

Emissions Testing and Arctic Turbine Option

Flex Energy
August 23, 2011
Todd Coady

9/8/2011

CLEAN ENERGY FOR THE PLANET

FlexEnergy

1

FlexEnergy Presentation Overview

- FlexEnergy is a leading manufacturer in the gas turbine industry. FlexEnergy provides one of the cleanest power platforms in the world.
- **Project I: Emissions Testing**
emissions tests on an upgraded design were run, preparing it would pass CARB (California Air Resources Board) standards with design changes.
- **Project II: Arctic Turbine Option**
Initial design steps were taken to design a turbine that would survive and start after a cold soak to below -40°C



Figure 1: Newly Redesigned Microturbine

9/8/2011

Emissions Testing



Dilution Holes:
 \varnothing XX.xx mm

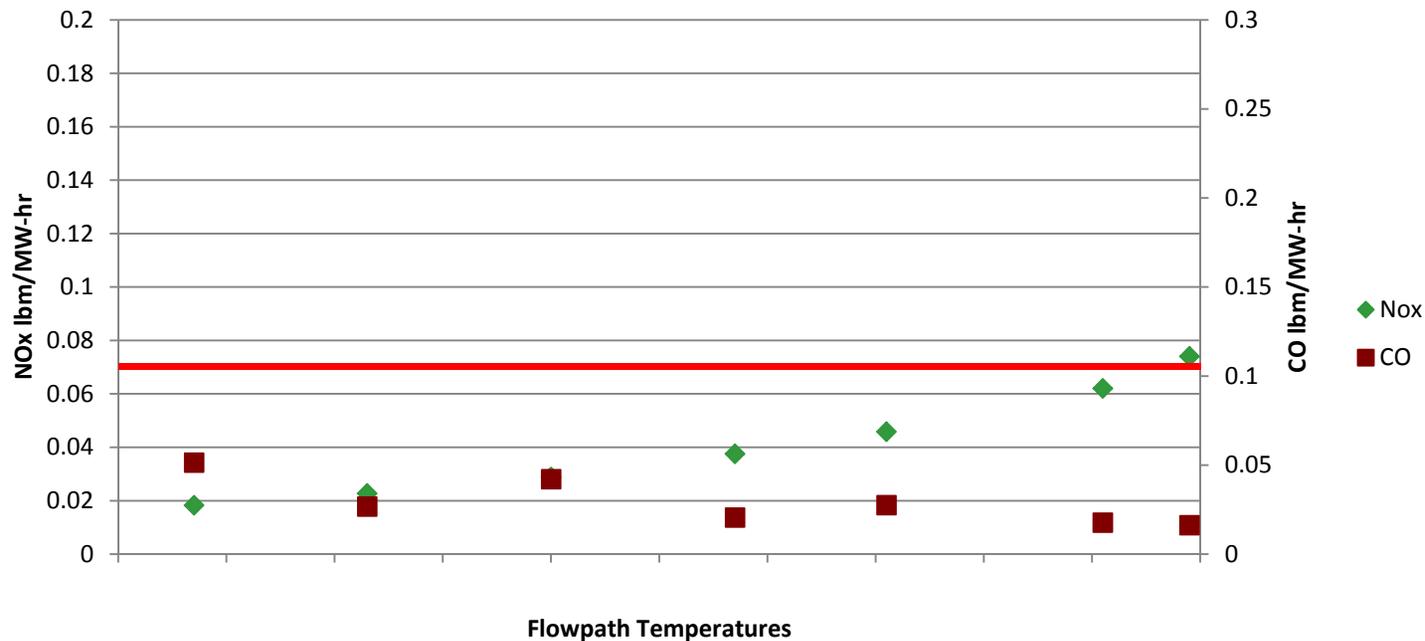
Figure 1: Combustor with dilution holes of XX.xx mm diameter

This initial combustor had dilution holes of diameter XX.xx mm as seen in the above figure. The holes control the flow of air through the combustor.

9/8/2011

Emissions Testing

XX.xx Dilution Hole Emissions data: CO and NOx July 7th, 2011



Results obtained for XX.xx dilution hole size combustor are seen above. CO levels pass for all flowpath temperatures, but NO_x levels are too high at high flowpath temperatures.

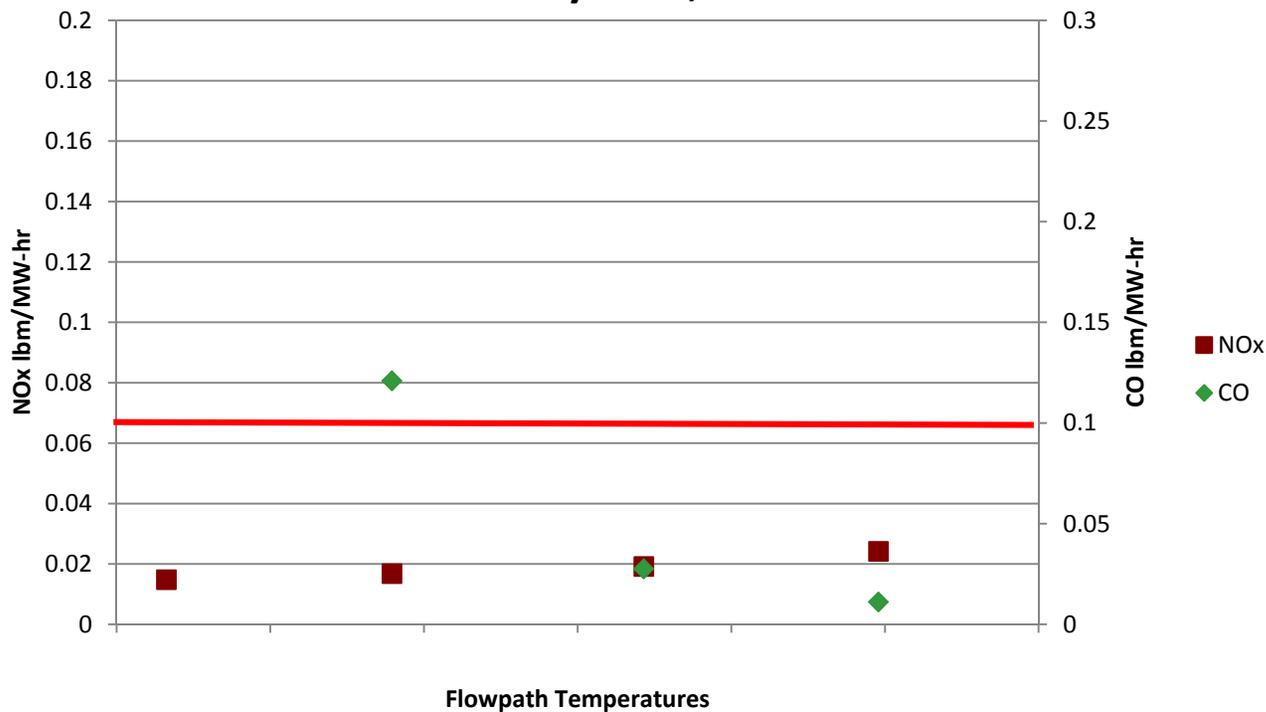
9/8/2011

4

Emissions Testing

For comparison, a combustor with dilution holes of diameter YY.yy mm were tested:

YY.yy mm Dilution Hole Emissions Data: CO and NOx July 28th, 2011



This combustor passes emissions standards for CO and NO_x for all flowpath temperatures of concern.

This combustor must also be tested for lean stability (Blowout margin)

9/8/2011

Emissions Testing

Both combustors were tested for Flameouts at various power ratings.

Testing for the YY.yy mm rating occurred at a much lower ambient temperature than the testing for the XX.xx mm combustor.

Values in table 1 are corrected to ISO conditions and normalized to the objective lean blowout limit.

A flameout below a power rating of 1.00 is acceptable to FlexEnergy standards.

Table 1: Flameout Data for Tested Combustors

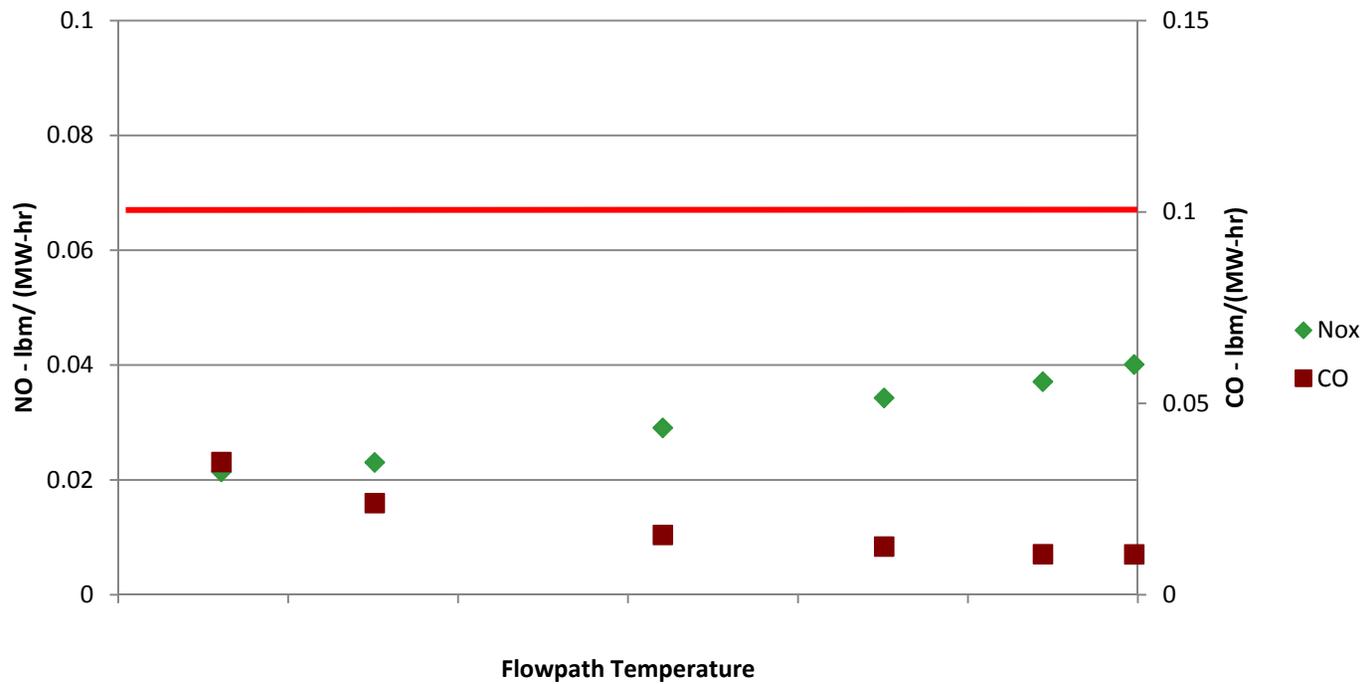
LBO Data		
Dilution Hole Size	YY.yy mm Rating	XX.xx mm Rating
Trial 1	1.05	0.88
Trial 2	1.05	1.08
Trial 3	1.03	0.97
Average	1.04	0.98

9/8/2011

Emissions Testing

A new combustor of dilution hole size ZZ.zz mm diameter was manufactured and tested:

Emissions Data for ZZ.zz mm Dilution Holes August 10, 2011



9/8/2011

Emissions Testing

Table 2: Flameout testing for ZZ.zz mm combustor

LBO Data	
Trial	KWpct
1	0.93
2	0.98
3	0.96
Average	.96

Flameout testing was also performed on this combustor to ensure it met our standards.

The combustor is clearly below the 1.00 required maximum power rating.

This combustor will be used for the official emissions stack test.

9/8/2011

Emissions Conclusion

- The new ZZ.zz mm combustor passes CARB standards
- The combustor meets our static stability requirements.
- The new combustor will be used for the emissions test, and will be manufactured for the new design.

9/8/2011

Arctic Turbine Option

FlexEnergy will begin to market cold weather microturbines that can withstand cold temperatures to below -40°C.

This project is in the initial design phase. All current parts of the MT250 that may be problematic at extremely cold temperatures were marked, and replacements were identified.

The lubricant system was completely analyzed, and the proper heating equipment was used to insure that warm oil was circulated through the machine.

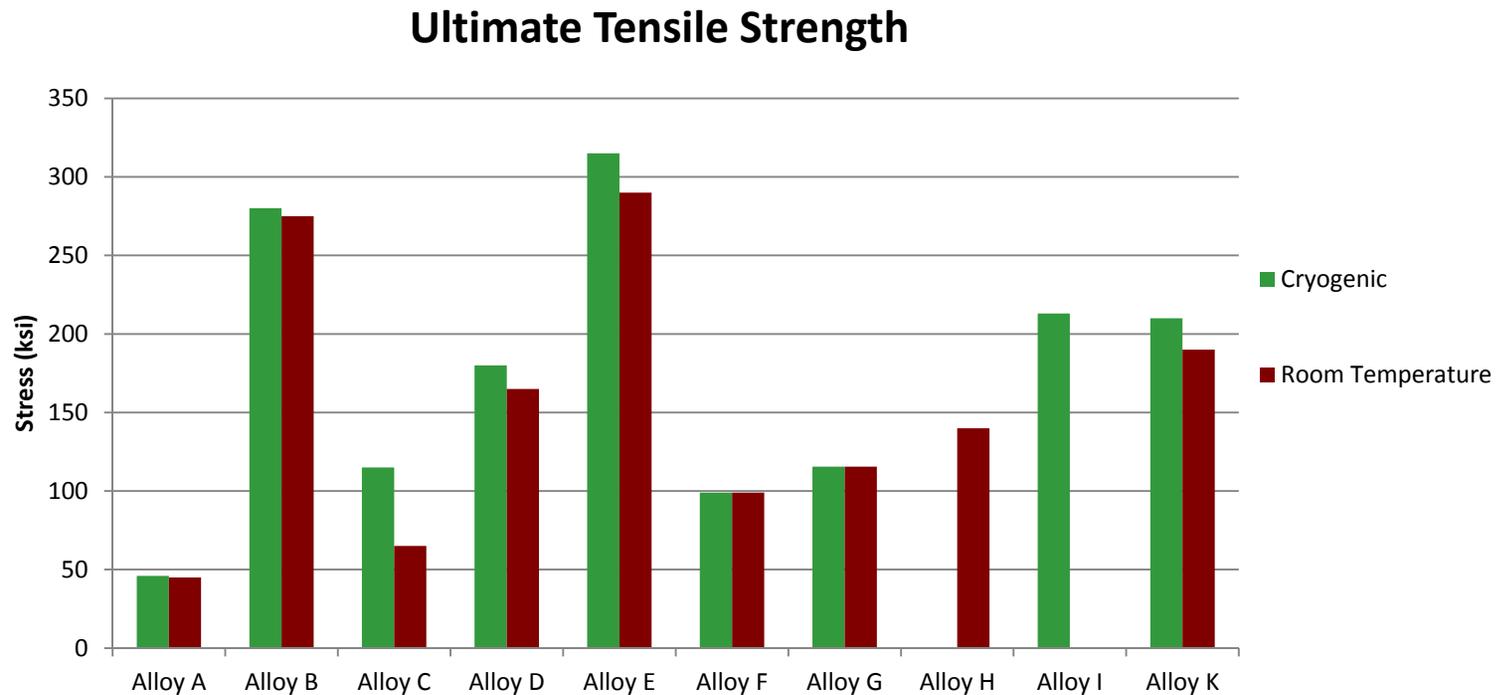
Considering that the compressor would receive inlet air at a temperature below -40°F in this scenario, a complete material analysis of the compressor blade alloy was also necessary.

9/8/2011

10

Arctic Turbine Option

Ten alloys were completely analyzed for various mechanical properties, and three were chosen as top candidates for the compressor

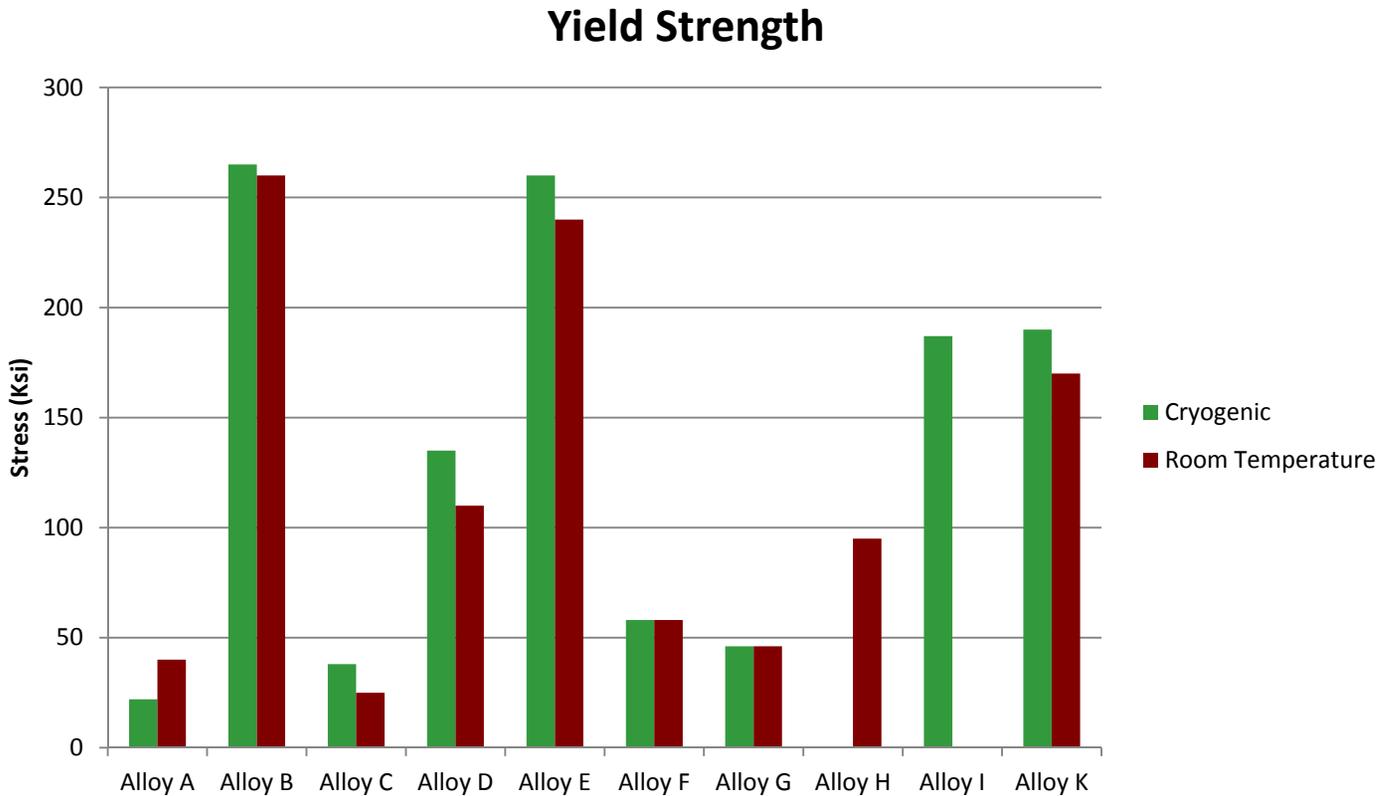


Ultimate tensile strengths for ten examined alloys

9/8/2011

11

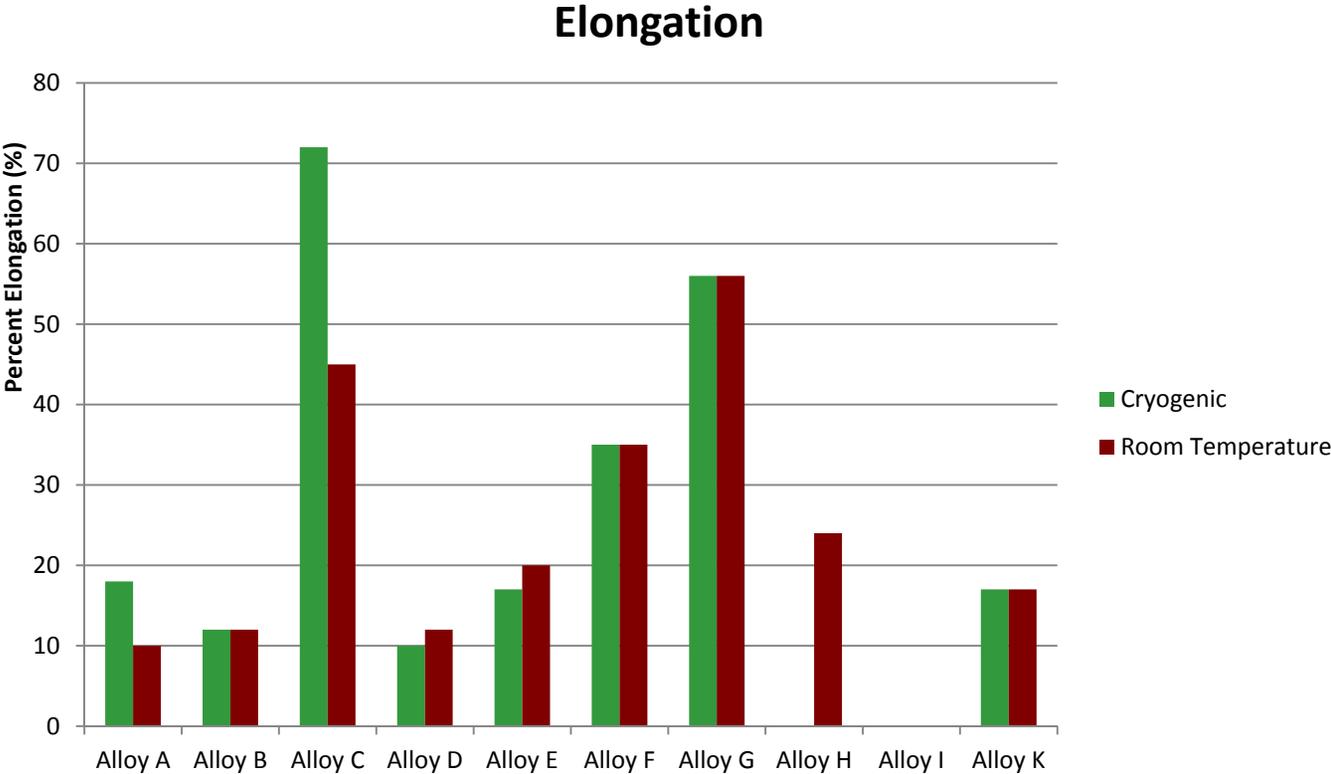
Arctic Turbine Option



Yield strengths for ten examined alloys

9/8/2011

Arctic Turbine Option

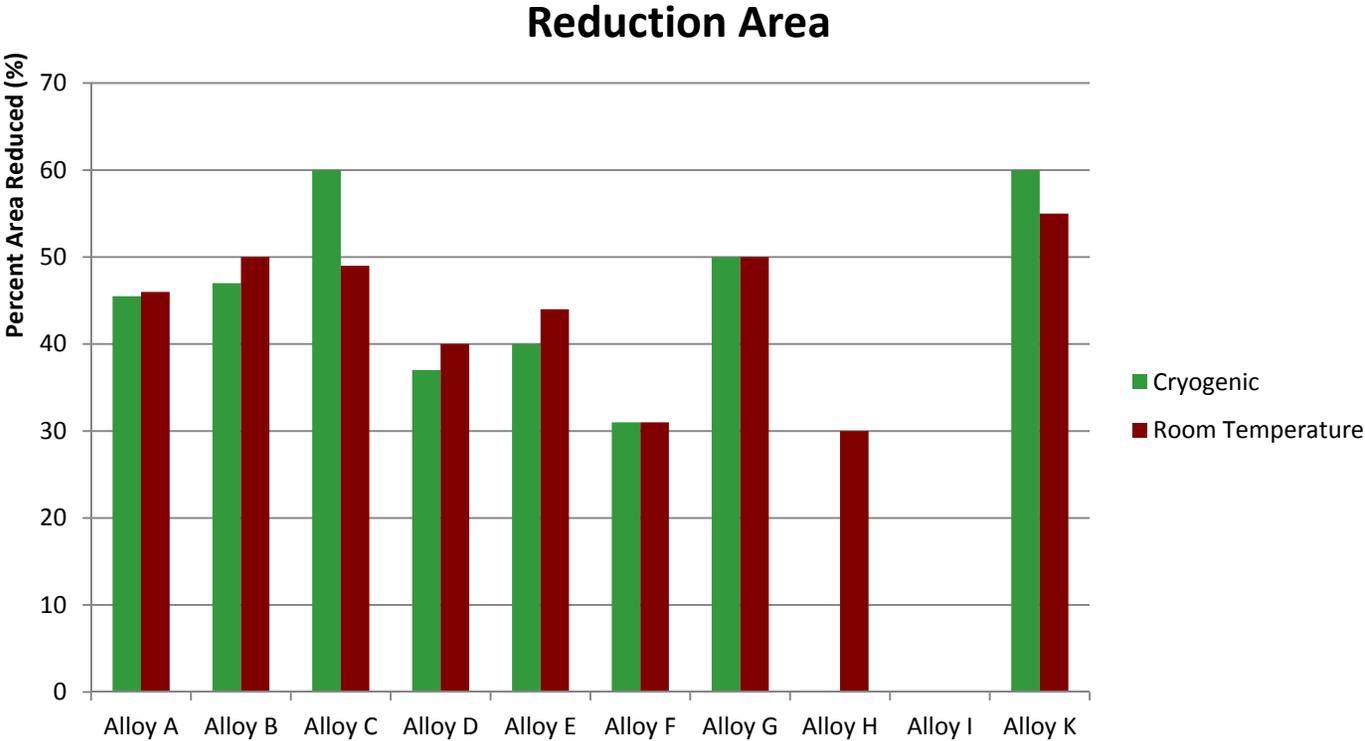


Elongation for ten examined alloys

9/8/2011



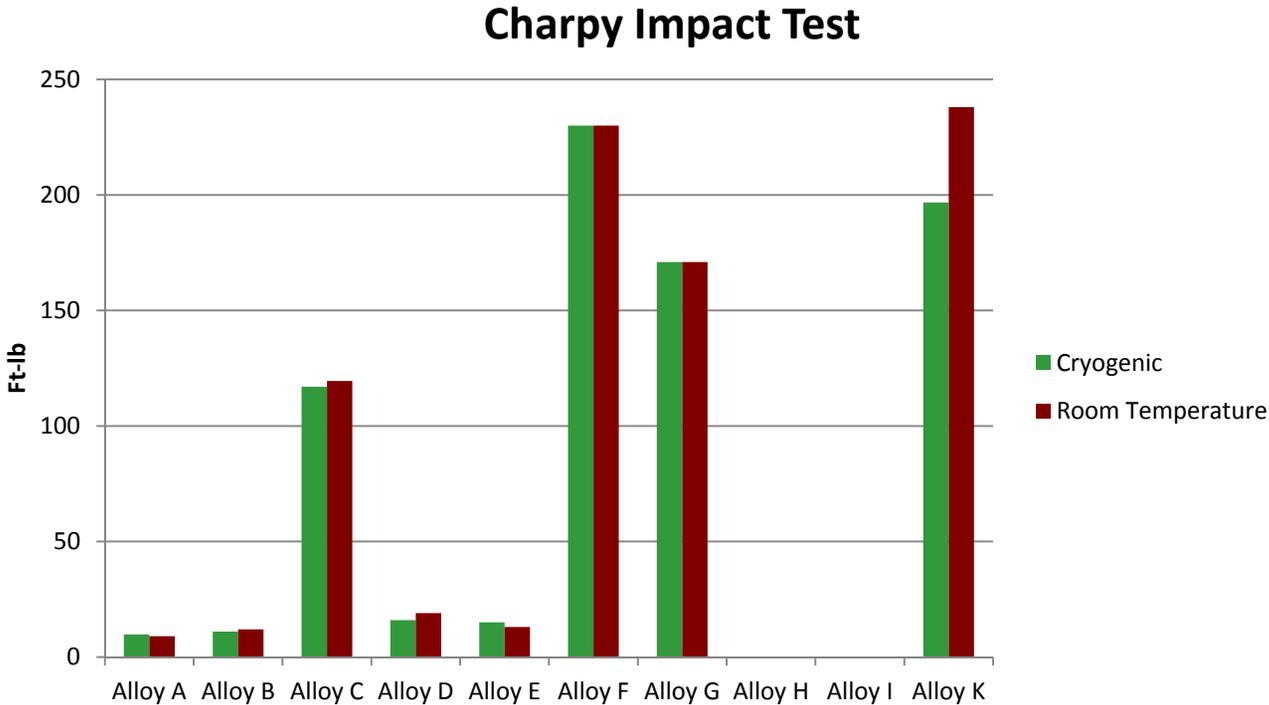
Arctic Turbine Option



Reduction area for ten examined alloys

9/8/2011

Arctic Turbine Option



Charpy impact for ten examined alloys

9/8/2011

Arctic Turbine Conclusion

Three top alloys were chosen, but further testing is required to determine the correct compressor alloy for cryogenic temperatures.

Testing strategies were identified for testing electrical parts, of which only seven are guaranteed to below -40°C requirement.

After all problematic parts have been replaced, the entire turbine will be cold-soaked to below -40°C environment to ensure that it can survive such a freeze.

9/8/2011

16

Acknowledgements

The UTSR Fellowship Program has been incredibly rewarding for me this summer. My experience at FlexEnergy has greatly expanded my knowledge of emissions, heat transfer, and materials science. This fellowship has also served as a valuable transition from the academic to the industrial world.

I'd like to particularly thank Jeff Armstrong, Thomas Hackett, Robert Mayoral, and many others who made my stay at FlexEnergy great. Thanks for your knowledge, guidance and patience throughout this summer!

I would recommend the UTSR program to all engineers interested in the gas turbine field. I'd also like to thank the Southwest Research Institute. Without them, this opportunity would not have been possible.

9/8/2011

17