Ultrasonic Velocity Profiler - from present to future

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Past and current activities related to UVP; physical and engineering fluid mechanics, industrial applications and development of methodology are surveyed. A general trend of its use and development is overviewed and future of UVP is discussed.

Keywords: UVP

1 UVP

After UVP was first applied to general fluid mechanical study in mid-80's [1], its application has been steadily broadening in wide variety of flow configurations. From beginning, the following three advantages are featured for UVP;

① Spatio-temporal information of flow fields,
② Applicable to opaque liquids
③ Efficient flow mapping.

Both for physics study and engineering work, these advantages attracted a great deal of interest of researchers in physics as well as engineering.

Development of UVP and its applications up to present will be surveyed on these two coordinates. Based on this, a future of the method and equipments will be discussed.

2 UVP TO PRESENT

2.1 Fields and configurations

By literature survey where UVP method is investigated and applied, fields and configurations are categorized, as shown in Table 1, by two coordinates of advantages and research fields. They do not include work for biomedical applications, civil engineering etc. More than 200 journal papers were found easily in the fields of physics and engineering fluid mechanics.

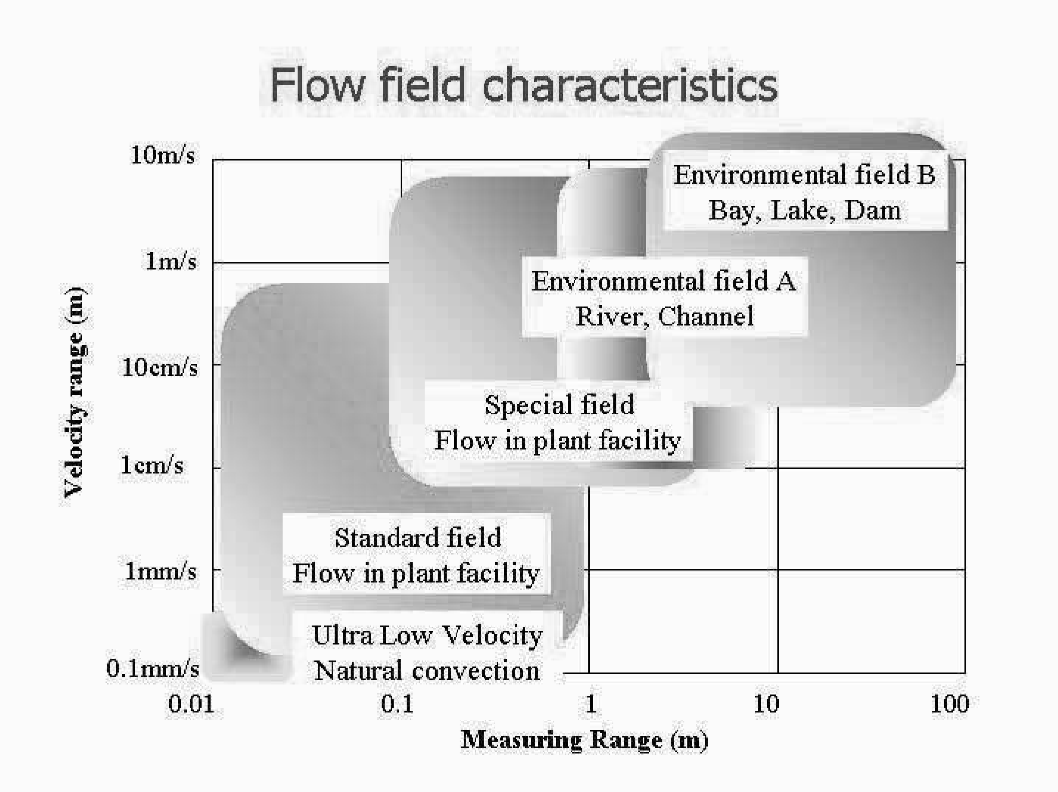
Physics study was made being related to flow instability. [2,3] This is due to a characteristics of problems where the change of spatial distribution appears prior to temporal changes, and because UVP is superior in detecting such changes in the flow fields. For investigation of turbulence, the present time and space resolution of the equipment is not sufficient that investigations for improving these weakness were attempted. [4]

More effectively, UVP is used for flow investigation of liquid metals. The liquid is Gallium [5] and the flow configuration is related to a geofluid dynamics such as mantle convection or astrophysical dynamics. [6] Especially effective is to investigate Magneto-Hydro-Dynamics using liquid sodium. [7] Ultrasound is the only possible wave to be used in such media. In the similar manner, many of the non-Newtonian liquids are opaque and UVP is used to investigate flow behavior for Rheology. [8]

As physics study has been and still is under way, more engineering applications has become popular. This is presumably because the method has been established and accepted by fluid mechanists and engineers through the investigations by physicists. Industrial application has also been made in flow metering.[9] The accuracy of flow rate measurement has been made breakthrough, improving its level down to 0.1%. A commercial product of novel type flowmeter using UVP principle has been developed and now available in the market.[10]

Table 1 Fields and configurations of UVP applications

	Physics	Engineering
Spatio-temporal	Instability and nonlinear problems flow transition and turbulence	Velocity profiling in devices Flow metering
Opaque liquids	Geoscience MHD and magnetic effect, Rheology	Liquid metal and food flows Material processing
Flow mapping	Measurement of distributions of stream function and vorticity	CFD code validation Design of flow and thermal devices Environmental flow



2.2 Trends

By viewing these accumulated results of investigations, a general trend can be found such that more and more engineering applications will be made and also industrial applications might take a larger part of the activity in near future.

Especially, applications in medical engineering and civil/environmental engineering, although they are not mentioned in the present survey, are foreseen with a considerable growing rate

3 UVP FOR FUTURE

As seen above, the applicable flow field ranges in enormous breadth. It is not only the measurement range in space but also its velocity levels, as depicted in Figure 2. The measurement length would be from a couple of mm for boundary layer flow to a couple of 10 m for a coastal flow. The velocity level also ranges from 1 mm/s for natural convection flow to a several or 10 m/s in the environmental and industrial flow fields.

The preset measurement systems have been developed for a standard flow field that is anticipated to be found in laboratory experiments, [11] and because of it, they cannot cover the whole range of flow field and velocity level. In one hand, different systems must be provided, or a flexible system to adjust those measurement ranges to the required characteristics of flow fields. Moreover, physics research are seriously concerned about spatial and temporal resolution. Signal processing algorithms which can realized such requirement have been made and further development is expected. This is also the case for multi-component measurement of flow velocity vector. [12]

On other hand, an industrial application requires less flexibility of system parameters. Each application has its specific ranges of depth and velocity of limited scale. It is required therefore the system be robust against poor reflection of ultrasound. These were found in the course of development of novel type of flow meter. Their experience would be used for other applications too.

A challenge in physics study using UVP is under way into the space. Marangoni convection will be investigated using UVP in the Japanese mission of ISS, JEM. [13]

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