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# S1.2.3 - *Numerical and Deep Learning Models to Predict Performance of Pleated Fibrous Filters*

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Pleated fibrous filters are used in many applications like HVAC, cabin air, automotive, aerospace, and industrial filtration. Pleated filters are highly effective as they provide a large surface area for contaminant filtration in a small package. The filters are usually pleated and packaged either as cylindrical cartridges or rectangular panels. The performance of these filters has been studied extensively both experimentally and numerically in the past. Initial pressure loss, separation efficiency, and filter life are usually the performance parameters of import. Numerically simulating flow and contaminants transport, through the filter is a computationally complex task due to the different scales involved, viz the fiber microscale, the pleat scale, and the filter housing macroscale. Different approaches are followed to represent the flow of the fluid and contaminant virtually. Some simulations focus only on the microscale and few others focus on the macroscale simplifying the micro-scale. It is computationally infeasible to resolve all the scales in a single simulation but considering all the scales in some form is required for accurate filter performance predictions. One method is to fit a reduced-order model to represent the filter micro-scale phenomenon and use that functional relationship in the filter macro scale simulations. With the advent of machine learning in recent years, techniques like neural networks have successfully

been applied to represent complex nonlinear and multi-dimensional functional responses. These neural networks can be successfully trained to mimic the real-world performance of filters or model the micro-scale filtration phenomenon. In the current investigation, a first-principles physics-based 1D model is developed for predicting the initial pressure loss across a diesel engine lube filter. The flow resistance of the composite wire-backed structure of the pleated lube filter is simplified by defining a transverse permeability number. Then a dense feed-forward deep learning network architecture is developed from scratch and trained on the experimental dust loading data of the pleated lube filter. All the usual procedures of machine learning are followed in training this network. The number of layers, number of nodes in each layer, and the activation function at each node is carefully selected to best approximate the experimental data. Mean squared error is used as the cost function metric to evaluate different network architectures, the so-called hyperparameter tuning. Finally, the models were deployed as a web application for use by product development engineers, enabling virtual optimization of lube filter design for various applications.

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Arun Janakiraman is an engineering professional with many years of experience using CFD and other techniques for simulating fluid flow and heat transfer in Diesel engine filtration systems. He leads a global team of analysts focused on providing thermal and fluids modeling support to product development engineers for optimizing filter design.

**Keywords:**

Numerical modeling

Machine Learning

Lube-filter Performance prediction