

An Overview of Some Recent Developments of Pebble bed and Prismatic Block Gen IV Nuclear Reactors and their TRISO Fuel Particles Manufacturing

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Abstract:

Nuclear energy will play an important role in the global energy mix as the world works toward achieving its energy demands. Today, fourth-generation (Gen IV) nuclear reactors are being designed and investigated around the world. Among the six candidates of Gen IV nuclear reactors is the very high temperature reactor which is either pebble bed or prismatic block reactor. Both are graphite-moderated and helium gas cooled nuclear reactors. They use TRISO nuclear fuel particles that are manufactured in gas-solid spouted bed coaters. Transforming these reactors and fuel manufacturing from concepts, lab scales and pilot plant demonstrating scales to commercial plants require extensive research to properly design and operate them and to ensure their safe operation and reliability. The pebble bed structure, flow dynamics of the pebbles, the interactions of the pebble with the flowing coolant gas, the heat transfer from the surface of the pebbles to the gas phase, and the dynamics of the flowing coolant gas are complex phenomena due to interrelated complex interactions and transports among the phases. Related to Prismatic blocks, natural convection and circulation between the upper and lower plena and the heat transfer from the inner surfaces of the channels to the circulated gas are not well understood and there is a lack of benchmarking data for validating CFD codes and models with the related heat transfer computation. The process of coating the TRISO nuclear fuel particles with four layers of carbonic materials is another challenge. This is due to complex interactions among the phases which makes the scale-up of these coaters for commercial production while maintaining the fidelity of coating and the particles integrity a difficult task and one of the bottlenecks for safe commercializing these high temperature gas cooled reactors. Accordingly, to advance the knowledge and understanding of these interplay phenomena for safe and efficient design, scale-up and operation of these systems, investigations using advanced measurement and computing techniques are needed. Recently, our

research laboratory (Multiphase Flow and Reactors Engineering and Applications (mFReal)) has been developing novel approaches, integrated techniques and separate effects experiments toward studying these complex phenomena under various nuclear programs DOE funding. In this presentation, the new developments and the recent advancement that we have made for advancing the technology of pebble bed and prismatic block nuclear reactors and the TRISO nuclear fuel particles coaters of gas-solid spouted beds for the 4th generation nuclear energy will be overviewed and presented.

Bio:

Dr. Muthanna Al-Dahhan is the University of Missouri Curators' Distinguished Professor of Chemical and Biochemical Engineering and of Nuclear Engineering and Chair of the Chemical and Biochemical Engineering Department at Missouri University of Science and Technology (Missouri S&T), Rolla, Missouri. He is AIChE Fellow. He holds three degrees in chemical engineering (BSc, Master degree and Doctoral degree). He was faculty member (Assistant, Associate and Full Professor) at Washington University in St. Louis (1994-December 2008). He is IAEA expert. Co-Founder with Sandia National Lab works shops on lab security and safety for Iraqi graduate students studied outside Iraq. He is advisor and supervisory board member of TOMOCON, Germany of 15 PhD projects in Europe Universities - European Marie-Sklodowska-Curie Innovative Training Network. Dr. Al-Dahhan is the member of Delft Process Technology Institute – Delft Technical University. He directed from 1999-2008 industry-academia consortium on gas conversion to alternative clean fuels and chemicals. He obtained over \$12 million in external funding. His h-index: 43 (Scopus, April 2019) and 50 (Google Scholar, April 2019). He has graduated about 50 PhD and a number of MS students and supervised a large number of post-doc fellows, research associates and undergraduate students on a wide range of topics. His research activities include more than 226 publications in peer reviewed journals, 7t publications in peer reviewed proceedings and 46 Keynote/Plenary lectures, 149 invited talks and 483 of national and international conference presentations. Dr. Al-Dahhan has received many national and international awards and recognitions and his graduate and undergraduate students received many awards for the work done under his supervision. He formed, chaired, and co-chaired a number of national and international conferences. He has been expert and consultant to IAEA, UNESCO, many companies and research organizations in USA and from around the world. *He has developed at Missouri S&T research laboratories, which are a unique global resource.*