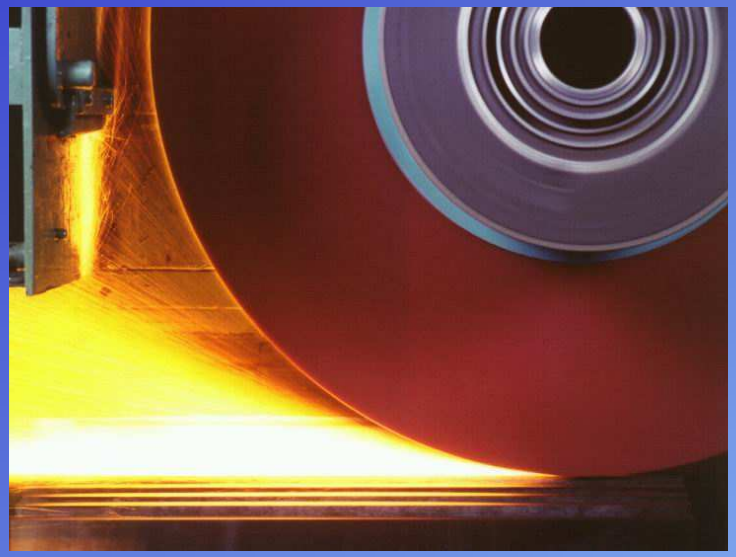
Innovative Manufacturing Processes

Grind-Hardening

Process Overview



Grind hardening utilizes the dissipated heat in grinding in order to induce martensitic phase transformations in the surface layers of the processed components.

Process Capabilities:

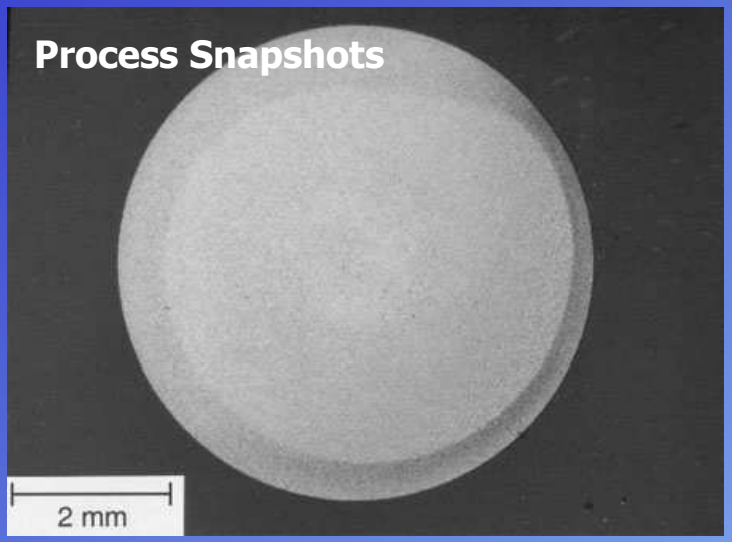
- Manufacturing of a part with one machine set-up
- Reduction of production time
- Better material handling with lower logistic expenditure
- Reduction of energy consumption
- Eco-friendly process
- Easily adaptable to installed production plants
- Maximum
  - hardness: 50 – 60 HRC
  - hardness penetration depth: 2 mm

Innovative Manufacturing Processes

Grind-Hardening

Process Overview

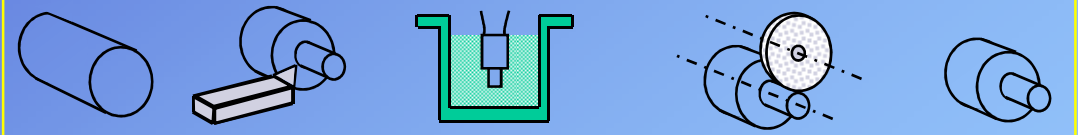
Process Snapshots



Process Chain Steps Reduction:

Conventional Production Sequence

START → Soft Machining → Hardening → Finishing → END



- Turning
- Milling
- Drilling

- Induction Hard.
- Nitriding
- Case Hard.

- Grinding
- Honing
- Hard Turning

Integrated Production Sequence

START → Soft Machining → Abrasive processing → END

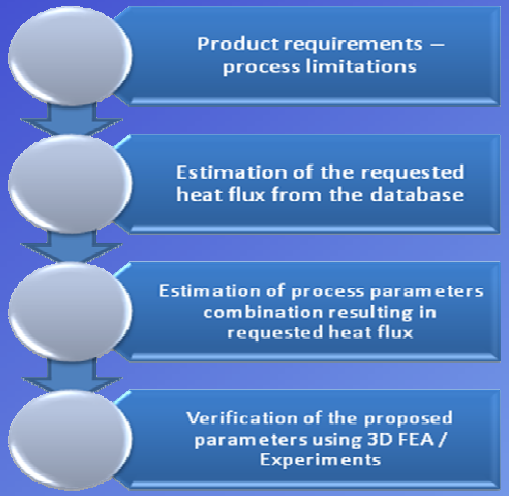
- Turning
- Milling
- Drilling

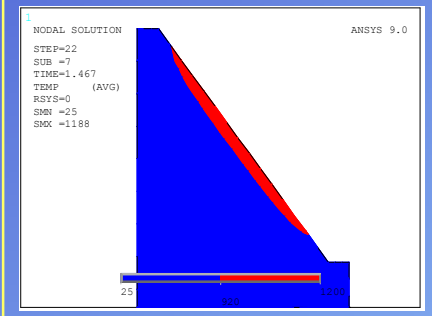
- Grind Hardening
- Finish Grinding

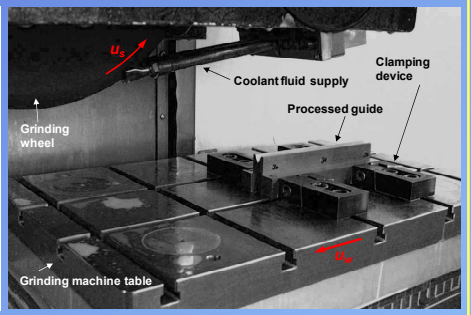
Innovative Manufacturing Processes

Grind-Hardening

Holistic methodology for the simulation of grind hardening

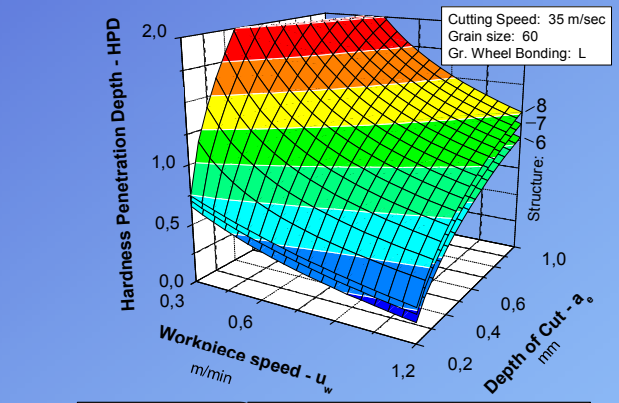


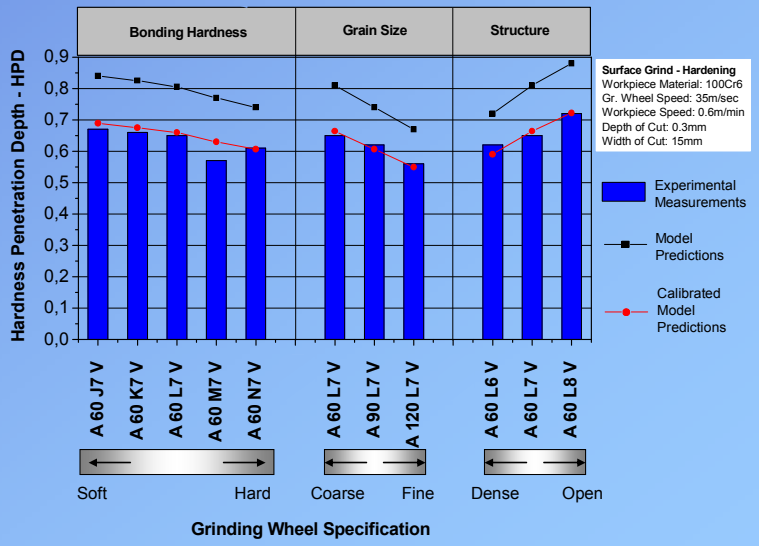




REF: Salonitis K., Stavropoulos P., Stournaras A. and Chryssolouris G. (2007) "Finite Element Modeling of Grind Hardening Process", *Proceedings of the 10th CIRP International Workshop on Modeling of Machining Operations*, pp. 117 – 123, ISBN 978-88-95267-04-3

Grinding wheel effect





REF: Salonitis K., Chrondros T. and Chryssolouris G. (2007) "Grinding Wheel Effect on Grind-Hardening Process", *International Journal of Advanced Manufacturing Technology*, In Press (Published online), DOI 10.1007/s00170-007-1078-9

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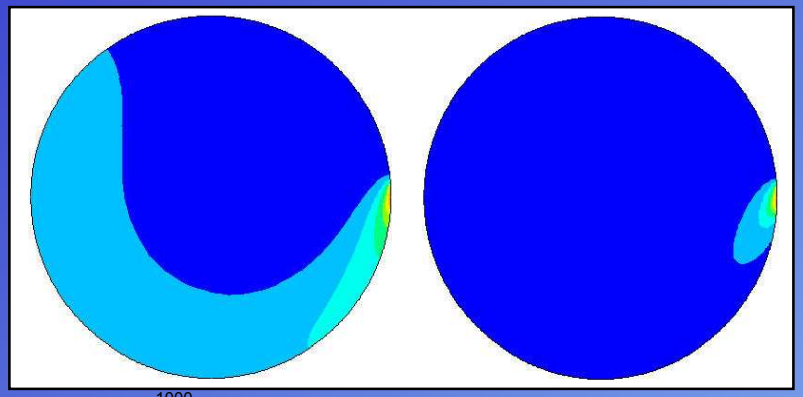
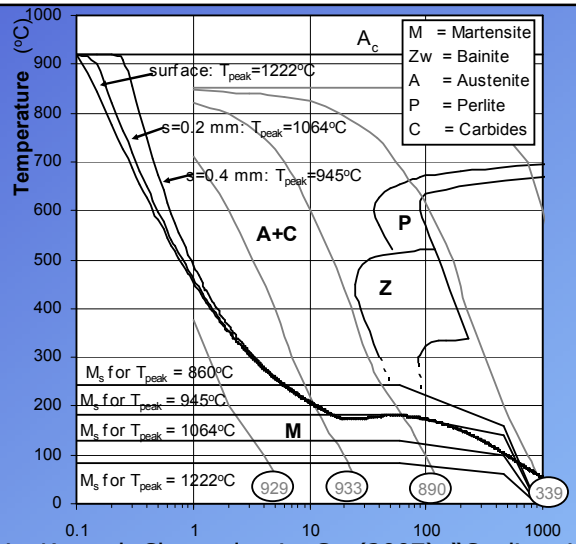
Grind-Hardening

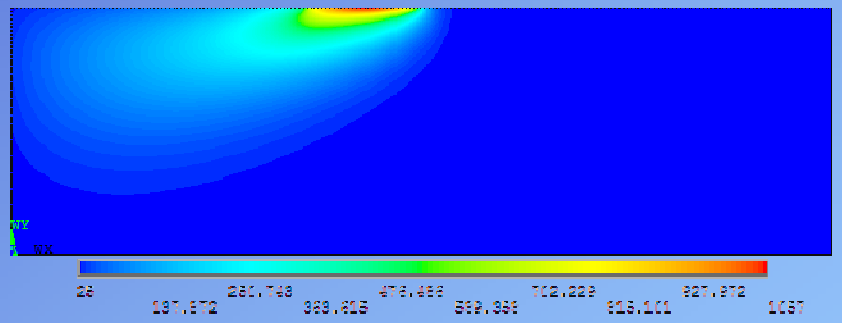
Coolant fluid significance in grind-hardening process

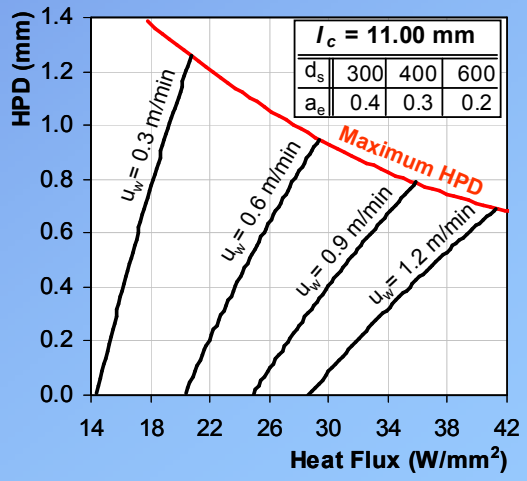




REF: Salonitis K. and Chryssolouris G. (2007) "Cooling in Grind-Hardening Operations", *International Journal of Advanced Manufacturing Technology*, Vol. 33, No. 3-4, pp. 285 – 297

Prediction of the hardness distribution and hardness penetration depth





REF: Salonitis K. and Chryssolouris G. (2007) "Thermal analysis of Grind-Hardening process", *nternational Journal of Manufacturing Technology and Management,* Vol. 12, Nos. 1/2/3, pp. 72 – 92

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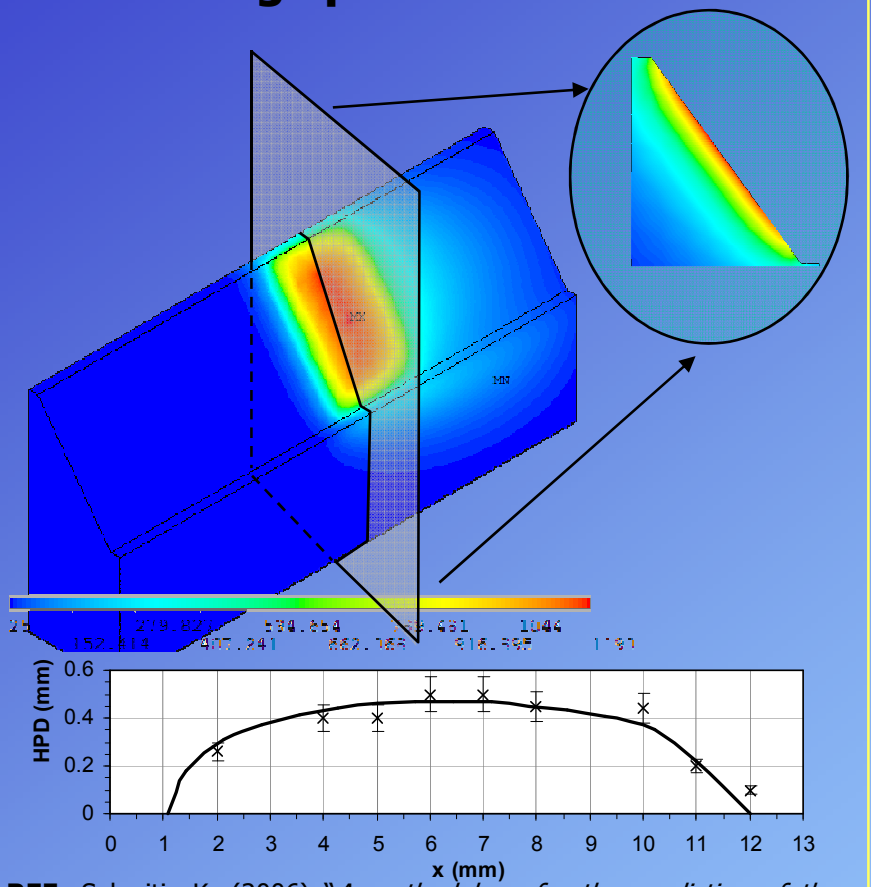
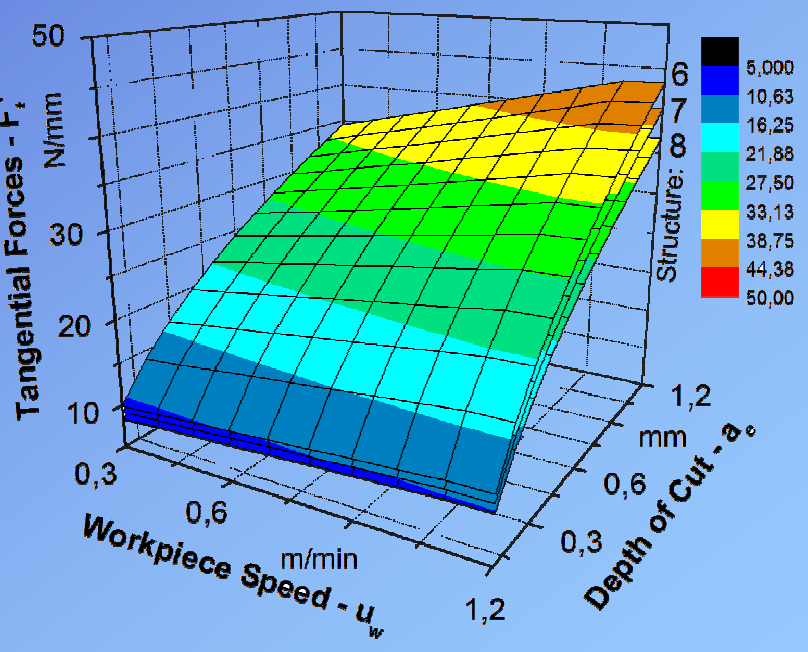
Grind-Hardening

Methodology for estimating the process parameters for achieving specified HPD



REF: Salonitis K. (2006) "*A methodology for the prediction of the hardness distribution and the hardness penetration depth caused by grind-hardening process*", PhD Thesis, University of Patras

Process forces modeling in Grind-Hardening

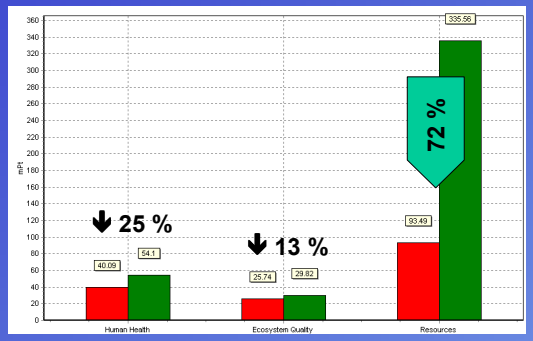


REF: Salonitis K., Tsoukantas G., Stavrapoulos P., Stournaras A., Chondros T. and Chryssolouris G. (2006) "Process forces modelling in Grind-Hardening", *Proceedings of the 9th CIRP International Workshop on Modeling of Machining Operations*, pp. 295-302

Innovative Manufacturing Processes

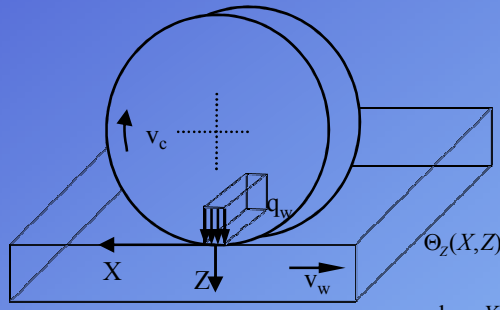
Grind-Hardening

Life Cycle Assessment of the process



REF: Salonitis K., Tsoukantas G., Drakopoulos S., Stavropoulos P. and Chryssolouris G. (2006) "Environmental Impact Assessment of Grind-Hardening Process", *Proceedings of the 13th CIRP International Conference on Life Cycle Engineering,* pp. 657-662, ISBN 90-5682-712-X

Analytical temperature model

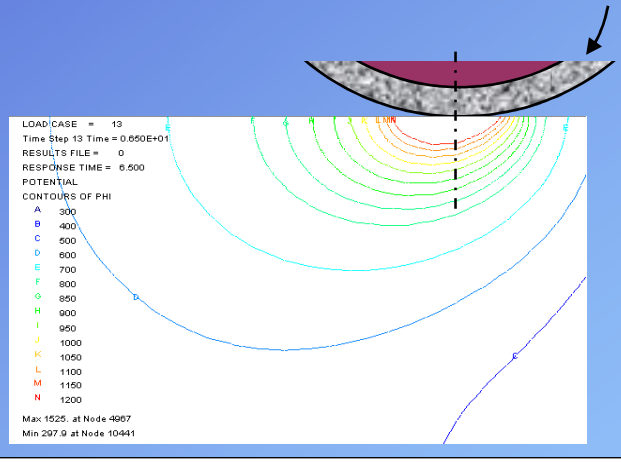


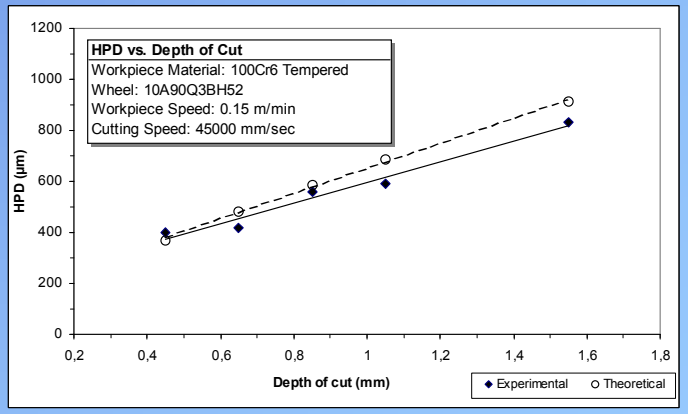
$$\Theta_Z(X,Z)=\frac{2q_w a}{\pi\lambda v_w}\int_{x-L}^{x+L} e^{-u}K_0\left(Z^2+u^2\right)^{1/2}du$$

$$\text{where } X=\frac{v_w x}{2a},\quad Z=\frac{v_w z}{2a},\quad L=\frac{v_w l_k}{2a},\quad u=\frac{v_w(x-x_0)}{2a}$$

REF: Tsirbas K. (2002), "*Theoretical and Experimental Investigation of the grind-hardening process*", PhD Thesis, Universeity of Patras.

Numerical temperature model





REF: Chryssolouris G., Tsirbas K., Salonitis K. (2005) "An analytical, numerical and experimental approach to grind-hardening", SME Journal of Manufacturing Processes, Vol. 7, No. 1, pp. 1 – 9.

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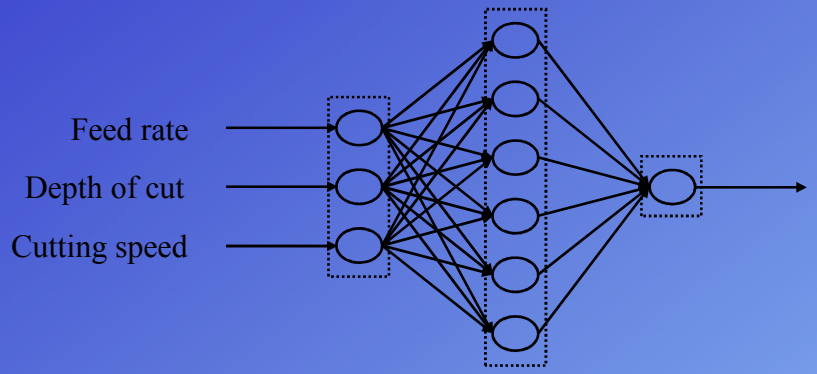
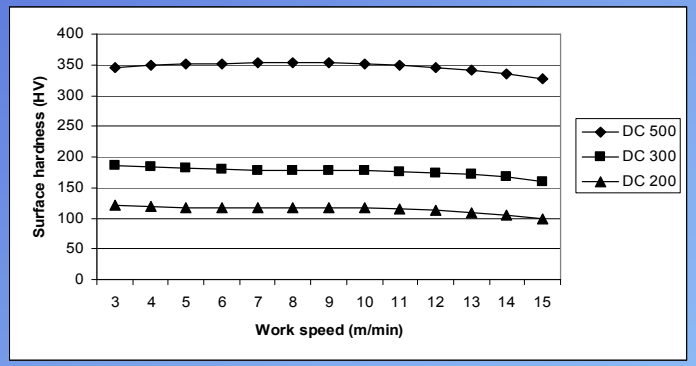
Grind-Hardening

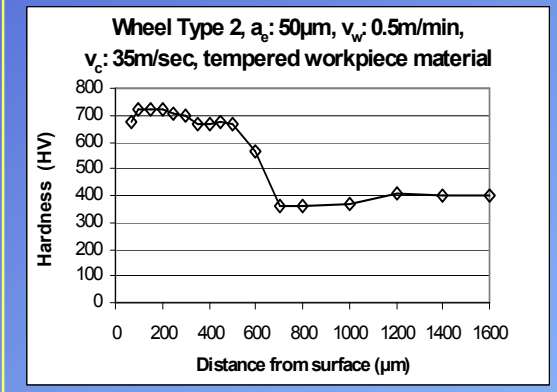
Modeling using Neural Networks

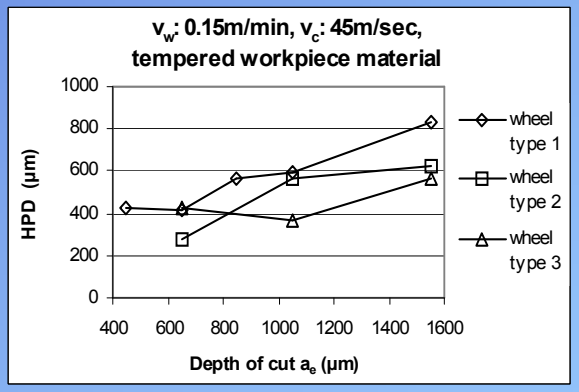


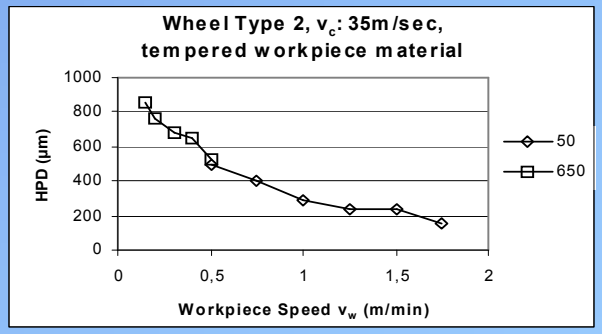


REF: Tsirbas K., Mourtzis D., Chryssolouris G. (1999) "Grind hardening modeling with the use of neural networks" *Proceedings of the AMST'99 5th International Conference in Advanced Manufacturing Systems and Technology*.

Experimental Investigation of the process







REF: Chryssolouris G., Tsirbas K., Zannis S. (2001) "An experimental investigation of Grind Hardening", *Proceedings of the 34th International CIRP Seminar on Manufacturing Systems*.