CFA-20-19205 Robust bullet-time tagging and tracking system based on computer vision for individual ex-core TRISO-fueled pebble identification

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ABSTRACT:

A novel robust bullet-time tagging and tracking system based on computer vision techniques that is reliably validated is proposed to tag and track each individual pebble in Pebble Bed Reactors. Our unique non-invasive Residence Time Distribution (Transit time) (RTD) and Radioactive Particle Tracking (RPT) techniques will be used to validate and refine the developed method, using our continuous cold flow pebble bed experimental setup. A reliable validation step of the developed tagging and tracking system using proved advanced techniques of RTD/RPT is equally important as the main development. The proposed project will focus on the following: (1) Developing and examining robust and economic patterns of Ultra-High Temperature Ceramic (UHTC) embedded and flush mounted on the graphite pebbles surface that are suitable for operation under harsh conditions, (2) Developing high-speed camera array with high survivability under high temperature and radiation in order to obtain sufficient number of images for pebble identification by setting up the minimum number of cameras for least cost, (3) Developing robust and rapid methodology of image processing and recognition system. Multiple images will be captured for each pebble, covering multiple viewpoints around it. These images will be used to locate and segment the pebble from the background in the image, in order to identify each tagged pebble. To recognize each pebble, features of the pebbles' tagging need to be extracted from the images for the pebbles digital recognition. We propose to investigate two ways to extract image features:(a) Image Features from Each Viewpoint Independently. (b) Image Features from All Viewpoints Jointly, (4) Modifying our continuous cold flow pebble bed experimental system to be fully adaptive for the experiments proposed in this work using pebbles of 6 cm diameter. The adaptation is to allow the camera array system to be mounted at the exit of the pebble bed reactor without disturbing the smooth recirculation operation of the current system and the RTD/RPT techniques implementation. In addition, further modifications, such as changes in the bed diameter to 3 ft and 2 ft height, and inlet and outlet sections of the bed for 6 cm pebbles, which can be manufactured and adapted in our machine shop, (5) Arrangement of our Residence Time Distribution (Transit time) (RTD) and Radioactive Particle Tracking (RPT) techniques. For this, a composite pebble with 0.05 mm Co-60 radioactive particle will also be tagged with embedded UHTC pattern so that the transit time of this pebble can be simultaneously measured by both the developed method and RTD and RPT techniques allowing also to refine and tune the tagging and tracking algorithm, (6) Assessment and validation using proven non-invasive RTD and RPT techniques on our cold flow measuring system. It is impossible to transform the development into real practice and application as per the need in RC-4.2 of the solicitation without its reliable validation, (7) Evaluation of the tagged pebbles surface abrasion at prolonged time operation, (8) Assessing transformation of the developed tagging and tracking system under high temperature desired for efficient pebble bed nuclear reactors with the involvement of our industrial and national lab partners to develop protocols and procedures for real industrial implementation and transition.