World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Effect of Cutting Tools and Working Conditions on the Machinability of Ti-6Al-4V Using Vegetable Oil-Based Cutting Fluids

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Abstract : Cutting titanium alloys are usually accompanied with low productivity, poor surface quality, short tool life and high machining costs. This is due to the excessive generation of heat at the cutting zone and difficulties in heat dissipation due to relatively low heat conductivity of this metal. The cooling applications in machining processes are crucial as many operations cannot be performed efficiently without cooling. Improving machinability, increasing productivity, enhancing surface integrity and part accuracy are the main advantages of cutting fluids. Conventional fluids such as mineral oil-based, synthetic and semi-synthetic are the most common cutting fluids in the machining industry. Although, these cutting fluids are beneficial in the industries, they pose a great threat to human health and ecosystem. Vegetable oils (VOs) are being investigated as a potential source of environmentally favourable lubricants, due to a combination of biodegradability, good lubricous properties, low toxicity, high flash points, low volatility, high viscosity indices and thermal stability. Fatty acids of vegetable oils are known to provide thick, strong, and durable lubricant films. These strong lubricating films give the vegetable oil base stock a greater capability to absorb pressure and high load carrying capacity. This paper details preliminary experimental results when turning Ti-6Al-4V. The impact of various VO-based cutting fluids, cutting tool materials, working conditions was investigated. The full factorial experimental design was employed involving 24 tests to evaluate the influence of process variables on average surface roughness (Ra), tool wear and chip formation. In general, Ra varied between 0.5 and 1.56 µm and Vasco1000 cutting fluid presented comparable performance with other fluids in terms of surface roughness while uncoated coarse grain WC carbide tool achieved lower flank wear at all cutting speeds. On the other hand, all tools tips were subjected to uniform flank wear during whole cutting trails. Additionally, formed chip thickness ranged between 0.1 and 0.14 mm with a noticeable decrease in chip size when higher cutting speed was used.

Keywords : cutting fluids, turning, Ti-6Al-4V, vegetable oils, working conditions
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020