Round 1 Proposal

1. What is the title of your proposal?

The title should reflect the scope, goal and benefits of your idea. In addition, if you wish, you can also give us an acronym or shortened version of the title for reference.

Boundary layer control through the application of Knudsen pumps, to reduce skin friction drag and increase aircraft efficiency.

2. What do you understand to be the state of the art in the area of your idea?

What is the current operational practice in the subject area of your idea and what new approaches are already under development in this field?

Knudsen pumps themselves are state of the art considering they have no moving parts and utilise thermal transpiration to effectively control gas flow. To date there are no known applications of Knudsen pumps within aircraft. There are currently several methods of boundary layer control applied to aircraft, through aerofoil shaping, wall cooling and turbulators. Boundary layer suction is presently carried out through suction slots; however there is a limit to the volume of air that can be extracted. The addition of Knudsen pumps would allow more low energy air to be extracted from the flow.

3. Please explain your idea.

Explain the main features of the idea and what challenges need to be overcome for it to be implemented. Ensure you mention the way(s) in which your idea is new or innovative in relation to the state of the art.

The basis of the idea is to utilise Knudsen pumps to provide suction of the boundary layer. In doing this low energy air is extracted from the flow, allowing it to remain laminar for longer and delaying flow separation.

Knudsen pumps utilise thermal transpiration, which in simple terms involves creating a temperature gradient that causes gas molecules to move from one side of a tube to the other. Placement of Knudsen pumps within the wing should allow this methodology to be applied to the boundary layer.

Challenges that will arise include meeting the current aircraft design and safety standard; the location and quantity of Knudsen pumps required to extract air at the desired flow rate; the cost of implementing the pumps and maintenance of them during working life.

As Knudsen pumps have not been used in aircraft applications previously overcoming these challenges will be increasingly difficult due to the innovation behind the idea. The concept will be compared with the current technology available and benefits of each shall be evaluated.

4. What benefits do you expect your idea to generate?

***Explain the benefits of your idea in relation to the challenge you have chosen with particular attention to positive environmental, economic and social impact*.**

Through the application of Knudsen pumps to provide boundary layer suction on the leading edge of the wing, the transition from laminar flow to turbulent flow is delayed. As a result the skin friction drag across the wing can be reduced, thus enhancing aerodynamic performance and increasing efficiency of the aircraft. Increased aircraft efficiency and reduced fuel consumption leads to a positive environmental and economic impact. Knudsen pumps also have the benefits of using no moving parts, allowing for an extended lifecycle.

5. If your team progresses to Round 2, what new work do you intend to carry out to test and validate your idea?

Please outline a plan of how you will develop your idea and how you will measure the benefits.

A detailed analysis on Knudsen pump performance will be carried out using both mathematical and computational methods. From this, the output pressure and temperatures required for effective thermal transpiration will be recorded. The performance of an Airbus wing incorporating boundary layer suction techniques will be evaluated. Upon completion of this the performance benefits of Knudsen pumps will be investigated. An analysis detailing the potential increased aircraft efficiency through the use of Knudsen pumps shall then be completed.

shamus.mcnamara@louisville.edu

University of Louisville

Knudsen pump expert guy from America. Might be worthwhile to email him and get some information on them.