OPTICAL VISUALIZATION OF GAS-PARTICLE FLOW INSIDE A CENTRIFUGAL IMPELLER

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Fans of centrifugal impeller are widely used in industrial dusty environment, where large amount of solid particulars enter and impact the impeller with serious erosion, which in turn induces impeller's mechanical failure and flow performance distortion. It is therefore of engineering interest to investigate the gas-particle flow phenomenon in order to design anti-erosion fan's impeller.

BACKGOUND

Alternative models have been proposed in literature to analyze the gas-particle flow inside the centrifugal impeller, which indicate that the inlet area on blade pressure side is under the heaviest erosion and blade erosion is mainly composed of impingement and slide ones. To verify the erosion mechanism in those models, a gas-particle flow visualization system is designed with optical instruments to visualize the gas-particle flow inside rotating centrifugal impeller.

EXPERIMENTAL

The experimental setup is shown in Fig.1, where the key instrument is the "Rotator Lens" based upon the principal of optical compensation. When the impeller rotates at high speed, namely 900*rpm*, the "Rotor Lens" rotates at about 1/3 of the impeller's speed. Thus a relative stationary picture of the rotating object can be taken through the "Rotator Lens" and the particle trajectory can therefore be recorded by high-speed camera or video CCD.

The impeller tested is made of Plexiglas with limited rotating speed of 1000*rpm*. Three kinds of blade profile were photographed to compare particle trajectory inside the impellers. 1) The impeller is a backswept straight blade, 2) backswept circular blade and 3) a forward one circle with a radial outlet blade. Tobacco seed was chosen as the experiment particle, with an average diameter of 0.396 mm and a mass density of 1020 kg/m^3 ,for its roundness and good ability to flow with air. The statistic distribution of particle diameter, Fig.2, was obtained by an alternative dimensional grid.

RESULTS

Figures 3-5 demonstrate the visualization of particle trajectories in the three different impellers. The impeller's rotation is counter clockwise. Blade inlet angle was chosen for gas flow of radial absolute velocity at design flow rate. Due to the velocity lag between particle and gas movement, as well as discrepancy of predicting the gas inlet incidence, the direction of particle entering impeller was evidently away from the blade inlet with incidence on the blade pressure surface. Blade inlet pressure side was under particle impingement. After rebounding from blade surface, the particle's trajectory depends on the blade shape and installation manner. Inside the backswept impeller the rebounded particles were ejected out of blade passage nearly parallel to the blade pressure surface, while much less particles were rebounded into blade passage inside forward swept impeller, but remained upon over blade pressure surface sliding into volute. The figures 3-5 suggest that particle trajectory can be controlled by a carefully aero-designed blade shape as well as blade stagnation. Particle erosion may also vary its impinging position and level in different impellers.

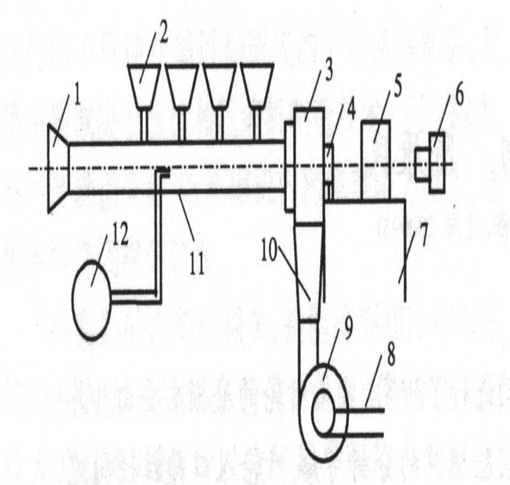

Figure 1: Sketch of experiment system

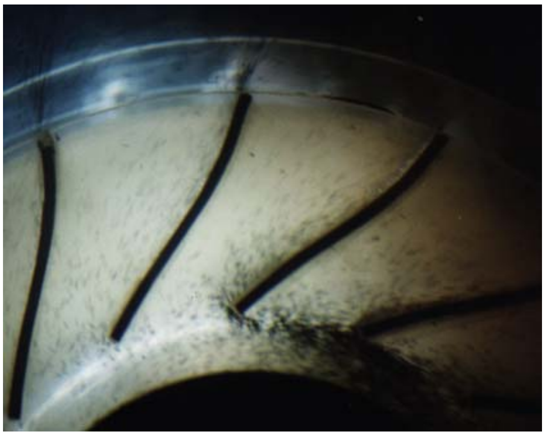

Figure 3: Particle trajectory in backward straight impeller

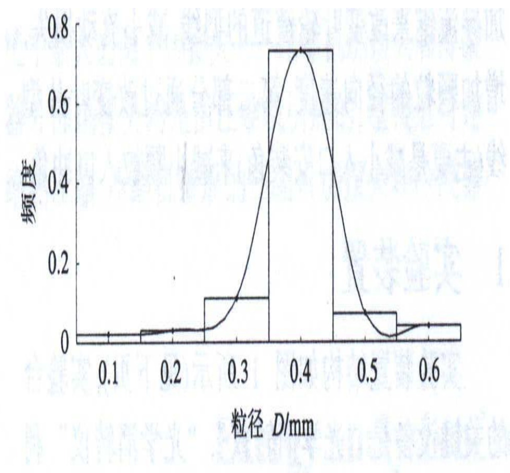

Figure 2: Distribution of tobacco particle diameter

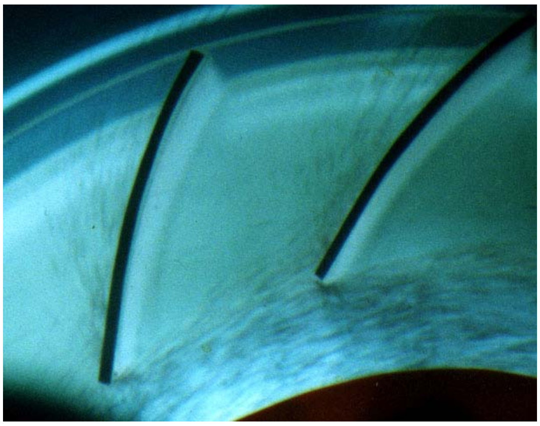

Figure 4: Particle trajectory in backward circular impeller

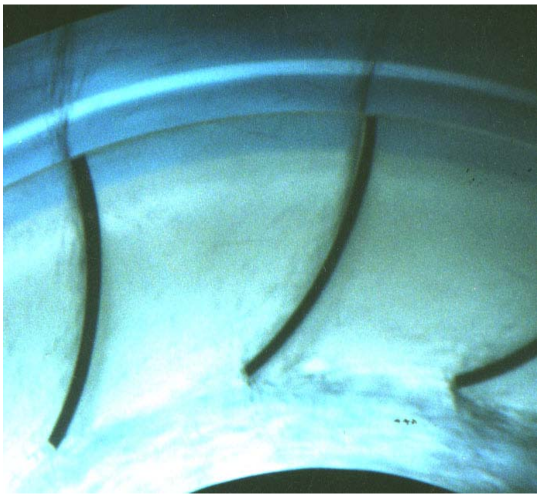

Figure 5: Particle trajectory in radial outlet impeller