TOWARD END-TO-END IMPROVED COOK STOVE OPTIMIZATION

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While it is possible to build and test the performance of prototype Improved Cook Stoves without significant capital investment, if the amount of time that it takes to optimize candidate stove designs could be drastically reduced, then cook stove technology could reach the hands of many more in developing nations. It was identified that an end-to-end modeling and optimization effort for Improved Cook Stove (ICS) design could aid in the development of more efficient and cleaner-burning stoves. The thermodynamic and heat transfer processes underlying cook stove performance are tightly coupled, which makes modeling a challenge. The following analysis is a first attempt at capturing each of the underlying processes of stove performance. The model is formulated so as to facilitate the optimization of stove geometry. This effort helps pinpoint the deficiencies of the current state of stove modeling and attempts to demonstrate the eventual power of a predictive stove model.

A rocket stove was chosen as the target for modeling. The major thermodynamic, fluid mechanic, and heat transfer processes were identified. Analytical expressions based on the fundamentals of heat transfer as well as experimental correlations were written. Finally, numerical techniques were applied to design a stove with an optimal thermodynamic efficiency. Samuel Baldwin's work on the engineering design of cook stoves was used as a primary source, but it was augmented by a number of more modern articles.

As a proof of concept for the usefulness of a cook stove simulation, a novel design combining a skirted rocket stove and an interior nozzle was optimized. The resulting model suggested that an interior nozzle was not desirable since it contributed a large pressure drop that lowered overall convective heat transfer. Three major geometric parameters: gap size, pot height, and stove diameter were optimized for overall stove efficiency, as well.

Unfortunately, the model presented in this report is not quantitatively predictive of actual stove performance. The effort of attempting to capture all of the coupled processes related to stove performance serves to pinpoint the areas ripe for future work. For instance, predicting combustion characteristics for improved cook stoves proved to be out of reach for a model based on analytical expressions. However, convective and radiative heat transfer processes were captured relatively completely. Another area of improvement would be in the interface to interacting with the model. For now, the implementation was performed in MATLAB, which makes modification error-prone (though relatively quick in the hands of someone familiar with the model). The ultimate vision of this project is a flexible stove modeling application that allows relief workers in developing nations to generate optimal stove designs based on local materials and cooking habits. Over the course of the design project, groups looking to deploy stove technology in relief efforts approached the team on three separate occasions; there is significant interest in ICS deployment, and modeling could help turn that interest into effective action.