Name of the project: Aerogel Combustion Chamber

Area: Aerospace Engineering

Authors: Manuel Cachón, Iñaki Carrera, Laura Collazo, Íñigo Estébanez

Description of the project:

The design of an aircraft requires taking into consideration countless amounts of variables and limiting aspects that can affect the functioning of the vehicle. One of the main ones is weight. The heavier the components used, the more energy will be required to operate the aircraft, and therefore less efficient will be: it will consume larger amounts of fuel, have higher costs and expel more contaminating gases.
There are other factors that are not so evident but might also have a huge impact in both the efficiency and cost of an aircraft operations. The improvement of these parameters does not only improve performance but has also an impact in the emissions to the atmosphere, decreasing them as less fuel is required.

The purpose of our project, *Aerogel C.C.* (*'Aerogel Combustion Chamber')*, is to obtain improvements in the efficiency of a jet airplane by two means: reducing thermal losses at the combustion chamber of the engine and an additional weight reduction.
To achieve so, aerogel and ceramics are implemented in the combustion chamber wall, substituting a percentage of the thickness, originally formed by a superalloy.
Aerogel is a material developed during the last years, which shows an amazing performance in terms of weight and heat isolation: it is incredibly light due to its low density (down to 1kg/m^3) and has an extremely low thermal conductivity (around 0,004W/(m·K). The only issue with aerogel is the melting point: around 1200 degrees Celsius, which is relatively low when compared to that of conventional combustion chamber alloys, which can sustain temperatures of around 2000 degrees Celsius. To combat this, a ceramic plate is placed between the aerogel insulating panels and the alloy walls of the combustion chamber. By placing this ceramic plate, the temperature is lowered down to a level that does not affect the properties of aerogel. This obtained temperature is around 1000 degrees Celsius, which allows aerogel to efficiently perform.

When the results of carrying out our aerogel-ceramics combustion chamber wall idea were being analyzed by our team, we came to some important points to take into consideration for the design of our product. First, it is necessary to realize that to maintain a reasonably similar combustion chamber wall width it is possible to substitute a percentage of the alloy volume with aerogel, so that the basic structure is not altered but a much higher thermal isolation is achieved, and therefore heat transfer losses reduced. Not only heat transfer would be reduced, but weight will also decrease up to a point.
Taking a look at other options, it would be possible to maintain a constant mass and therefore reduce considerably more heat loss, but that would require a much larger volume and changing the whole structure of the engine. On the other hand, heat transfer could be maintained and only reduce mass, but since the combustion chamber wall is not that significantly heavy part of the aircraft, it is more interesting to reduce the heat loss and save fuel.

Taking into consideration these points, our team could set some assumptions and carry out the calculations, starting from the basis that most of the heat transfer occurs by means of conduction, and assuming a 5mm layer for every material. The results for these results, in which we took the structure of an ideal combustion chamber, show how we could save more than 50% of the actual combustion chamber weight, and an incredible heat flux reduction out of the combustion chamber of more than 90% of the actual values.

Once the idea is proven to have a very interesting potential, in terms of efficiency improvement and therefore weight, cost and emissions saving, a business point of view analysis had to be carried.

First of all, the first step towards setting up these idea was knowing to whom we are interested to sell our product. After evaluating our different options, the most interesting one was working with engine manufacturers, such as *General Electrics* or *Rolls Royce*, which are the main aircraft jet engine suppliers for *Boeing* and *Airbus*. Then, the path to materialize our idea and design, and start working was decided, finding three main milestones. The first one will be the combustion chamber development, which includes its design, creating a prototype and the manufacturing itself. Then, the integration testing is the next main step, which allows us how our product works once integrated with the selected engine. And finally, the certification and final testing step, would give us runway to start commercializing our product.

Taking a look at the marketing aspect and the potential demand for *Aerogel C. C.*, a very important point to make is that in the aerospace industry, everyone searches for more efficient components. And we are providing to the market a product which allows their aircrafts to save fuel, reduce their emissions and reduce their weight. This makes us a very interesting product, not only for the engine manufacturers, but for the whole industry, going from airlines to passengers.

Other very important factors which will define our path are initial investment, production costs and certification. For the first one, we will require an external investment, from a big company or fund, to whom we will explain how our product will be a hit in the whole aerospace sector. Regarding the production costs, there is a certain thing which will help us a lot: they will fall, as new companies start using aerogel and more producers enter the marketing, offering more competitive prices. Furthermore, as our product becomes more relevant, more aerogel will be required, and a future possible diversification into other markets which would also beneficiate themselves from better insulated combustion chambers would increase as well aerogel production and reduce their cost, due to economies of scale and bulk operations. Finally, regarding certification processes, it is known that this is one of the most important costraints, in the aerospace sector. However, this allows us not to worry about this: all the new engines which big manufacturers will require certification, just at the same time our combustion chamber alternative is implemented and certified jointly.

To conclude up with, we just have to insist, one final time, in the permanent search carried out by every aerospace sector company of more efficient, less heavy, less expensive and less contaminating products to integrate into aircrafts. And this is exactly what our product, *Aerogel Combustion Chamber*, has the potential to provide.