Simulation of a catalytically assisted burner using a simplified combustion model

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The utilisation of expensive catalysts can be limited by spatial maldistribution of the species in its feed. Such a maldistribution may be caused by mixing of two fluid streams upstream of the catalyst. In such situations, numerical investigations and optimisations of the mixing section taking into account the salient effects of the porous medium and heterogeneous reactions is useful in order to asses alternative designs virtually and cost effectively.
The local release of heat within the catalyst has a marked effect on the local pressure drop. This alters the flow distribution upstream and limits the usefulness of cold flow analysis. On the other hand, the heterogeneous reaction kinetics of catalysts are often unknown. This lack of information prevents the (hot) analysis at operating conditions.
In this work, an idealised combustion model for steady-state situations where the conversion rate is nearly 100% by design is presented. The model takes into account variations of the feed across the frontal plane onto the heat release rate within the catalyst without explicit data mapping. The model has been derived, implemented and tested on simple test cases. It has then been applied on an industrially relevant geometry. Results have been obtained for a wide range of operating conditions. The results show the expected physical behaviour and good numerical performance. It can be concluded that the model allows the investigation of the mixing processes in front of the catalyst while taking into account the effects of locally changing pressure drops due to maldistribution at moderate numerical costs.