Paper 12.5

LASER-SHEET CT-SCAN TYPE 2-D INSTANTANEOUS CONCENTRATION METER with application of wavelet transform technique for high resolution

by
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ABSTRACT

A heap of knowledge accumulated in recent years on the coherent structure of turbulence made it possible to connect the structure of concentration field with that of turbulence, and the needs for advancement of physics of concentration structure are rapidly increasing.
This paper presents several improvements of both hardware and software for the concentration instrument reported at the 1998 Int. Symp. on Applications of Laser Techniques to Fluid Mechanics. The improvements increased remarkably the performance of CT-scan type 2-D instantaneous concentration meter.

Improvement in Laser Shedding and Scanning Mechanism : Laser shedding mechanism has been changed from mechanical scan by stepping motor, to shedding laser sheet expanded by cylindrical lens, avoiding rotating parts completely. Laser lights from an array of emitters are switched on and off, successively. Signals of laser light from emitters which passed through the concentration field have been received by an array of receiving units and recorded continuously, the sampling period being considerably shortened.
Improvement in Analysis System – Application of Wavelet Transform Technique : The conventional means to express an unknown field in the inverse problem is to recourse to the double Fourier expression. However, as we have described in the previous paper, this does not give a favorable result, because the information obtained from the one directional search of the field is too scarce. While the "Virtual Load Method" proposed by Hino(1975), an idea similar to the spline approximation, is successfully applied. A 2D concentration field, arranged to a vector form, is expressed, as the deflection of virtual load (vector w_p). The intensities of laser lights passing through the concentration field and received by receiving unit (arranged in a vectorial from R1) are expressed in terms of virtual load vector and the integrated Green's function matrix. The problem reduces to an inverse problem to solve for w_p. Substitution of w_p (virtual load thus obtained as a result of inverse problem) into the fundamental relation between the virtual load and the concentration field gives concentration field.
In general, signals received by a receiving unit are contaminated by random or pulse-like noise. Wavelet transform has been applied to suppress noise and recover the pure signals. The wavelet spectrum of the received light intensity vector is cleaned by cutting off the high frequency and/or higher level fluctuations. Finally, the estimated concentration field determined.