# Brake Torque Variation Due To Caliper Machining Quality

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## Background

Excessive BTV (Brake Torque Variation) value during development could not be theoretically explained for Caliper A, and was higher than 1st Prototype caliper.

Main parameters affecting BTV sensitivity were investigated but found not to be the cause:

- Caliper stiffness
- Disc thickness variation (DTV)
- Friction µ

This investigation identifies a new sensitivity factor.

## BTV Sensitivity Investigation

Abnormalities found on Caliper A:

- Machining lines correlated with high Rpk values
- Surface profile of Caliper A: Visible machining lines, High Rpk
- Surface profile of Caliper B: No machining lines, Low Rpk

Reducing machining lines and reducing Ra, Rz, Rpk values could achieve ~20% reduction (not full 100%)

## BTV Influence due to Built-up Edge Deposits

Theoretical influence of built-up edge deposits

- Material work-hardens and becomes part of the tool cutting edge.
- As it builds up, it cuts deeper into the material creating surface anomalies.
- Eventually, the build-up detaches from the tool tip and deposits into the machined surface.

### Process parameters affecting BUE:

- Rotation Speed
- Feed Rate
- Cutting Temperature
- Tool rake angle
- Tool material

## BTV Confirmation

The roughness of Caliper C, is higher than Caliper B.

Controlling roughness by surface profile measurements is not robust enough to confirm BUE presence

No clear correlation between roughness values and BUE deposits.

## Conclusion

A new influencing parameter was found for BTV performance: built-up edge deposits.

- The presence of built-up edge deposits in the caliper housing piston bore has been shown to double the BTV value for this caliper design.
- To reliably identify built-up edge deposits, microscopic visual inspection is necessary (Ra, Rz, Rp, and Rpk are not reliable indicators of BUE existence).
- Built-up edge is a production concern, but should not be neglected by the designer.

**BTV** \(= \text{Calculation} + 100\%\)

**BUE** \(= \text{Calculation} + 80\%\)

<table>
<thead>
<tr>
<th>Caliper</th>
<th>Improved machining process caliper</th>
<th>BUE deposits</th>
<th>Visible lines</th>
<th>Rz</th>
<th>Rp</th>
<th>Rpk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caliper A</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>18.72µm</td>
<td>9.99µm</td>
<td>5.35µm</td>
</tr>
<tr>
<td>Caliper B</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>18.38µm</td>
<td>7.76µm</td>
<td>3.42µm</td>
</tr>
<tr>
<td>Caliper C</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>2.61µm</td>
<td>7.76µm</td>
<td>3.42µm</td>
</tr>
</tbody>
</table>

BUE deposits affect BTV sensitivity. BUE cannot be identified using surface roughness measurements.