AN ADAPTIVE STATISTICALLY BASED CONTROLLER FOR THROUGH-FEED CENTERLESS GRINDING

Precision Manufacturing Research Consortium

Industrial Advisory Board

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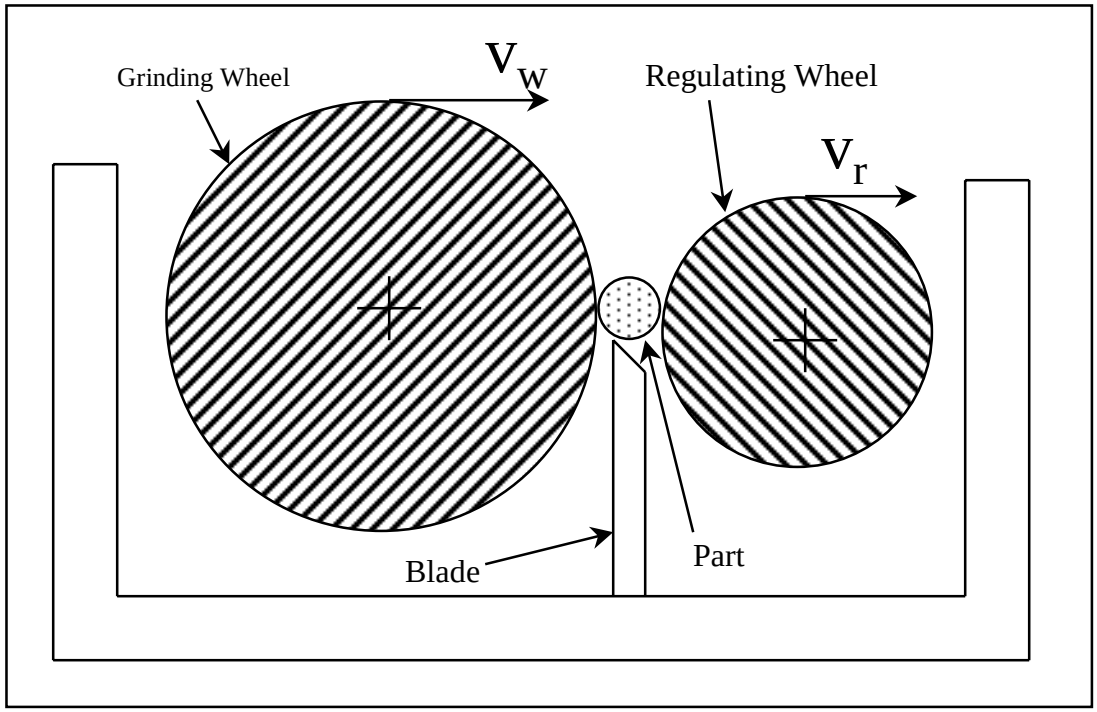
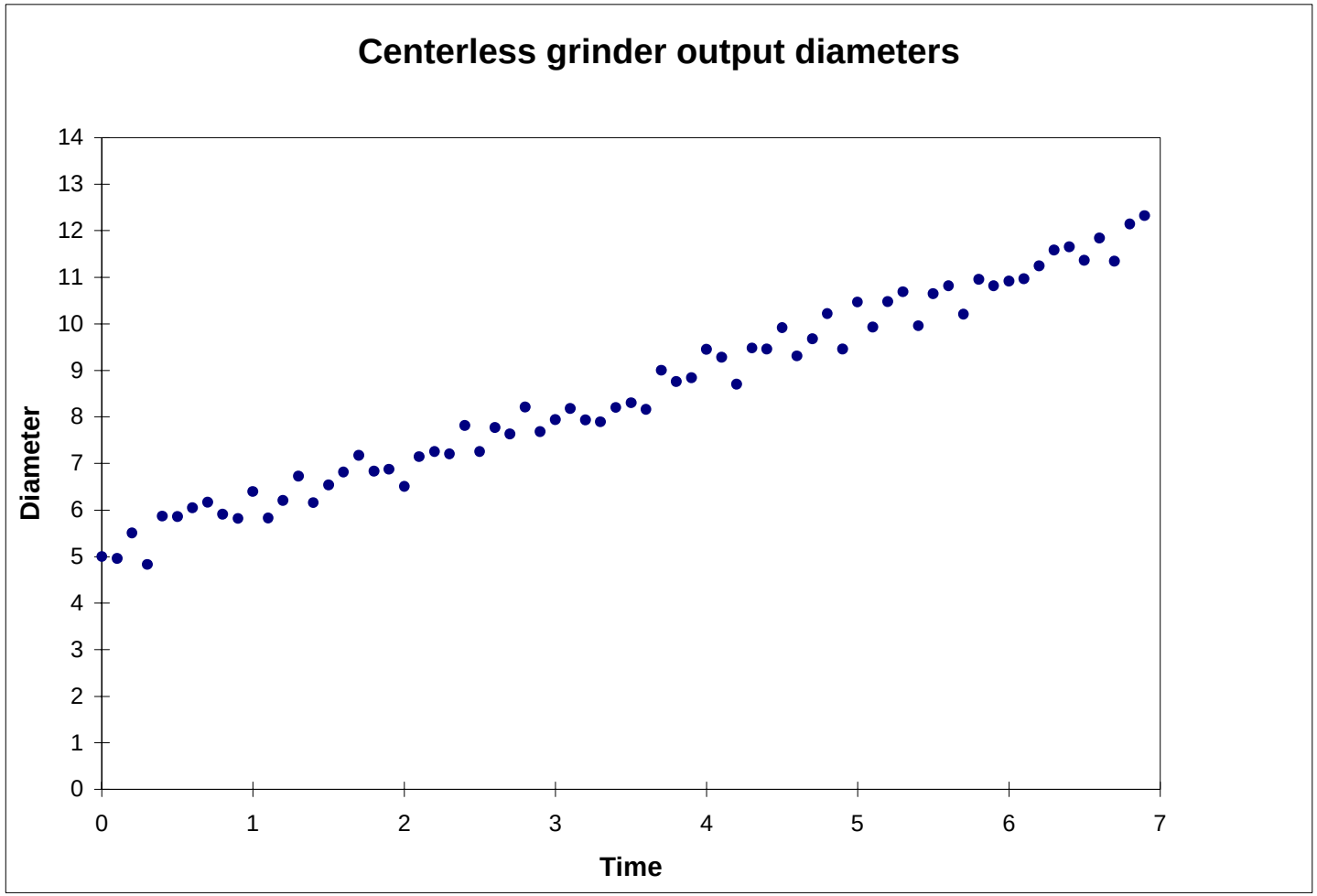
The Argument for Self-tuning Statistically Based Control

- Current methods like Cumulative Summation (CUSUM) have drawbacks due to fixed tuning parameters.
- The self-tuning method compensates for changes in machine precision.
- The self-tuning method requires little machine-specific tuning.
- It is inherently “portable.”

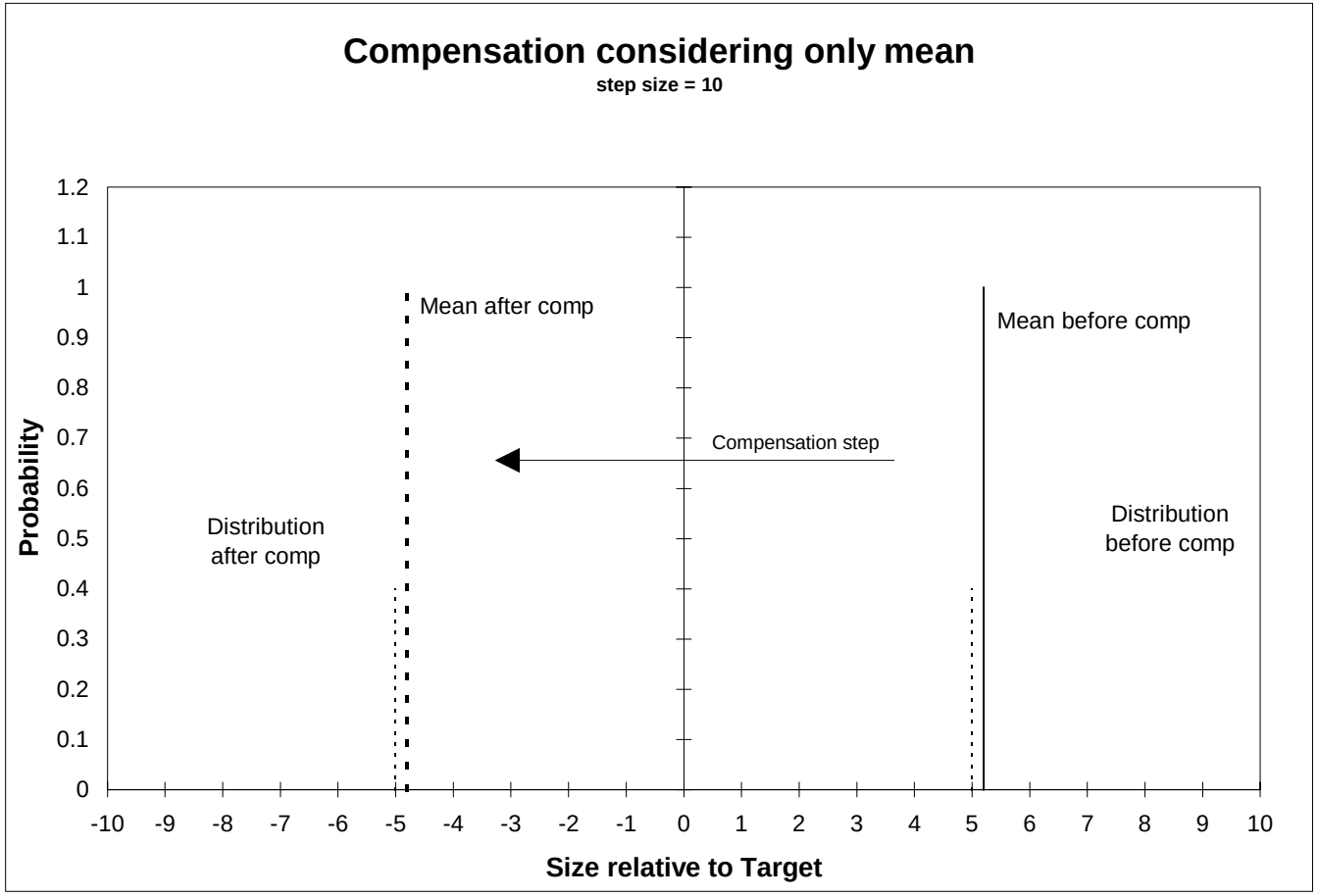
Through-feed Centerless Grinding Schematic



Typical Data to be Controlled



Compensation Conditions

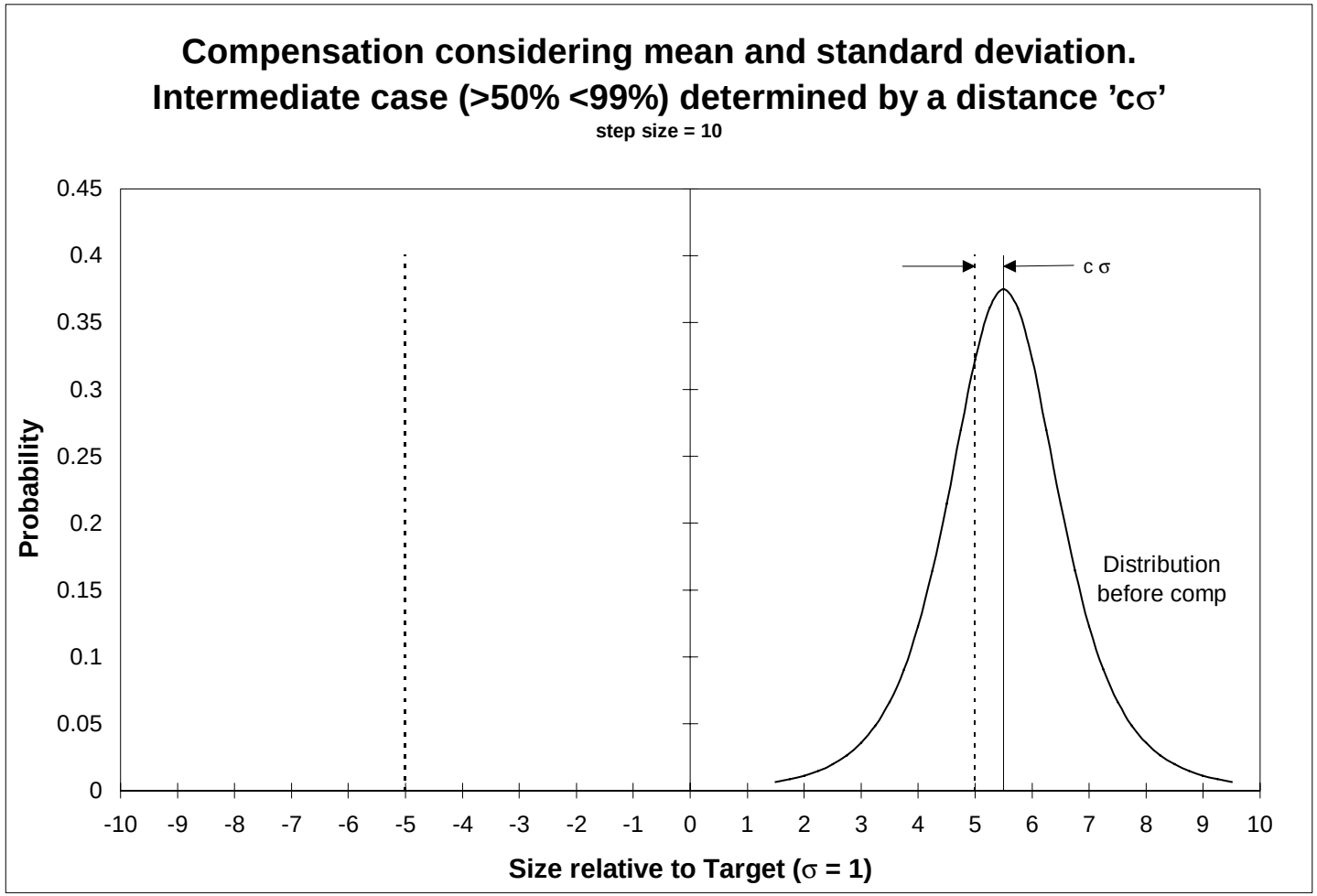


Mathematical Description of the Process

- The process is modeled as a 4 DOF student's *t* distribution.
- The mean, μ, and standard deviation, σ, are calculated with each iteration.
- Hypotheses tests are performed that compare the mean with the two boundaries of interest,

$$T \pm 0.5 * STEP$$

The Intermediate Case



The Hypothesis Tests

- With what amount of certainty is the measured mean outside of the region: $T \pm 0.5 * STEP$?
- Two tests are performed one with respect to each of the boundaries.
- The statistics of interest are:

$$t_u = \frac{\sqrt{n}}{s}\left(\bar{x} - \left(T + 0.5STEP\right)\right)$$

$$t_l = \frac{\sqrt{n}}{s}\left(\bar{x} - \left(T - 0.5STEP\right)\right)$$

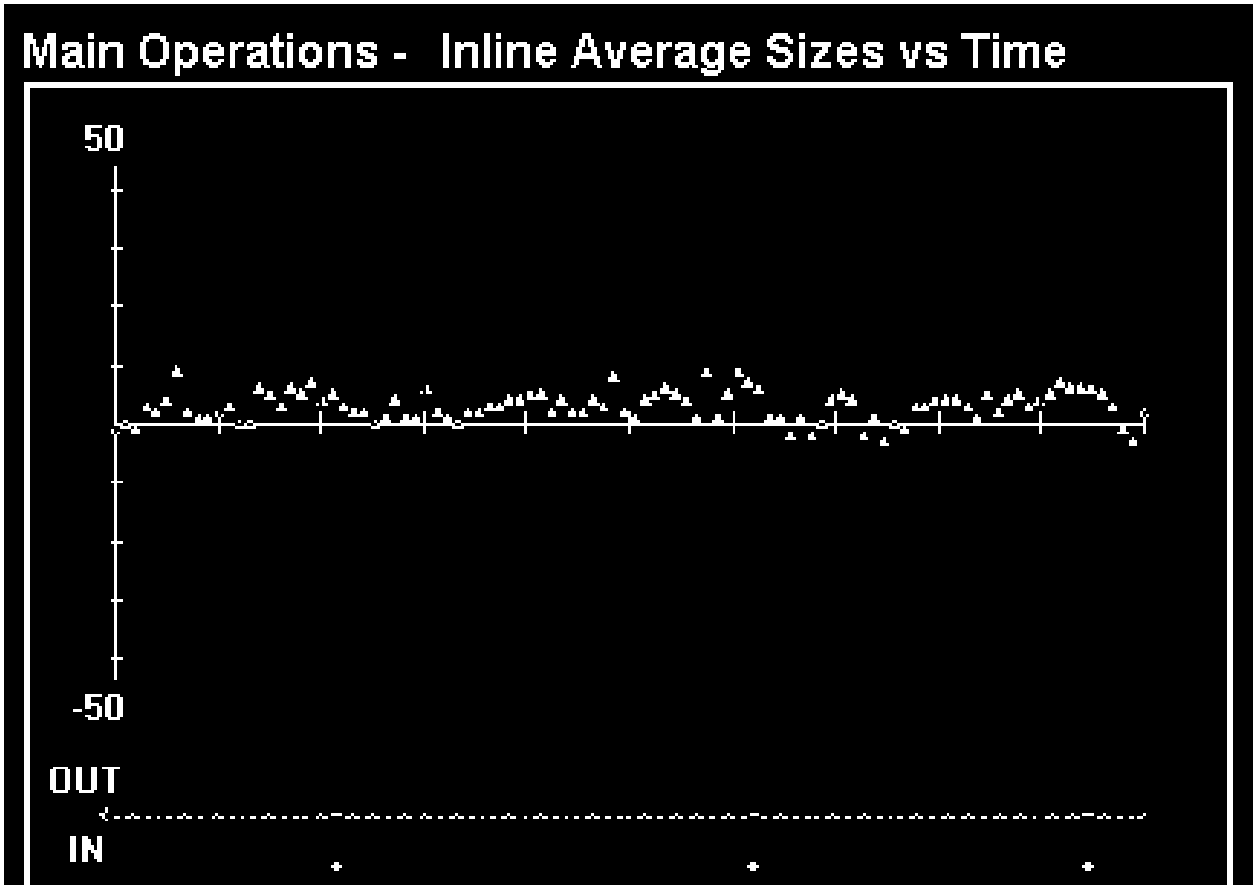
Compensation Decisions Based on Hypothesis Tests

- Compensation decisions are made according to the following table:

CASE	DECISION
$t_u > t_d$	Compensate in
$t_l < -t_d$	Compensate out
else	Do not compensate

- Where t_d is the desired value.

Experimental Results: Steady State



Conclusions

- SBC works. Avoids the pitfalls of constant parameters.
- The self-tuning nature of this algorithm allows it to adjust for unpredictable changes in machine precision.
- Can be used on any similar machine with few if any changes made to the algorithm.
- Billions of bearings are made this way each year. Every small increase in precision and accuracy has significant benefits.