental setups, with an exponential behaviour. One might wonder if it is the only behaviour that will exist in every setup activity. If this is the case, the answer is that it will be different for every case, yet it should be noted that this behaviour can exist in some instances in time. Again, taking note that this minimum limit exists in every activity. Thus, this article stresses that this is the only behaviour, of this sort, that will happen or exist in every setup activity due to this reason.

The equation will give you the coefficients, signifying that each behaviour is unique. These coefficients of time (or factored variables) are the behaviour of these individuals performing the work of an independent activity. The curve is straightforward, self-fitted as explained by its equation. This method of calculating the minimum setup time in each activity is proven with known estimation error. The following is the explanation in brief.

The exponential reduction curve has three factored variables. The curvature of this curve is a steady reduction to a certain limit. This is the minimum limit of the characteristic of the curve. Figure 1 shows the curve based on a study [1]. The equation for this curve is shown in the following:

$y = 6.3 + 3.2 \exp(-0.2x)$ Equation 1

The first coefficient, 6.3, is the minimum limit of this curve as and when more setups are required, because exp (-0.2x) equals to zero. As for the initial point, when x is zero, this will equate to an initial point, 6.3 + 3.2 * (1) equals 9.5, this is the second coefficient. The third coefficient is 0.2. This represents the reduction behaviour of the curve, which means that if it is 0.9, the reduction is done very quickly. In other words, the third coefficient is the steepness of the curve which shows the reduction behaviour.

In Figure 1, the start time is roughly 9.5 hours, whereas the minimum limit is 6.3 hours and the relative reduction speed is a factor of 0.2. These variables indicate the behaviour of this curve.

THE LIMIT DETERMINER

A limit determiner is used to roughly calculate the minimum machine setup time. In every machine setup, there is a minimum limit yet to be discovered. Although you might not be aware of it, if you plot a curve similar to the above, first by sorting the data from highest to the lowest, you will at least notice that there is a minimum time in your

(To be continued on page 22)

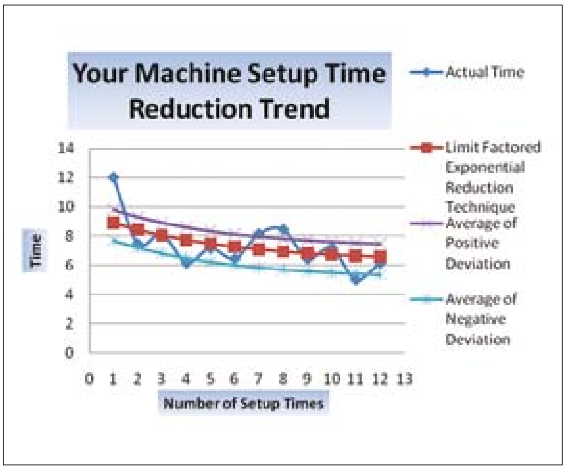

Figure 1 : Exponential Reduction Curve

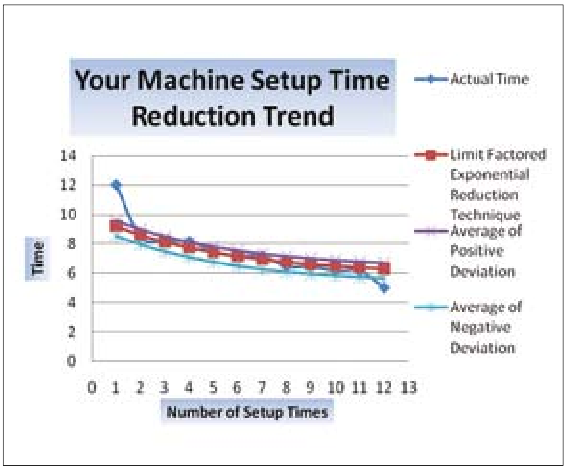

Figure 2 : Data Sorted

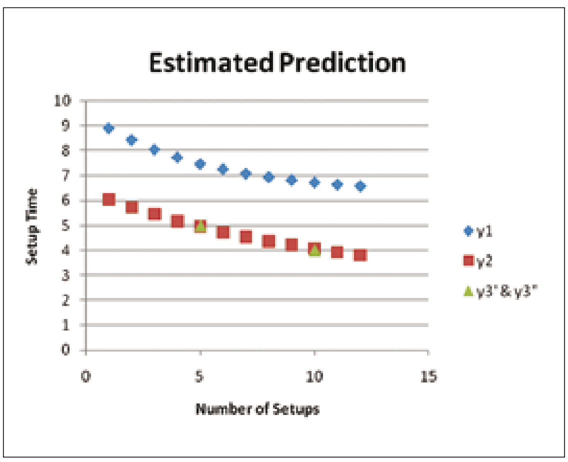

Figure 3: Transposition of Equation

situation and the trend will have an exponentially reduction characteristic. Figure 2 shows the sorted curve. The equation of this curve is as follows:

y = 6 + 4 exp (-0.2x) Equation 2

This equation shows the characteristic of this curve, with the recorded time sorted. The reason for sorting this is to show that the minimum time of this setup is actually six hours instead of 6.3 hours. Equation 1 shows the actual reduction behavior whereas Equation 2 shows that for the sorted curve that is in every setup behavior, there is a minimum time. In this case, it is as shown in Equation 2.

A limit determiner will show the minimum limit of a particular machine setup activities. It will indicate the minimum setup time of a series of activities. The limit determiner is a measurement tool that will determine the minimum setup time of a machine.

TRANSPOSITION OF EQUATION

The transposition of an equation to fit best into another behavior is to move an existing behavior to another machine behavior. This is something that could be used to discover the minimum setup time in other machines, transposing an equation based on a study to apply in other situations. In which case, it could be two data points minimum or more, with the accuracy depending on the number of data; the more data collected, the more accurate the limit estimation.

Thus, transpositing this equation will calculate the minimum limit of another machine setup behaviour. In Figure 3, the time at two different points is observed from a guess situation of an unknown operation as an example in this article. The two points are five hours at the 5th setup and four hours at the 10th setup. Transposing Equation 1 above, the transposed equation that represents these two data points as it behaves exponentially is as follows:

y^2 = 2.7 + 3.7 exp (-0.1 x) Equation 3

With this, the behaviour of every setup activity can be known with at least two points, with more accuracy at every increment of a new data point - as the data point increases. This is applicable to machine operations that require a firm setup time, in order to plan or forecast the number of setups that will be profitable to the operation.

y^1 = 6.3 + 3.2 exp (-0.2 x)
- My modelled equation

y^2 = 2.7 + 3.7 exp (-0.1 x)
- Your (guess) setup reduction (based on 2 points)

$y^{3'}$ = 5 $y^{3''}$ = 4
- 2 points records (shown as an example)

CONCLUSION

As suggested in this article, machine setups (time) can be determined using a limit determiner. A known limit and its equation based on a known study [1] is transposed to two guess points of an unknown operation, as an example in this article, to calculate the minimum time of this guess behaviour. This is applicable in a case when two real points are known. It is also noticed that in every setup, a minimum setup time exist. The time in each setup is assured as it is firmly determined. ■

REFERENCE

[1] A Predictive Method in Analysing Past Data – A Real Case on Production Line Setup Time, JURUTERA, May 2009, pp 11 to 13.