Jun 29th, 12:05 PM - 1:35 PM

Tsallis Entropy Theory for Hydraulic Modeling

Vijay P. Singh
Texas A&M University, vsingh@tamu.edu

6th International Symposium on Hydraulic Structures Portland, Oregon, USA, 27-30 June 2016
Hydraulic Structures and Water System Management
ISBN 978-1-884575-75-4 DOI: 10.15142/T3DW2S

Tsallis Entropy Theory for Hydraulic Modeling

Vijay P. Singh[1],
[1]Department of Biological & Agricultural Engineering &
Zachry Department of Civil Engineering
Texas A&M University
College Station, Texas 77843-2117
USA
E-mail: vsingh@tamu.edu

KEYNOTE - EXTENDED ABSTRACT

Keywords: *Entropy, Principle of maximum entropy, Entropy number, Lagrangian function, Probability distribution function, Flux-concentration relation*

Hydraulic structures serve a multitude of human needs. They are needed for water supply, water transfer, water diversion, irrigation, land reclamation, drainage, flood control, hydropower generation, river training, navigation, coastal protection, pollution abatement, and transportation. Many of the structures, such as channels, culverts, and impoundments, have been with us since the birth of human civilization; some, such as spillways, dams, and levees, are more than two centuries old; and some are of more recent origin. In the beginning, structures were designed more or less empirically. Then, engineering and economics constituted the sole foundation of design. Nearly fifty years ago, planning and design of hydraulic structures went through a dramatic metamorphosis. These days, designs are based on both engineering and non-engineering aspects. The engineering aspects encompass planning, development, design, operation and management; and non-engineering aspects include environmental impact assessment, socio-economic analysis, policy making, and impact on society.

For designing hydraulic structures such as channels, reservoirs, levees, bridge piers, dams, and spillways, some key questions that need to be addressed relate to velocity distribution, sediment concentration and discharge, pollutant concentration and transport, river bed profile, hydraulic geometry relations, flow routing, and seepage through a dam. For water supply hydraulic systems, the key questions deal with the reliability, loss of energy in the distribution system, and pipe sizes. Likewise, pollution and pollutant transport, and pollution abatement are now essential components of hydraulic design.

In a similar manner, because of increased public awareness primarily triggered by environmental movement, non-engineering aspects of hydraulic design, dubbed under "socio-economic analyses" play a critical role. Besides engineering feasibility and economic viability, issues related to public health, political support, legal and judicial restrictions, and social acceptability determine to a large extent if the hydraulic project will go off the ground.

Survey of water engineering literature shows that there is a myriad of techniques for addressing questions pertaining to the design of hydraulic structures. For example, different techniques, ranging from empirical to semi-empirical to physically-based, have been employed for computing velocity distributions, sediment concentration and discharge, hydraulic geometry, and reliability. The techniques are based on different hypotheses and assumptions. The large diversity of techniques makes it difficult to present the subject matter in a unified coherent manner. This becomes particularly challenging when teaching hydraulic engineering design at the undergraduate level. There are, of course, some theories that do apply to a wide variety of problems, such as kinematic wave theory and diffusion wave theory. These theories can be applied to solve a wide variety of questions where the movement of water, sediment, and/or pollutant is involved. These aspects have been dealt with in the literature using different techniques that are based on different concepts and assumptions and that vary in complexity. The question we ask is: Can we develop a unifying theory for addressing these and related issues? To that end, the second law of thermodynamics permits us to develop such a theory that helps address these issues in a unified manner. This theory can be referred to as entropy theory.

The thermodynamic entropy theory is analogous to Shannon entropy or information theory. Perhaps the most popular generalization of the Shannon entropy is the Tsallis entropy that has been applied to a broad range of scientific areas, including hydraulics. This paper discusses rudimentary aspects of the Tsallis entropy theory and illustrates its potential for application in hydraulic engineering. Furthermore, many problems in hydraulic design, however, require a statistical treatment, which is afforded by the entropy theory as well.