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Robust model for optimization of forming process for metallic bipolar plates of cleaner energy production system

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A B S T R A C T

Energy production systems such as proton-exchange membrane fuel cell (PEMFC) has a promising future in the cleaner energy market due to zero emissions. Rubber pad forming (RPF) process of metallic bipolar plates of PEMFCs is gaining attention among the researchers. Studies based on design of experiments have been conducted to find the crucial parameters of the forming process. These methods are based on the assumptions of the model structure, correlated residuals, etc., which can cause uncertainty in estimation ability of the model on unseen data. Therefore, the present study focuses on the design of robust models of these parameters for PEMFCs using an optimization approach of genetic programming (GP). The inputs from the experiments considered in GP are radius, the friction coefficient, the filling factor and the minimum thickness. Experiments on PEMFCs validates the performance of the GP models. Further, the relationships between the two inputs and the three outputs for PEMFCs are generated as well as the contributions of each input to each of the output. Optimization of the models generated by GP can further determine the forming quality of metallic bipolar plates of PEMFCs by an appropriate setting of the two inputs.

Introduction

In the awake of degrading environment due to excessive energy consumption and production, energy production systems such as the fuel cells are considered as a prime alternative mean to produce and store cleaner energy and power the transport vehicles. Fuel cells operated vehicles are gaining popularity over the traditional ones due to their paramount advantages such as cleaner energy and almost zero emissions. These vehicles comprise of the hydrogen based fuel cells to power the transmission system. The fundamentals behind powering the vehicles are the production of electricity from fuel cells stacked in series by allowing the

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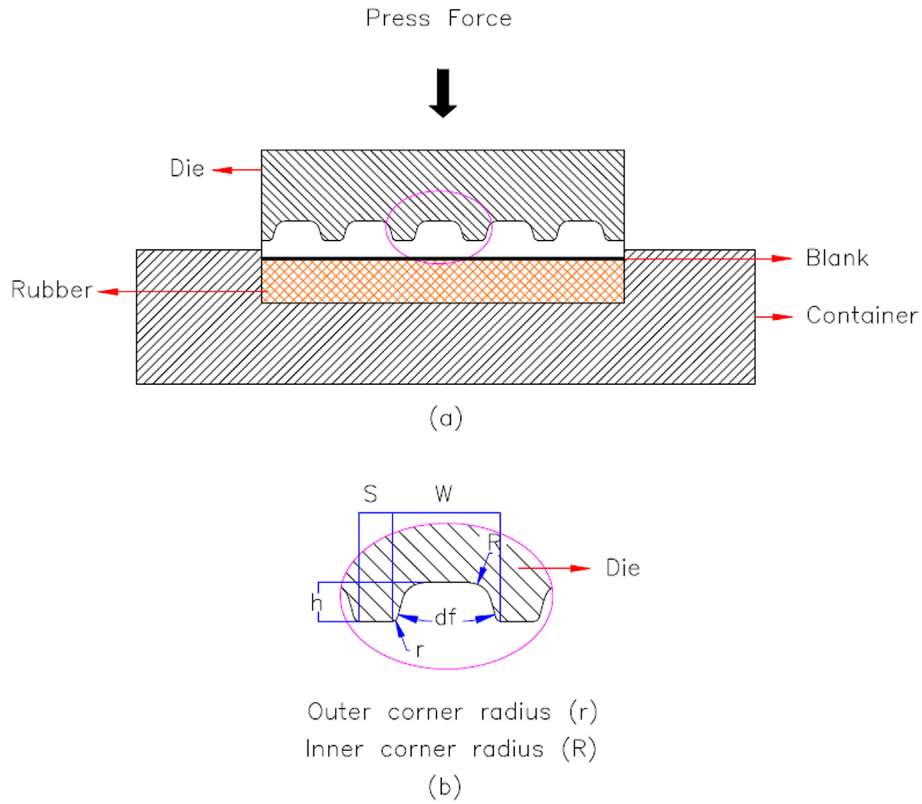

Fig. 1 – a) A schematic of the rubber pad forming setup, b) geometrical features of the die.

combination of oxygen from the air and the compressed hydrogen stored in the tanks. The hydrogen based fuel cells are classified based on the operating temperature, the charge mechanism and the electrolyte type. Among them, PEM fuel cells are considered cost effective and more ready for commercialization. However, further reductions in weight, volume and cost of the PEM fuel cell stacks are needed to make them competitive with the existing internal combustion engines. Bipolar plates in PEM fuel cell stacks are one of the obstacles for the commercialization. They comprise about 30–35% of the stack cost and 60–80% of the stack weight [1]. The bipolar plates carry out several tasks in a fuel cell stack i.e.: distribution of reactant gases on the active surface of fuel cell, directing electrical current from one cell to another, and conducting generated heat to the cooling media. Metallic

Table 1 – Range of main parameters.

Parameters	Low level	High level
Draft angle(df)	20	40
Friction coefficient (f)	0.05	0.2
Outer corner radius (r) (mm)	0.1	0.4

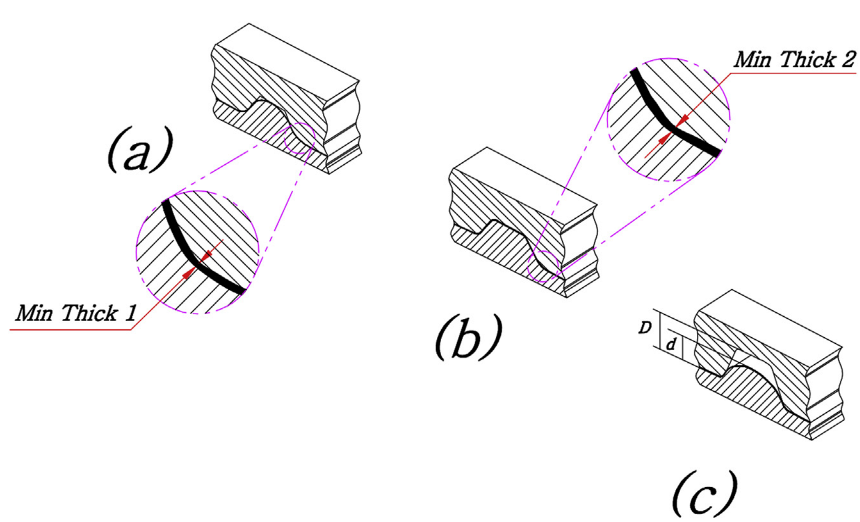

Fig. 2 – The schematic representation of the objective functions a) Min Thick 1; b) Min Thick 2; c) Filling Factor.