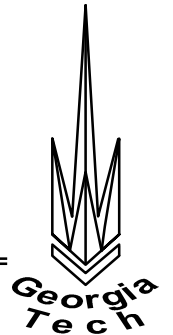


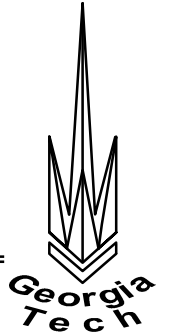
Statistical Control of Through Feed Centerless Grinding



Precision Machining Research Consortium
Industrial Advisory Board
Georgia Institute of Technology
29 October 1997

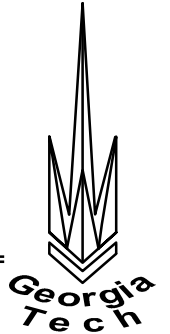
Richard W. Cowan
Advisor: Dr. Tom Kurfess

Overview



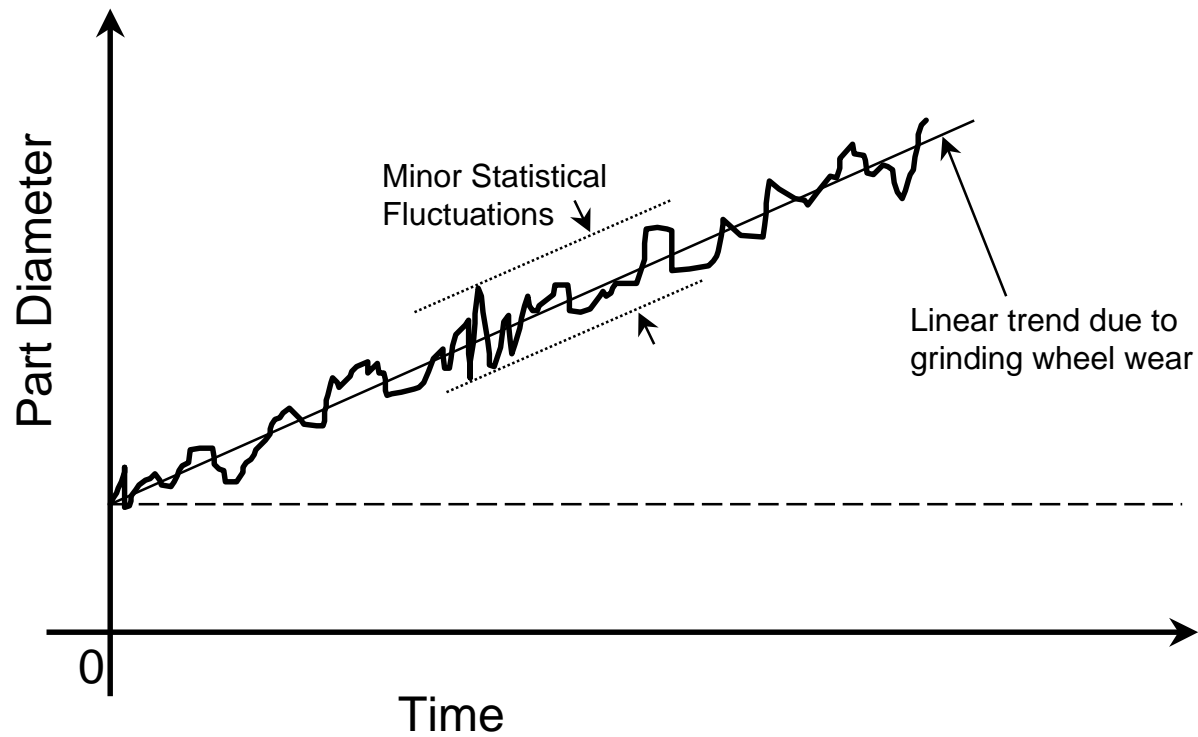
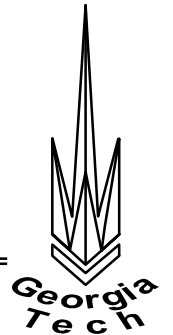
- ❖ Motivation
- ❖ Characteristic data of the grinding process
- ❖ Autogage
- ❖ CuSum (Cumulative Summation) method
- ❖ Statistical control method
- ❖ Conclusions

Motivation

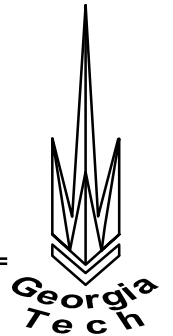


- ❖ CuSum requires several parameters which must be determined for each unique machine and process.
- ❖ These parameters do not vary with time.
- ❖ Problems may arise when significant shifts in process variance or some other anomaly occur.
- ❖ A different statistical method which monitors process drift and calculates real-time values of process variance could adjust its parameters to correct for anomalies.

Characteristic Data of the process



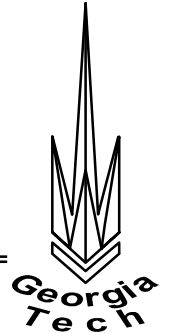
The Autogage



- ❖ This hardware is necessary to implement CuSum and other statistical control methods
- ❖ Autogage constantly measures diameter
- ❖ Diameters are calculated from the filtered signal.

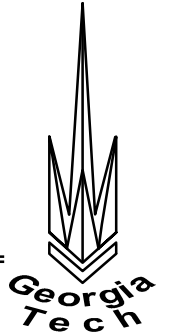


Cumulative Summation Control Method



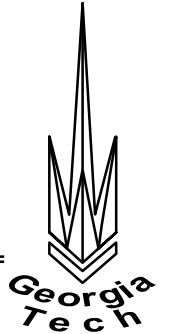
- ❖ Purpose: Accurately detect a small shift in the process mean using as few samples as possible.
- ❖ Uses standardized Z statistic:
 - $Z_i = (Y_i - \mu)/\sigma$
 σ = standard deviation of the grinder's 6σ capability.
 - Parameters
 - ◆ $S_{H,i} = \text{Max} \{0, (Z_i - K) + S_{H,(i-1)}\}$
 - ◆ $S_{L,i} = \text{Max} \{0, (-Z_i - K) + S_{L,(i-1)}\}$
 - ◆ K controls sensitivity to small errors
- ❖ Compensations are made when S_H or S_L exceed a constant value established beforehand.

Statistical Process Control Method



- ❖ The mean and standard deviation are continuously calculated for the last five parts. The average of the previous five standard deviations is also continuously calculated.
- ❖ The distribution is approximated as a student's t distribution. A 95% confidence interval is used.
- ❖ The limits of the confidence interval are calculated.
- ❖ A comparison is made between the current mean and standard deviation with the target to determine whether or not to compensate.

Conclusions



- ❖ CuSum requires several parameters which must be determined for each unique machine and process.
- ❖ These parameters do not vary with time.
- ❖ Problems may arise when significant shifts in process variance or some other anomaly occur.
- ❖ The Statistical method adjusts the decision parameter, σ , as the process changes. It can:
 - Adjust for changes in variance.
 - Absorb the occasional outlier without consequence.
- ❖ CuSum takes into account each individual datum while the Statistical method makes decisions only on the trend of the data.