Interpreted Needs

Prior to meeting with the sponsor, Mike Schoenfeld, the team formulated a rough list of questions that were general enough as to not be exposed to too many specifics early on. These questions were designed to get an idea of the scope of the project and to become familiar with the nomenclature involved with the design. The team asked direct questions that allowed for responses that answered “what” not “how”.

Therefore, questions were posed at learning more about the physical conditions that the design will be exposed to, and the limits of the design space. The interpreted needs from the design’s physical conditions is that pressures and temperatures will be monitored and that the geometry and physics of the heating are parameters that can be controlled. Furthermore, for the design space the interpreted need is that the design can be used in the testing chamber.

Questions were also brought up about issues with the existing conditions. Then, some basic questions about broader engineering categories such as heat transfer, fluid dynamics, and physics were asked to narrow down the fields of engineering that will be used during the project. After the meeting, the team discussed key takeaways and formulated more specific questions. These questions were emailed to the sponsor so that more time could be spent on the answers. These questions were directed at understanding the subsystems the design might interact with to form a functional decomposition. Some other questions were posed at understanding the underlying physics of the problem.

The interpreted needs taken from these questions framed some specifics about the instrumentation and measurement devices that can be used, and the nature of the hydrogen’s interaction with the test devices. As far as the materials science of this design, the sponsor was clear about what is needed.

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| **Question** | **Customer Response** | **Interpreted Need** |
| What design space is the heat exchanger restricted to? | Within test chamber, where the other heaters are located. | The design can be incorporated into the existing test space. |
| What parameters will the group have control over? | Power delivered to induction coils, geometry of coil. | The design accounts for the power delivered and geometry of the preheater. |
| How do the current test articles differ from true nuclear heating? | Nuclear heating is a volumetric heating phenomenon, whereas induction heating is a surface heating phenomenon. | The test articles will be heated by induction. |
| Does the hydrogen gas undergo any appreciable compression before it reaches the test articles? | No, there is turbomachinery to move the fluid, but doesn’t undergo significant compression. | The design neglects compressibility effects. |
| Will radiation be modeled? | No |  |
| What flow physics will be considered? | Heat transfer, not so much fluid dynamics. |  |
| What are the desired temperatures at outlet of test chamber? | 2000-2500 K. | The fluid can be heated to around 2000-2500 K at the outlet of the heat exchanger. |
| What effect does hot hydrogen have on the vessels that enclose it? | It is highly corrosive. |  |
| What issue does the absence of hydrogen pre-heating cause? | Without hydrogen pre-heating, the hydrogen temperatures in the furnace will depend on the test article temperature and heat exchange efficiencies.  The intent of the test article is to be exposed to hot, flowing hydrogen.  Thus, the capability to independently control the hydrogen conditions is needed.  Currently the facility can control pressures and flow rates.  What is remaining is the inlet temperature. | The design allows for independent temperature control. |
| Is the goal to increase the temperature of the hydrogen to the desired temp in a smoother fashion so that deltaT of inlet of normal heaters is less, rather than large deltaT of cold hydrogen to hot test article? | Not really. More about controlling the temperature of the hydrogen the test article is exposed to. | The design can heat the hydrogen to a specific temperature. |
| Is the inlet mass flow rate fixed to a specific value, and if so, is it independently controlled? | The inlet mass flow rate is throttled. The facility can provide H2 mass flow rates from about 0.1 – 1,000 g/s. |  |
| Is the corrosion caused by the hot hydrogen acceptable to a certain point? | That criterion is set by the test article designer and the people using the test articles. Our focus is to create the correct exposure conditions and monitor for the corrosion via sampling streams that go to a mass spectrometer to examine composition. | The design monitors physical conditions. |
| Why is the design space restricted to inside the test chamber? | For safety reasons, we prefer to contain the hydrogen and any potential leaks inside the chamber. Material strengths are weaker at elevated temperatures so having a high-pressure supply tube be hot is not a comfortable prospect. |  |
| What additional measurement devices are required in the pre-heater? | I’m open to recommendations. I would think in general anything related to performance. Inlet and outlet temperature come to mind. Inlet and outlet pressures or pressure drop as well. Knowing power deposition, it would be beneficial but if we used induction heating that would come from the heater equipment really. | Temperature and pressure are able to be measured. |
| Are the existing induction coils made in house or from a supplier? | Currently from a supplier; fluxtrol. |  |
| What material are the existing induction coils? | Copper tubes. |  |
| What is the material of the test article (the tube the Hydrogen flows through)? | They vary from refractory metal alloys (cermets) to ceramics (carbides) to graphite. | The design uses materials with high melting temperature and high thermal conductivity. |
| What is the desired outlet temperature of pre-heater? | ~2,200 K would be a good target to shoot for. It may be useful to know that we currently have an induction heater that is rated for 12.5 kW, if we buy another one and repurpose our current one, it is rated to 1.2 MW. We are pulling power from a substation that can provide no more than 10 MW. | The design displays power usage. |