Material Behavior Modeling for High Speed Machining Simulation of 6061-T6 and 7075-T651 Aluminum Alloys

Modelisation du comportment du materiau pour la simulation de l' usinage à haute vitesse des alliages d'aluminium 6061-T6 et 7075-T651

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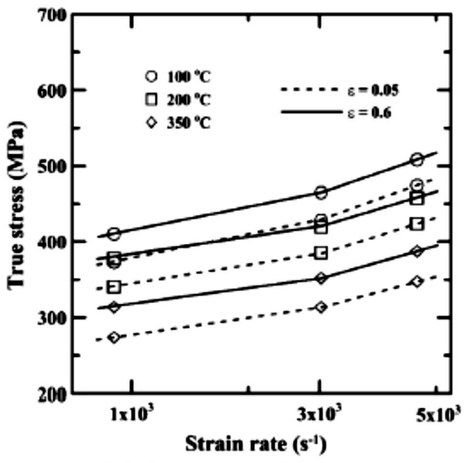
Abstract: the present study proposes an original method to identify the Marusich's constitutive equation (MCE) for finite element simulation of the high speed machining of aluminum alloys. The coefficients of the MCE, for the aluminums 6061-T6 and 7075-T651, were identified inversely using orthogonal machining tests and dynamic tests.

Strain rate sensitivity of aluminum alloys



Results for the 6061-T6 alloy from *(Lee, 2014)*

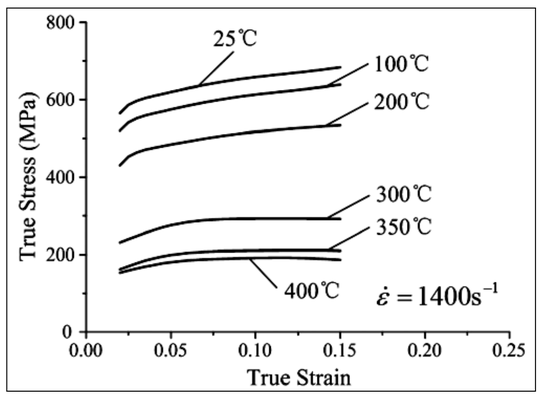
Marusich's constitutive equation (Marusich, 1995)

$$\left(1+\frac{\dot{\varepsilon}_p}{\dot{\varepsilon}_0}\right)=\left(\frac{\sigma}{g(\varepsilon_p)}\right)^{m_1} \quad if\ \ \dot{\varepsilon}_p<\dot{\varepsilon}_t$$

$$\left(1+\frac{\dot{\varepsilon}_p}{\dot{\varepsilon}_0}\right)\left(1+\frac{\dot{\varepsilon}_t}{\dot{\varepsilon}_0}\right)^{\frac{m_2}{m_1}-1}=\left(\frac{\sigma}{g(\varepsilon_p)}\right)^{m_2} \quad if\ \ \dot{\varepsilon}_p>\dot{\varepsilon}_t$$

$$g(\varepsilon_p)=[1-\alpha_{NL}(T-T_0)]\sigma_0\left(1+\frac{\varepsilon_p}{\varepsilon_0}\right)^{1/n_{NL}}$$

Hybrid approach for the identification of the material constants



Dynamic tests

7075-T651 *(Li , 2014)*

Low strain rate constants: σ_0, n_{NL}, and $m1$

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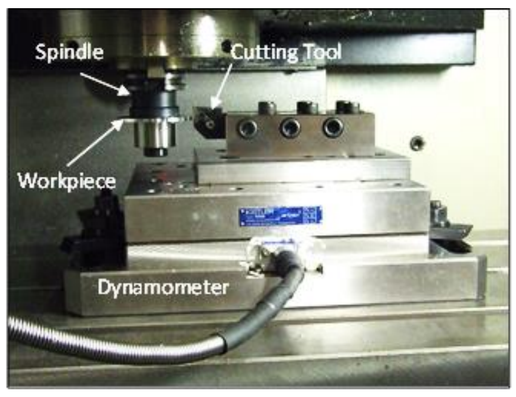


Machining tests

High strain rate constants: $m2$ and α_{NL}

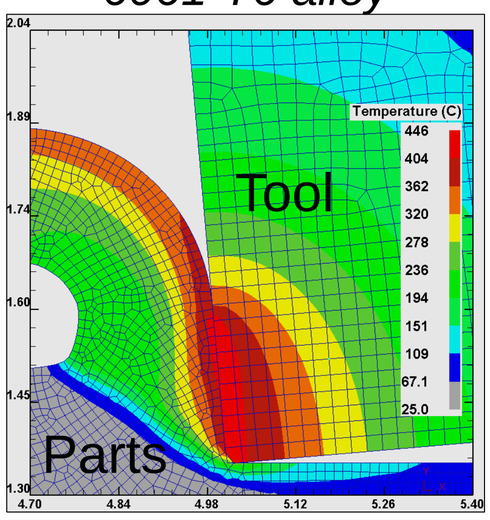
Material constants

Material	σ_0 [MPa]	m_1	m_2	n_{NL}	α_{NL}
6061-T6	278	4.3	150.7	3.3	0.0022
7075-T651	529	2.6	168.9	11.2	0.0017

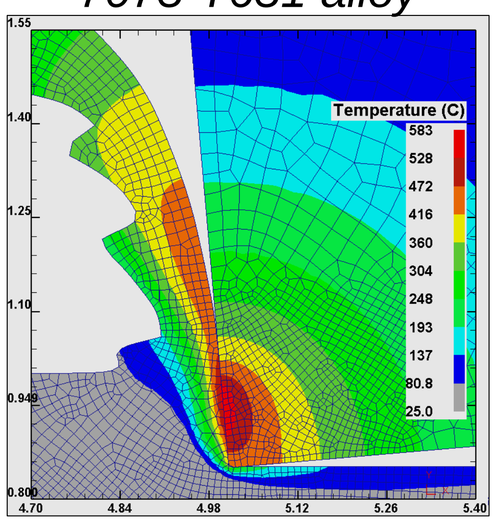
Material	ε_0	$\dot{\varepsilon}_0\ [s^{-1}]$
6061-T6	0.1	206
7075-T651	0.025	2400

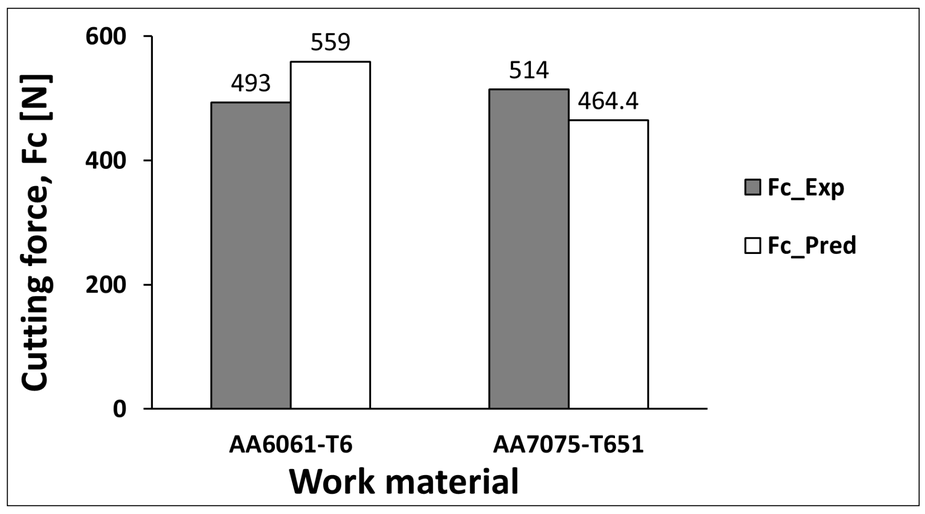
Results: finite element simulation of high speed machining 6061-T6 and 7075-T651 alloys

6061-T6 alloy



7075-T651 alloy





Dry cutting conditions, Speed=1145 m/min, Feed=0.15 mm/rev, and uncoated carbide inserts

Conclusions: the Marusich's constitutive equations for 6061-T6 and 7075-T651 aluminum alloys were identified. The obtained material models were successfully implemented into an finite element modeling (FEM) of high speed machining using *DEFORM 2D* software. The FEM was validated using experimental data such as cutting force.

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