Clean Machining: A Comparative Analysis of Cooling Systems in Subtractive Manufacturing Using Biphasic CO2 as a Safe and Environmentally Sustainable Alternative

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The goal of this research was to demonstrate that Biphasic CO2 is a viable alternative to liquid coolants used in subtractive manufacturing, in all ways: health, environmentally, and functionality. The investigation started by reviewing MWFs (Metal Working Fluids) used in subtractive manufacturing (milling, drilling, turning, etc.) and their respective limitations. A test matrix for controlled milling and drilling was configured so as to provide data for a comparative analysis of: cutting tool wear, part surface finish, chip size, and exposure. Biphasic CO2, liquid MWF, and Air Blast was used on three different alloy steels. The functionality data collected consisted of: cutting tool wear as measured by changes in cutter weight and optical inspection, resultant test block surface finish in Ra measured using a profilometer, and chip size determined by visual comparative analysis. The analyses of the health and environmental differences were more subjective, as no quantitative data was garnered. When compared to CO2, the MWF netted 11x more end mill wear, and air blast 3x, as measured by weight loss. The surface finish with the CO2 was 16.30% smoother than MWF and 2.61% smoother than Air Blast. The drilling was inconclusive. The research proved that Biphasic CO2 is a functional alternative to industry standard MWF coolants currently being used in subtractive manufacturing. As no airborne MWF mist is produced either within the machining center or workspace environment, it is speculated that the health hazards should be mitigated. As Biphasic CO2 nets dry chips higher metal unit recyclability is possible.

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