USE OF WAVELET TRANSFORM FOR SIZING PARTICLE

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ABSTRACT: A new method for sizing particles from in-line Fraunhofer holograms by using wavelet transform is proposed. The amplitude transmittance of the holograms is a modulation of a chirp signal with an envelope function whose minima is proportionally equal to the product of the particle size and the spatial frequency of the chirp function. By wavelet transforming the hologram and taking an absolute value of its resultant transformation, the spatial frequency at the minima positions can be obtained. The particle size which is merely a function of this frequency can then be calculated. Feasibility study of the proposed method is done by conducting simulation and experimental verifications for line object.

KEYWORDS: Fraunhofer holography, particle sizing, wavelet transform

1. INTRODUCTION

In-line particle holography is a useful method for measuring particle size and its spatial position. The in-line particle hologram is generated by recording an interference pattern of a transmitted and a diffracted waves from particles illuminated by coherent light. When a distance z between the particles and the recording plane satisfies the far-field condition, an amplitude transmittance of the in-line Fraunhofer hologram of a small opaque or semi-transparent line object with a radius of a can be mathematically expressed as (Tyler and Thompson 1976)

$$I(x) = 1 - \frac{4a}{\sqrt{\lambda z}}\cos\left(\frac{\pi x^2}{\lambda z} - \frac{\pi}{4}\right)\left[\frac{\sin\frac{2\pi a x}{\lambda z}}{\frac{2\pi a x}{\lambda z}}\right] + \frac{4a^2}{\lambda z}\left[\frac{\sin\frac{2\pi a x}{\lambda z}}{\frac{2\pi a x}{\lambda z}}\right]^2, \quad (1)$$

where λ is the wavelength of the illuminating light. The second term of Eq. (1) predominates in the interference pattern; because the first term corresponding to the directly transmitted light is a constant background, while the amplitude of the square of a sinc function in the third term is much smaller than the other terms. In the second term, the recording distance z and the particle size a are encoded in the frequency of the chirp signal and the sinc function, respectively. In order to extract the desired information, the hologram is illuminated with the same coherent light. The information about the particle size can be obtained by analyzing the reconstructed image of the particle. However, in real applications, we may deal with a huge number of particles. As a consequence, the conventional reconstruction process is very tedious and time consuming. In order to obviate these problems particle sizing from in-line particle holograms by using absolute value of the wavelet transform (WT) is proposed.

2. METHOD

From the second term of Eq. (1), the frequency of the chirp signal equal to $x/\lambda z$, while the minima positions of the interference pattern corresponding to the zero-crossing positions of the sinc function appear at $2ax/\lambda z = n$, where n is integer determined by the order of minima. Thus, the frequencies of