A Method for Dynamic Fracture Toughness Evaluation of Ductile Cast Iron for Safety Assessment of Radioactive Material Transportation Casks -ABSTRACT

In this paper, a method is presented for dynamic fracture toughness evaluation of impact loaded pre-cracked beam specimens made up of Ductile Cast Iron (DCI). Use of thick walled monolithic cask constructions is on rise in recent years and DCI is the most commonly used material of construction for these designs. The regulatory standards require that the containment design certified for transportation have to maintain structural integrity under hypothetical accident conditions such as 9m drop on unyielding target. Therefore, under these loading conditions, the influence of strain rate on the material behavior has to be considered within design and safety analysis of containers and relevant material characteristics have to be provided. The safety assessment of cask design under dynamic loading is often based on combined approach involving material testing and numerical simulations. Quality assurance is must for control of properties to be attained in serial production. The fracture toughness of DCI is strongly influenced by its microstructure parameters, especially the pearlite content as well as size, morphology and distribution of graphite nodules in the ferritic matrix. In large DCI castings the microstructure is often not homogeneously distributed over the wall thickness. The fracture toughness values of DCI at higher rates of loading show a remarkable reduction with decreasing temperature and a significant shift in transition temperature. In the present work, vibration analysis of a pre-cracked beam specimen is carried out to obtain a simplified formula for evaluation of dynamic fracture toughness properties of DCI at elevated rate of loading. The analytical approach is verified with two dimensional finite element solutions. The method is applied for analysis of experimental test data obtained on DCI specimens. The safety assessment of typical DCI containment geometry posing an appropriate fracture mechanics problem is presented in this paper. The critical crack size is calculated as function of the applied stress, wall thickness and material property.