Measurement of Laser Vibration Using Laser Reflectivity Change

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As modern industry develops, the utilization of ultra-precision equipment is increasing. In processes such as milling operations using tools like end mills, the end mills may be worn out. The worn-out end mills tend to deviate from the milling axis, leading to asymmetrical operation. To enhance the efficiency of precision machining tasks, a vibration measurement technology capable of assessing end mill wear is required. Current non-contact vibration measurement technologies encompass Laser Doppler Vibrometer, CCD camera, and so on. However, due to their high costs, they are not suitable for assessing the worn of end mills. In this study, we developed a cost-effective vibration measurement technology using single-wavelength laser diodes. By applying the principles of confocal microscopy and chromatic aberration, vibrations can be measured based on the difference of the target reflectivity. In this research, laser diodes with wavelengths of 405nm and 658nm were used as light sources, and the surface of a vibrating speaker was used as the sample. The optical paths of the two light sources were matched, and the light was directed to hit the sample near the focus of the lens, reflecting back to the sample. The reflected light from the sample was split into two wavelengths and designed to enter each photodetecter through a pinhole. The single lens through which the two light sources passed has different focal points due to the principle of chromatic aberration. Additionally, as the focal length of the single lens increased, the distance between the two focal points increased. To create chromatic aberration, a single lens with a focal length of 18mm was used, resulting in a distance of 0.05mm between the two focal points. The amount of reflected light changes as the sample vibrates, with the highest reflectivity occurring when the sample is at the focus of the light source. Placing the pinhole in front of the photodetecter under high focus conditions maximizes the photodetecter signal. Therefore, when the vibrating sample passes through the focal points of the two light sources, the signals from the photodetecters corresponding to each wavelength appear periodically in the form of peaks. The distance between the peaks of the photodetecter signals is equal to the distance between the two focal points due to chromatic aberration. Assuming the vibration to be sinusoidal, the vibration frequency and displacement of the vibration function were reconstructed.