

Explosive Pulsed Power: Milling Operation Limits of PBX 9501 and PBX 9502

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Explosive-driven pulsed power performance benefits from modern polymer-bonded explosives. Owing to the explosives' fast reaction, high voltage pulses with microsecond to nanosecond duration may be produced. In the fabrication of explosively driven devices, high precision in the dimensional shape is required in practical application, and high machining speeds are desired. The range of allowable machining speeds is dictated by the US DOE-STD-1212-2019 with general coverage of all explosive materials. As previously demonstrated for lathing, the machining of the new polymer-bonded explosives may be safely exceeded. To establish new, safe boundaries, the thermal response of PBX 9501/9502 under conventional milling methods is studied. The presented work focuses on face milling performed with dry machining on a CNC, remote-controlled milling machine. Spindle RPM, feed rate, step size, and depth of cut were chosen as the primary parameters of interest. While pushing some parameters a factor 4 higher than presently allowed in the standard, the temperature was monitored via high-speed IR videography and with a K-type thermocouple inserted into the endmill's through coolant holes. A 6-axis force sensor mounted beneath the HE samples records operational forces and torques.

Force and temperature curves are examined as a function of time, revealing behavioral differences for each material. Overall, milling regimes exist outside of DOE-STD-1212-2019 for which milling temperatures remain well below the HE critical temperatures. Characterization by the material removal rate allows for the generalization of the temperature trends and, more significantly, identification of milling regimes that maintain low temperatures and low cutting forces while allowing for relatively quick milling cycles. The analysis of empirical equations enables assessing the theoretical limits of the different parameters.

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