B. Derivation of surface roughness during SPDT

Appendices B is meant to derive an expression of theoretical surface roughness attainable during nanometric cutting by applying the principles of geometry.

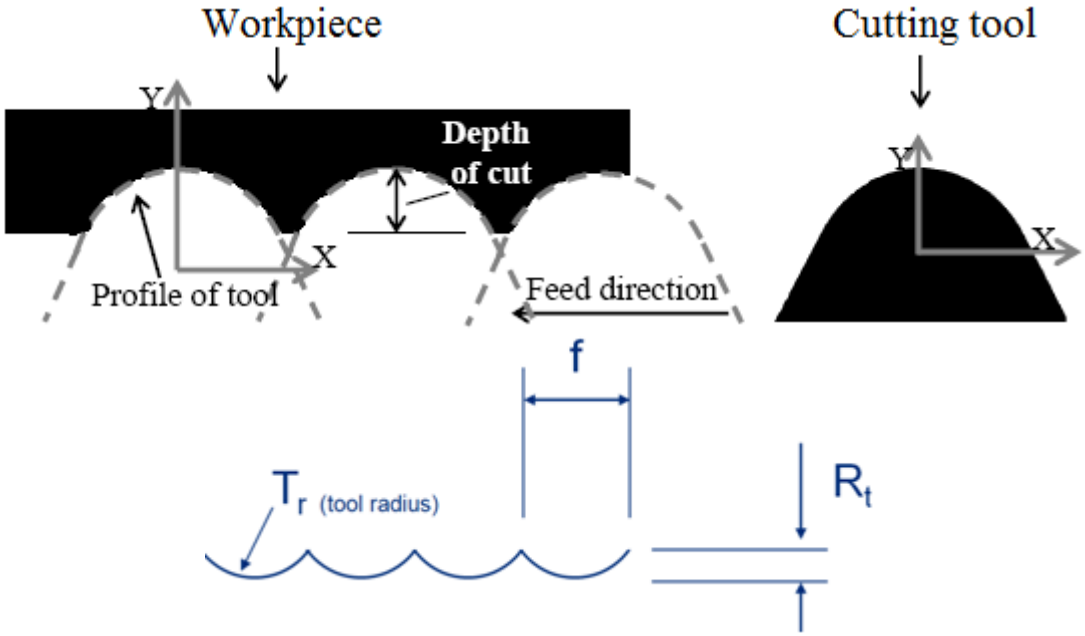

Figure B1: Schematic for model of surface roughness.

Conventionally, Scattergood *et al.* [22] gave the following empirical relation for the measurement of surface roughness (Rt) as shown in figure B1.

$$R_t \approx \frac{f^2}{8 * T_r}$$

where f = feed rate, Tr = tool radius, and R_t = maximum individual peak to valley height. However, this applies only if f/R < 1. A modification in the above equation was proposed later [302] to incorporate the asynchronous errors arising from the machine spindle as follows:

$$R_t \approx \frac{f^2}{8 * T_r} + K\{A_{asynchronous}\}$$

Author of this thesis has attempted to derive a fresh mathematical expression to deduce the mathematical expression of surface roughness for an ultra precision engineering operation such that of SPDT. Accordingly, figure B2 shows a schematic diagram to deduce a modified expression for surface roughness Rt.

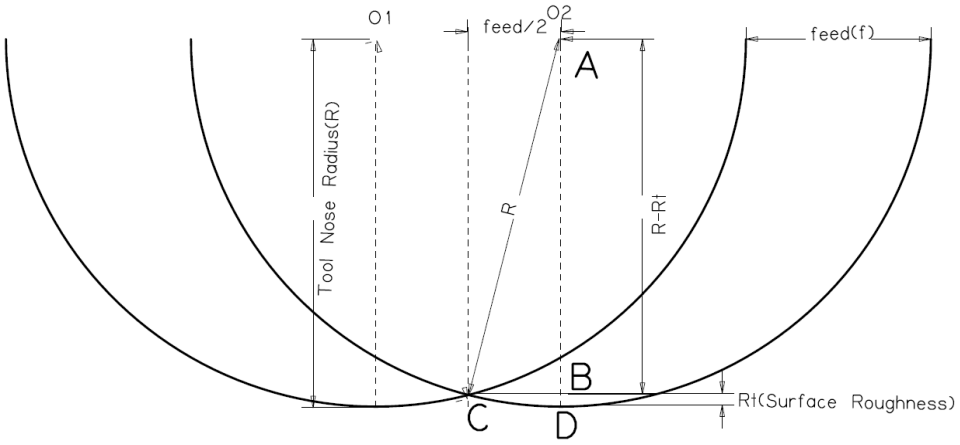

Figure B2: Proposed schematic to measure surface roughness.

In triangle ABC, using Pythagoras theorem,

$$(R-R_t)^2+\left(\frac{f}{2}\right)^2=R^2$$

Solving above equation

$$R^2+R_t^{\,2}-2RR_t+\left(\frac{f}{2}\right)^2=R^2$$

$$4R_t^{\,2}-8RR_t+f^2=0$$

This is a quadratic equation of a form $ax^2+bx+c=0$ with its root $\frac{-b\pm\sqrt{b^2-4ac}}{2a}$

In the above equation, a = 4; b = -8R; c = f^2

Therefore, $R_t=\frac{8R\pm\sqrt{64R^2-4X4f^2}}{2X4}$

$$R_t=R\pm\sqrt{R^2-\frac{f^2}{4}}$$

It shall be noted that since $R_t < f < R$ so, $R_t=R+\sqrt{R^2-\frac{f^2}{4}}$ may be neglected.

The final expression after incorporating the asynchronous errors arising from the machine spindle reduces to:

$$Rt=R-\sqrt{R^2-\frac{f^2}{4}}+K\{A_{asynchronous}\}$$

where *Rt* is the surface roughness, *R* is tool nose radius of the round tool and *f* is the feed rate.