LoCoMaTech

GA 723517

LoCoMaTech Project Talk

Innovative tooling techniques for low-cost and low-friction dies

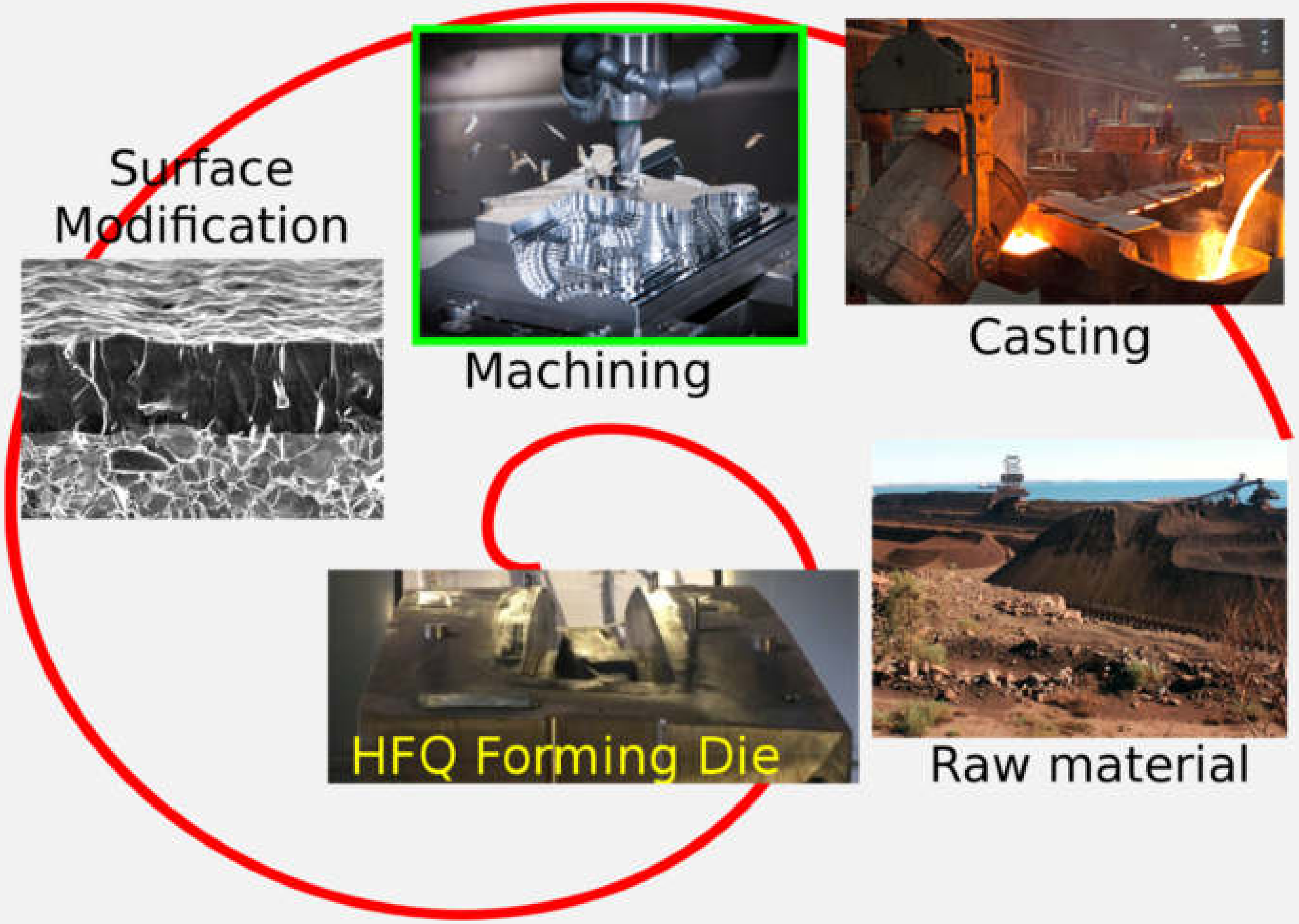
Genesis of Coating-Substrate-Stability

The main goal:
Investigations in to the mechanical and thermal Stability of Coating-Substrate-Systems

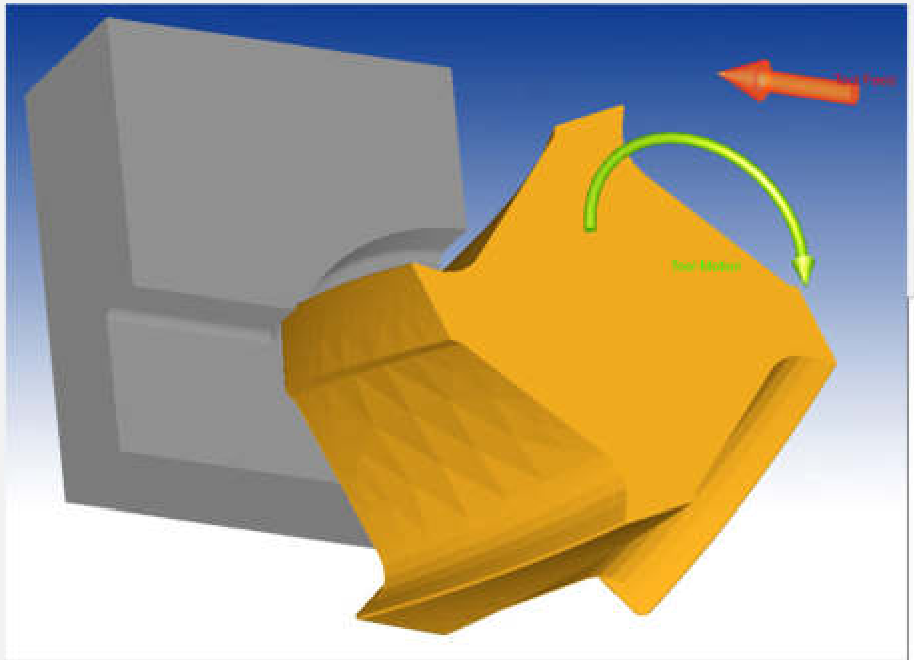
TBZ-PARIV

Jürgen Leopold

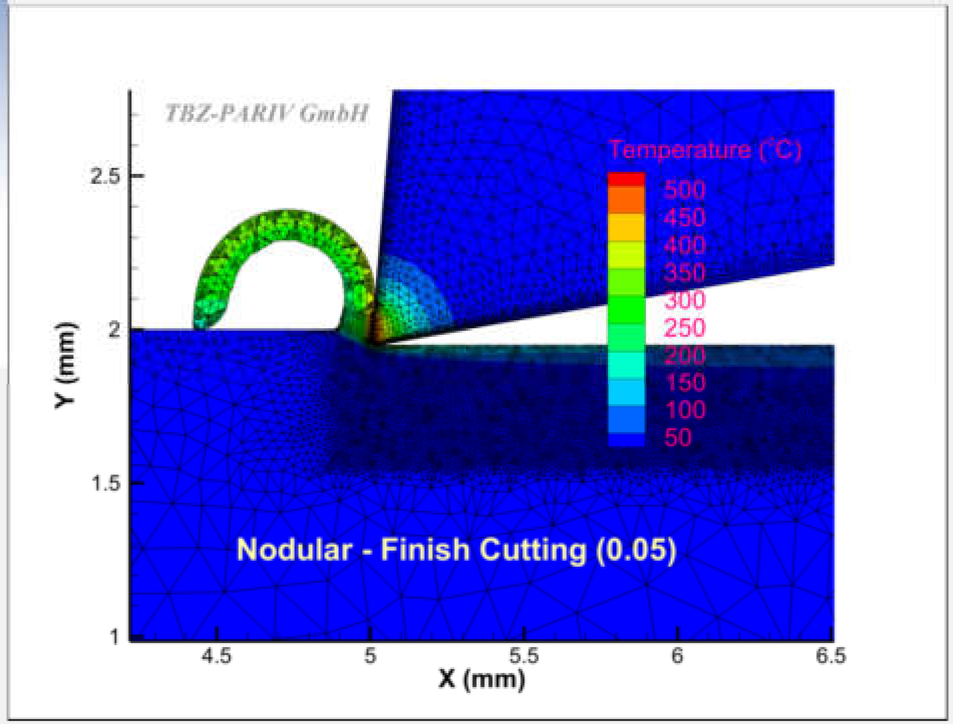
Genesis of the Coating-Substrate-Stability



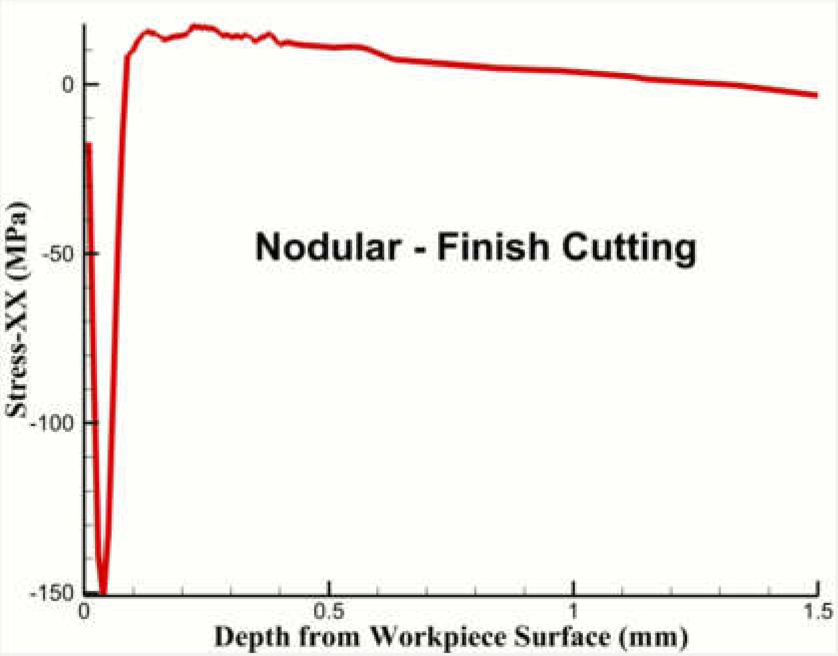
Influence of the Cutting Conditions

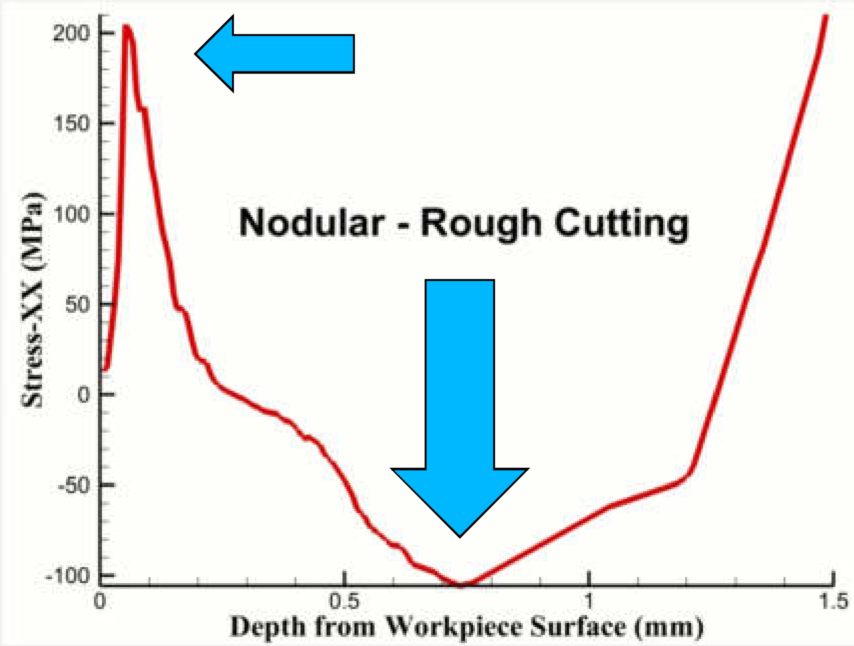


Cutting Speed
Feed
Depth of cut

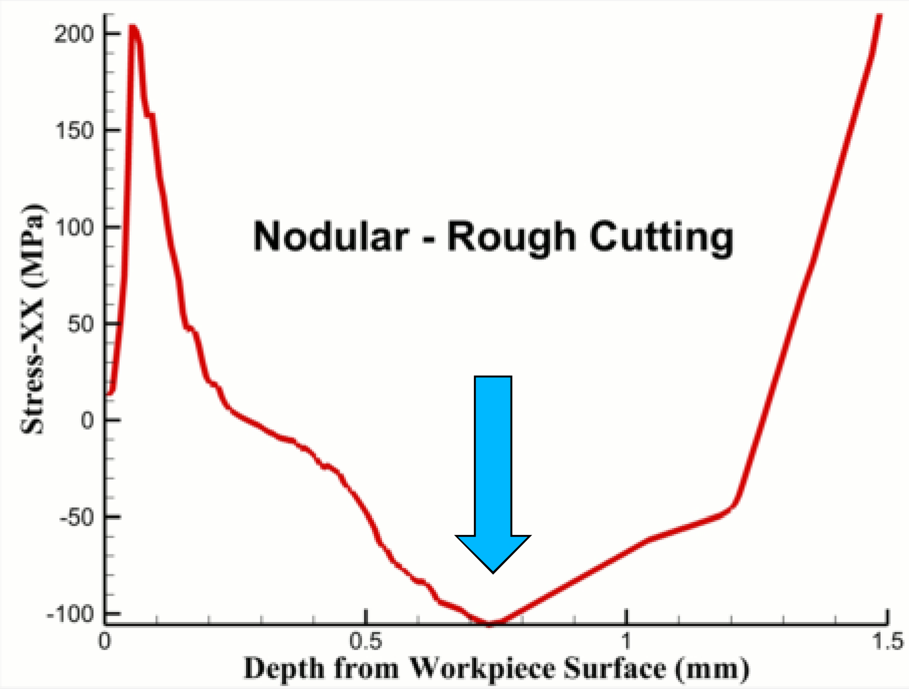


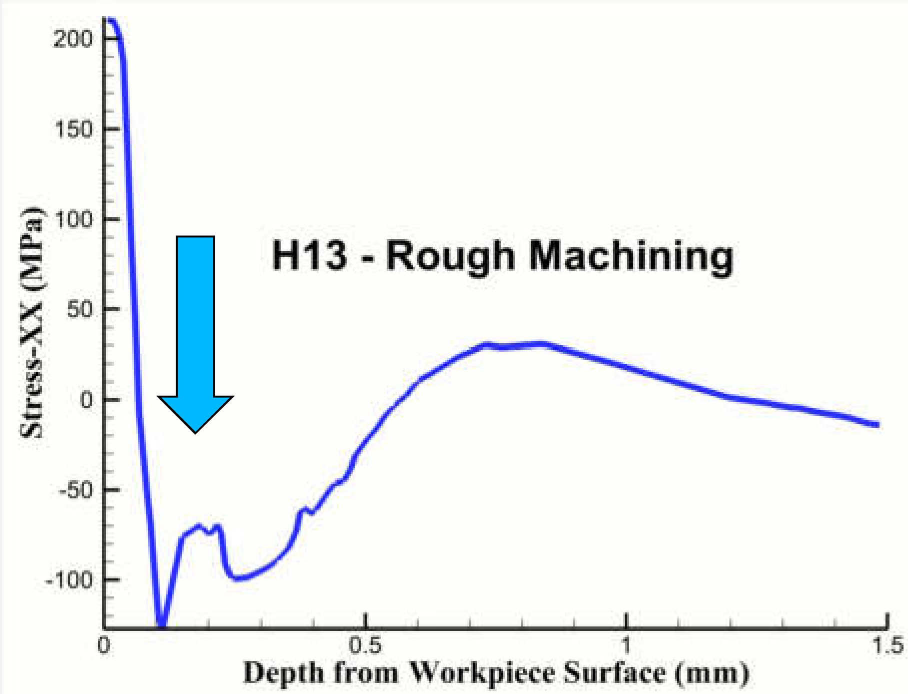
Residual Stress in the Machined Surface





Residual Stress in the Machined Surface





Summary

The stability of Coating-Substrate-Systems of HFQ© forming dies depends on the total manufacturing chain.

The cutting condions (speed, feed and depth of cut) influence the residual stress situation within the machined surface.

To prevent failures in the Coating-Substrate-System, accurately finish machining must be followed to rough machining.

Summary

APPENDIX : Basic equations

Power-Law-model

$$\bar{\sigma} = g(\epsilon^p) \times \Gamma(\dot{\epsilon}) \times \Theta(T)$$

Strain-Hardening

$$g(\epsilon^p) = \sigma_0(1 + \frac{\epsilon^p}{\epsilon_0^p})^{\frac{1}{n}}, \qquad if\ \epsilon^p < \epsilon^p_{cut}$$

$$g(\epsilon^p) = \sigma_0(1 + \frac{\epsilon^p}{\epsilon_{cut}^p})^{\frac{1}{n}}, \qquad if\ \epsilon^p \geq \epsilon^p_{cut}$$

Strain-Rate-Sensitivity

$$\Gamma(\dot{\epsilon}) = (1 + \frac{\dot{\epsilon}}{\dot{\epsilon}_0})^{\frac{1}{m_1}}, \qquad if\ \dot{\epsilon} \leq \dot{\epsilon}_t$$

$$\Gamma(\dot{\epsilon}) = (1 + \frac{\dot{\epsilon}}{\dot{\epsilon}_0})^{\frac{1}{m_2}}(1 + \frac{\dot{\epsilon}_t}{\dot{\epsilon}_0})^{\frac{1}{m_1} - \frac{1}{m_2}}, \qquad if\ \dot{\epsilon} > \dot{\epsilon}_t$$

APPENDIX : Basic equations

Thermal-Softening

$$\Theta(T) = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4 + c_5 T^5, \qquad if\ T < T_{cut}$$
$$\Theta(T) = \Theta(T_{cut}) - (T - T_{cut})/(T_{melt} - T_{cut}), \qquad if\ T \geq T_{cut}$$

List of Symbols

E	Young's modulus
L_0	original workpiece length
T	temperature
T_{cut}	linear cut-off temperature in the thermal softening function
T_{melt}	melting temperature
$c_0 - c_5$	coefficients of fifth-order thermal softening polynomial function
d	length of compression
$g(\epsilon^p)$	strain hardening function
m_1	low strain-rate-sensitivity coefficient

APPENDIX : Basic equations

m_2	high strain-rate-sensitivity coefficient
n	strain hardening exponent
$\Gamma(\dot{\epsilon})$	strain rate sensitivity function
$\Theta(T)$	thermal softening function
$\dot{\epsilon}$	plastic strain rate
$\dot{\epsilon}_0$	reference plastic strain rate in the strain-rate-sensitivity function
$\dot{\epsilon}_t$	threshold plastic strain rate in the strain-rate-sensitivity function
ϵ^p	accumulated plastic strain
ϵ^p_0	reference plastic strain in the strain hardening function
ϵ^p_{cut}	cut-off plastic strain in the strain hardening function
ϵ_{xx}	logarithmic strain along the compression direction
ν	Poisson's ratio
$\bar{\sigma}$	flow stress
σ_0	initial yield stress
σ_v	von Mises stress
$\sigma_{xx}, \sigma_{yy}, \sigma_{zz}, \sigma_{xy}$	stress components