Technical Assistance Request

Technical assistance is requested in two separate areas: basic sciences and engine development.

1. Basic Sciences

Basic science assistance is required to study high levels of water condensation in supersonic steam flows.

This work is needed because conventional steam engines are carefully controlled to avoid significant amounts of condensation. The underlying problem is that condensing water droplets cause severe damage to the high speed blades of conventional steam engines. Because of its commercial significance, this problem has been extensively for decades by the electric utility industry. For the latest developments, see the multiple sections in the ASME 2020 Turbo Expo conference, the world's leading professional meeting in this discipline:

https://www.asme.org/topics-resources/society-news/asme-news/registration-now-open-for-turbo-expo-2020

See particularly the papers devoted to the "last stage" part of the turbine, which is the exit zone where even small amounts of condensation cause unacceptable damage to these multi-million dollar power plants.

Because the condensation in the proposed technology goes well beyond this quite modest degree of common industrial condensation, additional data is needed in this uncharted area.

Unfortunately, obtaining this data is not a simple matter of a minor adjustment of a knob or two in some conventional laboratory. Instead, it has been known for more than half a century that large amounts of liquid water suspended in steam vapor greatly changes the properties of the mixture. In particular, the speed of sound at high droplet concentrations can reduce the speed of sound by about two orders of magnitude. Because the compressible flow relations (the equations that govern the behavior of high speed gas flows) depend on the Mach number, the behavior of the entire system changes greatly under such conditions.

This behavior must be well understood to optimize the proposed new engine. Unfortunately, there is inadequate theoretical knowledge of even such basic phenomena as non-equilibrium condensation under the operating conditions of the proposed technology.

The requested assistance therefore consists of detailed experimental analysis of steam flows in the transonic to supersonic range. Of particular need is high speed imaging, both photographic and videographic. Both shallow and deep fields would be helpful. Note that the fields will be highly obscured for high droplet density cases.

Likewise, other diagnostic testing for high speed steam flows would be quite helpful. Laser Doppler equipment would be quite interesting across the flow profile, again under the caveat of operation in high droplet density conditions. Color Schlieren imaging would be most useful near the ejection ports. Other techniques would also be considered as available, the key point again being the ability to work with high speed flows under the quite difficult condition of extremely high droplet loading.

If these techniques can be successfully executed under the extreme conditions in the proposed technology, the results will improve the efficiency and reliability of the new rotor, thereby greatly increasing its market value.

2. Engine Development

The proposed technology is based on a new turbine design. Preliminary tests demonstrate that this design is technically feasible, but it needs refinement to be marketable. Assistance is therefore requested to make this refinement.

Because the first product to be marketed will be designed for household use, the scale to be used in this effort is about 5 kW. This power level provides a unit that would be useful for household applications, driving a common residential generator. Assistance is therefore requested with relatively small equipment and instruments.

Because this is the first step in developing an entirely new engine, assistance is needed in all stages of developing the working prototypes into marketable products. The main concern throughout this effort is that the new technology operates at the extreme limits of existing procedures and materials.

Assistance is therefore requested with any emerging technologies in additive manufacturing, notably in enhancing the improved strength that is characteristic of 3d printed stainless steel components.

Assistance is also requested with commercially proven computer models of steam flows at supersonic speeds. Both the fundamental models themselves as well as supercomputer resources would be helpful.

Once constructed, the performance of the new engines must be carefully measured. Beyond the existing basic techniques, three separate areas are of interest.

First, the high speed imaging systems requested above for basic science work would also be useful here, as adapted for the visualization of rapidly rotating components in both open and partially sealed environments.

Next, the new technology has an unusual shape that is difficult to balance using conventional shop equipment. Smooth operation will therefore require the services of advanced balancing devices and techniques.

Finally, independent pilot testing will require a dynamometer capable of operating in the low kW range. The requested assistance includes a fully computerized system, with traceable calibration.