Editorial

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Dr. Debabrata Datta is working in Bhabha Atomic Research Centre (BARC), Mumbai, in the capacity of Scientific officer (H+) and *Head, Radiological Physics and Advisory Division* of Health, Safety and Environment Group. His academic excellences are: (a) *M.Sc in Nuclear Physics* (Kolkata University), (b) *Master of Philosophy (M. Phil) in High Energy Nuclear Physics* from SAHA INSTITUTE OF NUCLEAR PHYSICS (SINP), Kolkata, (c) Graduated from *BARC Training School under OCES in the field of Nuclear Engineering* in 1984–1985 and (d) *Doctor of Philosophy (PhD) in Computer Science* from Mumbai University in 2000.

His proficiency is on software development using soft computing technique, mathematical modeling and statistical analysis. He has developed many software in the field of radiation physics, safety and uncertainty modeling. Some of such developed software has been exported to Turkish Atomic Energy on their demand. He has contributed in the field of sensitivity analysis and uncertainty modeling of any physical system. He is well recognized internationally for his

enormous diverse contribution in statistical analysis of environmental data, fuzzy mathematics, evidence theory, artificial neural network, wavelets and wavelet neural network. He is the recipient of *Eminent Scientist Award*, “*Millenium Plaques of Honor*” from *Indian Science Congress Association*, in 2010. He has also received meritorious awards from *National Society of Radiation Physics (NSRP)*, and *Association of Medical Physicist's of India (AMPI)*.

He has been honoured as Professor in Physical & Mathematical Sciences in Homi Bhabha National Institute (Deemed University of Department of Atomic Energy). He has more than 200 publications in peer-reviewed international journals, book chapters, international and national conferences to his credit. He is the author of more than twenty application software and some of them are well validated and acceptable by Palisade Corp., USA. He is a recognized PhD guide in Engineering and Science disciplines. His research interests are mathematical modeling, statistical analysis of big data, data mining, optimization, neural network, Bayesian belief network, graph theory, bioinformatics, medical informatics, sensitivity and uncertainty modeling. He is the reviewer and editorial board member of many international and National Journals. He is the Life member of many International and National Scientific Organizations.

I am delighted to bring out this special issue of Journal of Life Cycle Reliability and Safety Engineering. This issue contains papers focusing the issue of uncertainty modeling and life cycle reliability analysis of any engineering physical system. Uncertainty analysis of any engineering system being an ingredient of reliability analysis, this issue will provide various methods of handling uncertainty with the imprecise parameters.

This issue covers areas of uncertainty modeling with fuzzy or epistemic parameters. The papers provide a glimpse of the state of art in the subject. I am grateful to various authors who have made significant contributions to the field of uncertainty modeling with imprecise parameters.

This issue comprises five papers which are summarized below.

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The first paper addresses the quantification of uncertainty under hybrid structure of probability-fuzzy parameters and as a case study Gaussian Plume Model has been taken into account to apply the methodology. Reasoning of this kind of approach is mainly due to the presence of both probabilistic and fuzzy parameters in any physical model such as Gaussian plume model generally used to estimate the air concentration of pollutant at any spatial distance or any sector around the industry. Estimation of uncertainty of air concentration in the presence of both kind of parameters provide a decision-making tool to provide a band of exposure (lower and upper limit of exposure) to the public or occupational workers. This band then provides a performance assessment of such type of plant in the sense that whether the air concentration or exposure is crossing the upper limit of exposure or not. It is known fact that if air concentration or exposure crosses the upper limit plant performance is not good at all. The paper demonstrates the techniques how to handle the mixture of probabilistic and fuzzy parameters simultaneously to quantify the uncertainty of a system.

The second paper demonstrates fuzzy lattice Boltzmann Scheme—a numerical method to address the parametric uncertainty of solute transport process. Uncertainty analysis of solute transport model is important from the point of safety measures in the field of nuclear science and technology. Basically, solute transport model is represented by advection diffusion equation, wherein, the parameters are an admixture of stochastic and imprecise. Stochastic part is addressed and specified by probability distribution and imprecision is addressed by fuzzy numbers. However, traditional numerical method such as finite element or finite volume to solve such equation in presence of this combination takes a substantial computational load. Moreover, the uncertain parameters are very often microscopic due to the flow of solute through some porous media traditional numerical methods which are basically macro solver fails, and that is why, Lattice Boltzmann Scheme with fuzzy parameters of the governing equation is addressed. Paper presents the complete numerical scheme of Lattice Boltzmann method in detail. The basic point to remember here is that the present numerical method with fuzzy parameters as coefficients of the advection diffusion equation consists of collision and streaming which are described within the paper. Method presented here in this paper opens a new area of numerical solver such as fuzzy Lattice Boltzmann.

The third paper concerns in-vessel retention analysis for a typical PHWR. A very unlikely sequence of events with multiple failures of safety systems and human actions may lead to severe accidents such as simultaneous occurrence of Loss of Coolant Accident (LOCA), failure of Emergency Core Cooling System (ECCS) and Moderator Cooling System. This may result in the core disassembly and debris formation in the calandria vessel bottom. It is imperative to

study the coolability/retention of the debris/corium in the calandria vessel in the presence of the vault water as the only available heat sink. In the paper, analysis is performed with the objective to study the in-vessel retention and coolability of the corium in the calandria vessel by external cooling through calandria vault inventory. In-vessel retention capability with respect to the failure criterion based on failure due to reduced external cooling is investigated. System thermal hydraulic code RELAP5 is used to estimate the duration of the availability of the calandria vault water for removal of heat from the debris. Various cases are analyzed with different initial debris temperature and initial time of the transient (decay power). The achievement of coolability of the corium is presented.

The fourth paper reports on an analysis of life cycle reliability of a system in presence of imprecise failure data. In this paper, an approach has been aimed to develop a fuzzy Weibull model, where parameters of traditional probabilistic Weibull distribution are expressed in the form of fuzzy variable, with an objective to perform reliability analysis of life data with simultaneous estimation of epistemic uncertainty and deterministic result. Imprecise life data of machine component are modeled as a fuzzy set with triangular membership function. Alpha cut values of fuzzy parameters of Weibull distribution-based model are expressed in the form of an interval and these intervals are used to estimate Weibull model parameters by interval least square fitting method. Construction of a fuzzy variable is demonstrated by integrating these estimated intervals of the model parameters. Detailed methodology including all processes involved is demonstrated for life cycle data of ball bearing.

Numerical solution of any partial differential equation with deterministic parameters is traditional; however, if the coefficients of the governing partial differential equation representing any physical system are uncertain either due to probabilistic or epistemic, design and development of corresponding numerical solver is really an issue. With a view to this, an innovative method for solving partial differential equation representing the solute transport process with the existence of uncertainty in model's physical parameters such as diffusion coefficient, dispersivity, and velocity of flow, has been developed and details of the inner structure of the design of the numerical solver are presented in the fifth paper. New method is based on differential quadrature where the partial derivatives are expressed in terms of a quadrature. The technique demonstrated provides a decision-making tool in presence of uncertainty in the regulatory framework for safe discharge of liquid effluent in the environment. The uncertainty of the parameters is taken into account as triangular fuzzy number for its simplicity. Differential quadrature part is addressed with forward time (time-dependent part of the partial differential equation) difference and polynomial quadrature for spatial derivatives. Fuzzy vertex method is

embedded with the differential quadrature to compute the uncertainty of the solute concentration at any spatial and temporal coordinates, thus evolving the name of Fuzzy Differential Quadrature. Verification of this new development is completed by a comparison of the solution with its corresponding analytical solution.

I am also grateful to Prof. Varde for inviting me to bring out this special issue of Journal of Life Cycle Reliability and Safety Engineering. I am grateful to several reviewers for their comments and suggestions which helped in improving the quality of the papers in this special issue. I hope that this issue will prove to be a great success with the academia, researchers and engineers in the areas of uncertainty

modeling and interdisciplinary Research in Engineering, Management and Technology.

Guest Editor

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