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The analysis of tool life and wear mechanisms in spindle speed variation machining

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Abstract:

Regenerative chatter vibrations generally limit the achievable material removal rate in machining. The diffusion of spindle speed variation (SSV) as a chatter suppression strategy is mainly restricted to academy and research centers. A lack of knowledge concerning the effects of non-stationary machining is still limiting its use in real shop floors. This research is focused on the effects of spindle speed variation technique on tool duration and on wear mechanisms. No previous researches have been performed on this specific topic. Tool wear tests in turning were carried out following a factorial design: cutting speed and cutting speed modulation were the investigated factors. The carbide life was the observed process response. A statistical approach was used to analyze the effects of the factors on the tool life. Moreover, the analysis was extended to the wear mechanisms involved during both constant speed machining and SSV. The worn-out carbide surfaces were examined under a scanning electron microscope equipped with an energy dispersive X-ray spectrometer. Significant differences were appreciated. It was observed that SSV tends to detach the coatings of the inserts, entailing a mechanism that is quite unusual in wet steel turning and thus fostering the wear of the tool. The performed analysis allowed to deduce that the intensified tool wear (in SSV cutting) is mainly due to thermo-mechanical fatigue

Bibliografia:

Altintas, Y., Weck, M., Chatter stability of metal cutting and grinding (2004) CIRP Annals - Manufacturing Technology, 53 (2), pp. 619-642;

Kayhan, M., Budak, E., An experimental investigation of chatter effects on tool life (2009) Proc IME B J Eng Manufact, 223 (11), pp. 1455-1463., 10.1243/09544054JEM1506;

Siddhpura, M., Paurobally, R., A review of chatter vibration research in turning (2012) Int J Mach Tools Manuf, 61, pp. 27-47., 10.1016/j.ijmachtools.2012.05.007;

Inamura, T., Sata, T., Stability analysis of cutting under varying spindle speed (1974) CIRP Ann, 23 (1), pp. 119-120;

Yilmaz, A., Al-Regib, E., Ni, J., Machine tool chatter suppression by multi-level random spindle speed variation (2002) Journal of Manufacturing Science and Engineering, Transactions of the ASME, 124 (2), pp. 208-216., DOI 10.1115/1.1378794;

Insperger T, S., Comparison of analytical and numerical simulations for variable spindle speed turning (2003) Proceedings of IMECE'03 International Mechanical Engineering Congress, pp. 1-7., Washington, D.C., United States;

Radulescu, R., Kapoor, S.G., DeVor, R.E., An investigation of variable spindle speed face milling for tool-work structures with complex dynamics, part 1: Simulation results (1997) Journal of Manufacturing Science and Engineering, Transactions of the ASME, 119 (3), pp. 266-272;
Jayaram, S., Kapoor, S.G., Devor, R.E., Analytical stability analysis of variable spindle speed machining (2000) Trans ASME J Manuf Sci Eng, 122, pp. 391-397., 10.1115/1.1285890;
Insperger, T., Stefan, G., Stability analysis of turning with periodic spindle speed modulation via semidiscretization (2004) JVC/Journal of Vibration and Control, 10 (12), pp. 1835-1855., DOI 10.1177/1077546304044891;
Zatarin, M., Bediaga, I., Munoa, J., Lizarralde, R., Stability of milling processes with continuous spindle speed variation: Analysis in the frequency and time domains, and experimental correlation (2008) CIRP Ann, 57, pp. 379-384., 10.1016/j.cirp.2008.03.067;
Albertelli, P., Musletti, S., Leonesio, M., Bianchi, G., Monno, M., Spindle speed variation in turning: Technological effectiveness and applicability to real industrial cases (2012) Int J Adv Manuf Technol, 62 (1), pp. 59-67., 10.1007/s00170-011-3790-8;
Montgomery, D.C., (2001) Design and Analysis of Experiment, , 5 Wiley New York;
Albertelli, P., Mussi, V., Ravasio, C., Monno, M., An experimental investigation of the effects of spindle speed variation on tool wear in turning (2012) Process Mach Interact Conf Procedia CIRP, 4, pp. 29-34., 10.1016/j.procir.2012.10.006;
Che Haron, C.H., Ginting, A., Goh, J.H., Wear of coated and uncoated carbides in turning tool steel (2001) Journal of Materials Processing Technology, 116 (1), pp. 49-54., DOI 10.1016/S0924-0136(01)00841-X, PII S092401360100841X;
Dearnley, P.A., Rake and flank wear mechanisms of coated and uncoated cemented carbides (1985) Journal of Engineering Materials and Technology, Transactions of the ASME, 107 (1), pp. 68-82;
Chubb, J.P., Billingham, J., Coated cutting tools - a study of wear mechanisms in high speed machining (1980) Wear, 61 (2), pp. 283-293., DOI 10.1016/0043-1648(80)90292-6;
Nouari, M., Ginting, A., Wear characteristics and performance of multi-layer CVD-coated alloyed carbide tool in dry end milling of titanium alloy (2006) Surf Coat Technol, 200 (18-19), pp. 5663-5676., 10.1016/j.surfcoat.2005.07.063;
Jawaid, A., Sharif, S., Koksal, S., Evaluation of wear mechanisms of coated carbide tools when face milling titanium alloy (2000) Journal of Materials Processing Technology, 99 (1), pp. 266-274., DOI 10.1016/S0924-0136(99)00438-0;
Ginting, A., Nouari, M., Experimental and numerical studies on the performance of alloyed carbide tool in dry milling of aerospace material (2006) Int J Mach Tools Manuf, 46 (7-8), pp. 758-768., 10.1016/j.ijmachtools.2005.07.035;
Abdel-Aal, H.A., Nouari, M., Mansori, M., Tribo-energetic correlation of tool thermal properties to wear of WC-Co inserts in high speed dry machining of aeronautical grade titanium alloys (2009) Wear, 266 (3-4), pp. 432-443., 10.1016/j.wear.2008.04.023;
Nouari, M., Abdel-Aal, H.A., El Mansori, M., Analysis of coating delamination under extreme contact loading (2006) Tribology Letters, 23 (1), pp. 39-45., DOI 10.1007/s11249-006-9103-y;
Grzesik, W., Experimental investigation of the cutting temperature when turning with coated indexable inserts (1999) Int J Mach Tools Manuf, 39 (3), pp. 355-369., 10.1016/S0890-6955(98)00044-3;
Chiappini, E., Tirelli, S., Albertelli, P., Strano, M., Monno, M., On the mechanics of chip formation in Ti6Al4V turning with spindle speed variation (2014) Int J Mach Tools Manuf, 77, pp. 16-26., 10.1016/j.ijmachtools.2013.10.006
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