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Hydrolink

10 QUESTIONS TO... Prof. Iehisa Nezu

Interviewed by Cristiana Di Cristo and Colin Rennie

1 **What do you consider to be your greatest achievement in understanding hydraulic phenomena that you have obtained through experimental methods in the laboratory?**
During my degrees of Bachelor(1971) and Master(1973) Engineering, I had studied applied Dam Hydraulics theoretically and experimentally, especially hydraulic jump in conduits for new-type spillway development. However, I fully realized that it was very difficult to measure hydraulic jump (air/water two-phase flow) by hot-film anemometers, which had become just available commercially at that time. Just after the entrance to Ph. D course in Kyoto University, I decided to change my research topics completely and highlighted fundamental hydraulics rather than applied. It was very lucky for me to encounter "Organized and Coherent Turbulence" in our Department Library, which was just discovered in boundary layer flows by the Kline group (1967-1971). I concentrated my research on the differences between open-channel flows and boundary layers, and found that turbulence structures of open-channel flows are almost the same near the bed (i.e., in the near-wall region) as those of boundary layers. This motivated me to investigate bursting phenomena near the bed theoretically and experimentally (JFM, vol.80, pp.99-128, 1977 and vol.104, pp.1-43, 1981), which is one of my greatest achievements in journals. After then, my topics were focused on the outer-layer phenomena, i.e., secondary currents, and also the essential interactions between the inner-layer and outer-layer phenomena, which are still being investigated even now.

2 **Numerical models are increasingly used by researchers and practitioners to understand complex hydraulic problems. Why do you continue to employ experimental methods in the laboratory?**
Numerical models and computational methods are very powerful to compensate the related experiments, but they may not be able to reveal and to predict flow phenomena in nature without any experimental observation. In my opinion, numerical simulations are "virtual", whereas measurements are" real" to understand flow phenomena in nature. Even if the power of supercomputers will be further improved, I expect that experimental methods will still be necessary for research and education in the future. In an ironic sense, even the IT students who never learn hydraulics may be able to compute the N-S equations, but cannot understand the calculated flow structures physically.

3 **A fundamental difficulty with measurements is that it is generally impossible to measure all relevant parameters at all relevant scales in space and time, particularly without disturbing the flow field itself. How do you deal with this issue?**
Measurements without disturbing the flow field have progressed rapidly with the advent of laser-based devices, especially, laser Doppler anemometer (LDA) and particle-image velocimetry (PIV). At present, it may be possible to measure all three components of velocity and mass concentration using 3-D LDA and stereoscopic PIV with laser-induced fluorescence (LIF), which are all non-intrusive measurement devices in laboratory flumes. Recently, acoustic-based devices such as ADV and ADCP are available commercially in laboratory and field measurements. Nevertheless, it may still be difficult to measure accurately the boundary regions very near the bed (wall) as well as water surfaces.

4 **Water resources problems (flooding, contamination, water supply, etc) have important societal and environmental consequences. What role can experimental hydraulic research in particular play in the solution of such problems?**
Unlike fluid mechanicians, our hydaulicians, even fundamental academic researchers, should take a great interest in real water resources problems in the world, even though we are but one component to such real problems in which politics, economy, security, human activities, health, food and others are complicatedly linked to each other as well as water sciences and engineering. Experimental hydraulics will contribute to scientific and engineering aspects of such real problems. In these problems, real experiments and careful observations are more useful and contributory to such solutions than virtual numerical simulations.

5 **How has experimental research in hydraulics changed in the last twenty years?**
In the 1980's, hot-wire/film measurements were in their golden age, and hydrogen-bubble techniques took a turning point for qualitative flow visualization, by which bursting phenomena near the wall and vortex/pairing phenomena in jets were discovered. In the 1990's, laser-based velocimetries such as LDA and PDA (phase Doppler anemometer) became available commercially, although very expensive. In the 2000's, computer-aided flow visualizations such as PIV and PTV have become more popular although their accuracy and resolution are much lower than LDA. This is because the former is excellent in space-information of flow (vortex is easily measured by PIV), whereas the latter is excellent in time-information at a point in the flow (good resolution in spectrum). Experimental flumes have also been innovated in the last twenty years. Previously, water recirculation in a flume was controlled by a head-tank system. However, at present, a computer-aided recirculation system is used in many laboratories, by which it is possible to generate unsteady flows with arbitrary hydrographs and to simulate real flooding flows relatively easily.

6 **How do you foresee future development of experimental research in hydraulics? In your opinion, which measurement technique(s) will be most rapidly developed and have a major impact in the next few years?**
"Need is mother of development" is a proverb in Japan and other countries. In my opinion, experimental research is and should be a core of hydrodynamics in the same manner as fluid mechanics and aerodynamics. Measurements will never be considered redundant in the near feature, even if supercomputers will be further improved and be able to calculate large-scale turbulence (even the meteorological and geophysical scales) in direct numerical simulation (DNS); the present supercomputer can calculate only low-Reynolds-number flows, say Re=103-104, but geophysical flows such rivers and oceans have Re=107 and more. However, I consider that the development of measurement techniques

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may have plateaued at present. New and breakthrough devices much superior to laser-based ones such as an LDA (previously called "perfect and ideal instrument") will not be invented in the near future. Instead, I foresee that a relevant combination with LDA and PIV/LIF will be most rapidly developed in laboratory experiments. In field tests, a lot of new instruments corresponding to LDA will be feasibly developed. It is even now difficult to use LDA in field tests such as in rivers, lakes, estuaries and oceans even if sufficiently-long fiber-optic LDA probes, say 1000m long, and ultra-high power laser light, say 100W laser power, will be developed. One possibility may be innovative techniques corresponding to PIV and remote sensing/image-based velocimetry. Even velocities below the water surfaces in natural rivers will be able to be measured in the near future by combinations between innovative PIV/remote sensing and illumination systems.

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Major new experimental hydraulic facilities and instrumentation require significant investment. Why should countries and institutions make such investments? How should the IAHR community best argue for such investment?

It is a real problem. Hot-wire/film anemometers, electromagnetic flow meters and acoustic Doppler velocimetry (ADV and compatible) are often used, as well as PIV/PTV, even in small unit laboratories of universities and institutes. However, LDA is very expensive and furthermore requires careful maintenance at all times. Even when no measurements with LDA are conducted, it is necessary to check the LDA optical arrangements and laser power every time. In many laboratories, experiments and measurements may not be conducted for 365 days, and thus some flumes may be under drying conditions. The running cost of experimental hydraulic facilities and instrumentation is probably much higher than numerical computers; the latter is often shared by many students and researchers. To overcome such investment difficulties in experiments, it may be necessary to use cooperatively hydraulic facilities and instrumentation in one key laboratory that is organized by government and universities. Unfortunately, Japan has not yet such a core and shared hydraulics laboratory although I understand there are some key shared laboratories in EU and other countries. If the IAHR community will foster common-used (shared) hydraulics laboratories, it may be very useful for students and young researchers in particular to study innovative and challenging research topics.

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How important is collaboration between instrument developers/manufacturers and hydraulic researchers and/or practitioners? How can such collaboration best be realized?

It is a real problem, too. The instrument developers/manufactures are not volunteers, but businesses. I know a good example of such collaboration. When LDA was in its development age, say 1980's -1990's, some LDA manufacturers organized and sponsored international conferences as well as some training courses for invited researchers and users. However, at present, unfortunately, such conferences may not exist. Only some exhibitions of instruments are conducted in conferences and symposia. To realize such collaboration and communication with each other as a first step, I think it will be very useful to organize a session/forum of instrument developers/manufacturers and hydraulic researchers and/or practitioners in conferences. Developers/manufacturers may like to deliver oral presentations of their developed instruments and software even if these may not be suitable to be included in the Proceedings.

9

What advice would you give to a new PhD student, who is beginning his/her experimental research in hydraulics.

I hope very much that a new PhD student should be more ambitious to solve various academic and applied problems, in particular in hydraulic research. Although this may be limited to Japanese students, recently they seem reluctant to go abroad and to visit laboratories in other countries. I think that one of causes is due to the development of the present Internet; enormous information is easily available via the Internet without visiting the other laboratories. Except for the language handicap, such situations may be true in other countries. Instead, I would like to advise a new PhD student to go out of deskwork and exchange with the other laboratories even in his/her home country. Computers are ubiquitously used, but experiments are uniquely conducted. One "seeing" promotes research much more effectively than one hundred "hearings".

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What do you propose the IAHR in general, and the EMI Committee in particular, should be doing for researchers and practitioners interested in experimental research in hydraulics?

I think that the IAHR is well organized in the international non-government style, and I would like very much to thank the Council members and Journal Editors, in particular the IAHR President, N. Tamai, who now contributes very much to renewal of the IAHR world. I would also expect that the EMI Committee will organize a relevant session of "fantastic World Cup of Measurements", like a soccer game, in some EMI Conferences. The concept is as follows. In advance, the EMI pre-announces the flow conditions of target research which should be measured and revealed, and then researchers/practitioners will try to measure such same flows in the world. As the results, the researchers will be able to present their measured data differently in the conference and compare/discuss with the other researchers; a kind of measurement competition, so called "World Cup". Our World Cup will stimulate students and young researchers/practitioners to challenge fantastic experimental Hydraulics, in which new breakthrough instruments and techniques/analyses are expected to appear in the Hydraulics community. Some examples of particularly challenging topics of flow conditions may be considered as follows: 1) compound channels, 2) vegetated flows, 3) flows over gravel/pebble beds (non-Nikuradse roughness), 4) backward step and dune-type flows, 5) wind-induced air/water interfacial layers and gas transfer, 6) particle-fluid interaction and sediment transport, and others. These topics should be first investigated experimentally rather than numerically, and researchers should reveal such flow structures and applications by using various velocity instruments (including new developed devices). The World Cup of Measurements would be a kind of "scientific amusement" in the same sense as sports, e.g., Olympic Games and World Cup.