Contribution ID: **922** Type: **Oral Presentation**

A vectorial finite element method for the pore-scale calculation of the high temperature thermal behaviour of periodic porous 3D architectures.

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In the field of carbon-free heat power generation, there is a growing interest in the design of compact and long-life high-temperature energy systems (HTES), such as thermochemical reactors, volumetric solar receivers and radiant tube inserts, among others. These energy converters have long been based mainly on porous reticulated ceramics (porosity ~75-95%, cell size ~0.1-10 mm) which can be described as a continuous ligament network delimiting open cells through which a heat transfer fluid (reactive or not) can flow. The rapid development of processes based on the principle of additive manufacturing (AM) has recently extended the possibilities of fabricating new 3D periodised geometries ranging from hierarchical structures with different sets of unit cells to triply periodic structures with minimal surfaces. From a thermal modelling perspective, one of the main challenges is to accurately account for the exact contribution of thermal radiation from these new geometries in the HTES heat balance, both in transient and steady state. To tackle this challenge, two main numerical modelling approaches can be used today to determine the temperature and/or heat flux fields within the 3D structures. The first class of approach, at the continuous macroscopic scale, requires the radiative transfer equation to be solved rigorously as long as the ceramics studied follow a radiative behaviour governed by the Bouguer-Beer-Lambert law, i.e. the extinction of thermal radiation is characterised by a negative exponential function of the optical thickness. This integro-differential equation can then be simplified into an equivalent - but approximate - thermal conduction equation by respecting the appropriate Rosseland conductivity assumption if the medium is optically thick. When the optical thickness becomes smaller (<3), other more advanced analytical and numerical approaches can be used: P1 approximation, discrete ordinate method, Monte Carlo method. However, the recent regular 3D architectures obtained by AM processes clearly show, unlike the more conventional open-cell foams, a radiative behaviour that clearly deviates from the well-known beerian behaviour, which leads to the thermal problem being solved by calculations carried out at pore scale. The concept is to treat elementary heat exchanges at the pore scale using a representative 3D image of the ceramic, beforehand obtained by X-ray μ-tomography or by computer-aid based generation. Using a scheme implemented in a solver based on vectorial finite elements, we here propose a 3-step method for cases where convective transport is neglected: (i) solving the heat equation in the solid skeleton (ii) solving the radiative transport in the fluid phase (iii) solving the conductive-radiative coupling at the fluid-solid interface. This presentation will show the results of temperature fields calculated in periodised structures and will allow us to discuss how to model radiative transport on a continuous scale when beerianity is not satisfied.

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