Flue Gas Energy Recovery



Team Fire and Ice: Brandon Nafsinger, Scott McMurdie, Garrett Oman, and Bryan Perkins

The Problem

The steam plant at the University of Idaho has a large amount of waste heat that is expelled from many different surfaces. This is a common issue that occurs in many different power plants and industrial settings.

The Solution

- Utilizing Thermoelectric Generators (TEG) capture a portion of this waste.
- Achieved by imposing a temperature difference across the TEGs surfaces.
- Flared pin heat sinks and electric fans are used to attain this temperature difference.
- Heat that would normally be wasted is now turned into power used at the steam plant.

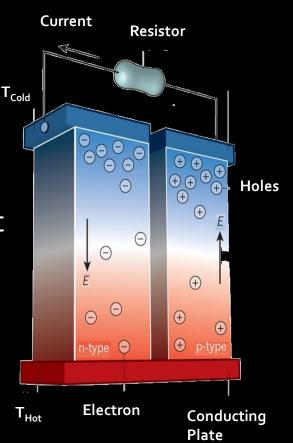
Project Learning

What is a TEG:

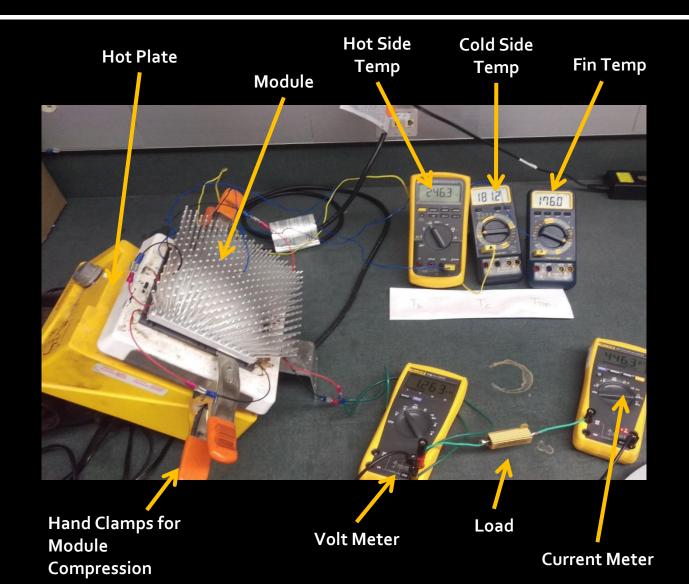
- Constructed of n-type and p-type semiconductors (Bismuth Telluride)
- Common efficiency between 5% to 9%

How a TEG works:

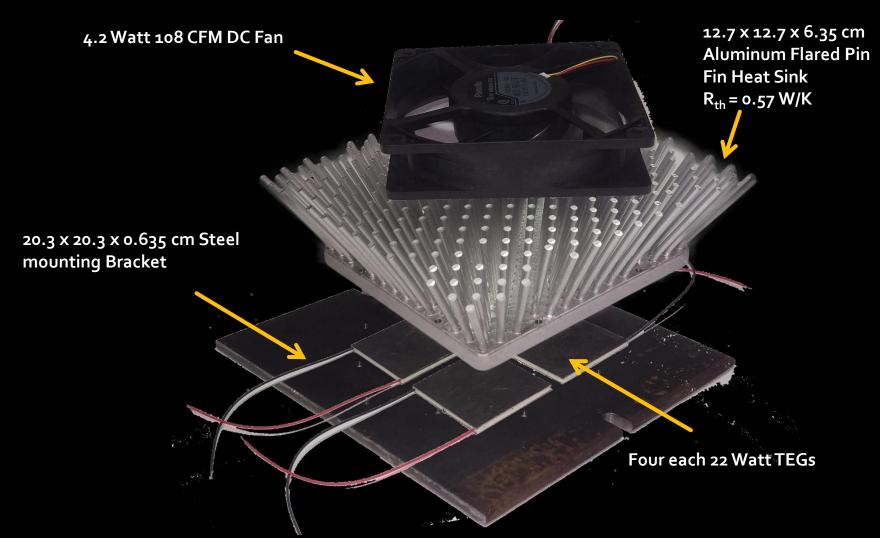
- Operate according to the Seebeck Effect
- ΔT across thermoelectric material is converted directly into electrical power
- The n-type create an excess of electrons and the p-type create valence holes for the electrons to flow into.



Testing



The Design



Results

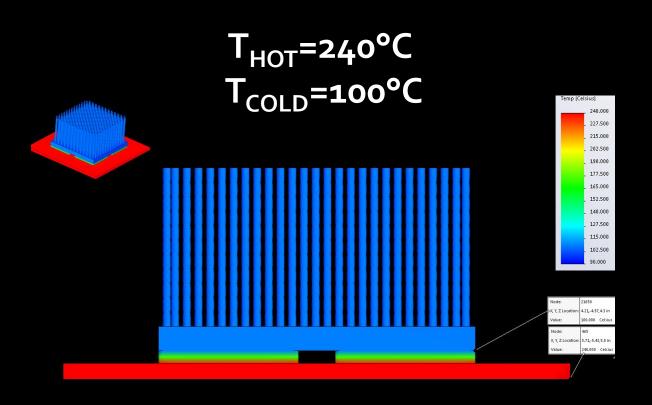
Max Power output happens when load resistance = TEG internal resistance





Thermal Distribution

- How the heat is dissipating thought the module.
- Largest drop in temperature across the TEGs



Manufacturing

Process:

- Our TEGs Require 4 kN of compression for maximum heat transfer
- The Module is preloaded using a hydraulic press
- Bolts are tighten while under compression
- Though bolt design increases strength



FEMA

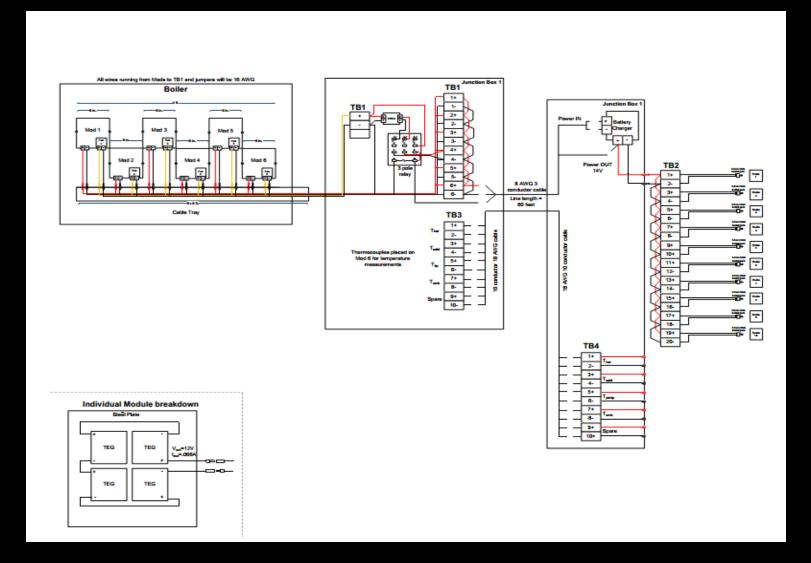
Item:	Waste Heat Recovery System		Responsibili	ty:	Facilities				FMEA number:		1.3				
Model:	7 7			Prepared by	y:	B.Perkins				Page :			1 of 1		
Core Team:		B.Nafsinger, S. McMurdie, G. Or					FMEA Date (Orig):	4/27/2017	Rev:			2			
	Potential	Potential Effect(s) of	s	Mechanism(s)	0 0 0 u r	Current Process Controls	D e t e	R P N	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
	Failure Mode		e v								Actions Taken	S e v	O C	D e t	R P N
Energy Recovery	TEG Failure	Decrease in power, Increased charging times	2	Frequent shutdowns and restarts	2	None	3	12	Replace Faulty TEG	Maintance should replace the TEG at the next boiler shutdown	Replace TEG	2	2	3	12
Cooling System	Fan Failure	Decrease in power, Increased charging times	2	Reach Lifespan of fan	4	Replace Fans at Scheduled intervals	3	24	Replace Faulty Fan	Fan should be replaced as soon as possible	Replace Fan and Clean regularly	2	2	3	12
System	Module Damage	Total system failure	4	Errant tool or equipment damages the system	1	Modules are out of the way and not in danger of damage		4	Repair damage	Repair as soon as possible	Replace Damaged parts or wiring	4	1	1	4
Electrical Transmission	Wire damage due to heat	Decrease in power, Increased charging times, Total system Failure	4	Ambient Tempature exceeds wire rating, Short circuit	1	Ensure adiquate ventalation near boiler	2	8	Replace damaged wires	Repair as soon as possible	Replace Wires	4	1	2	8
Electrical E Transmission	Electrical circuit damage	Outside force causing a short	5	Circuit shorted to ground	1	None	1	5	Replace Damaged componets, Install protection breaker	Repair As soon as possible	Install Breaker	2	1	1	2

Rating	Score	Guide				
Severity	1 to 5	1- Insignificant consequence of failure				
Seventy	1105	5- Catastrophic consequence of failure possibility for injury				
0	1 to 5	1- Low probability of failure occuring				
Occurance		5- High probability of failure occuring				
Detection	1 to 5	1- High probability failure will be detected				
		5- Low probability failure will be detected				

Green Engineering

- There are no toxic or hazardous materials used in the design
- The fabrication of the system requires only the energy to run the machine shop.
- All of the waste from fabrication is solid and minimal
- The system produces no waste through use during its lifetime.
- After the lifetime of the system only solid recyclables will be left.
- In addition to these features this system captures waste and recycles it into useable energy

Electrical Schematic



Bill of Materials

Bill of Materials											
Deliverables	Component	Part number	Part Description	Vendor	Qty	Units	Price	Cost			
	Thermoelctric Generator(TEG)	TGPR-22W-7V-56S	Tegpro High Temperature TEG Power Module - 22 Watt 7 volt 56 mm	Tegmart.com	24		\$57.50	\$1,380.00			
6 Modules	Heat Sinks 3-505024G		5x5x2.5 flared pin fin	coolinnovations.com			\$40.00	\$240.00			
	Steel for bracket		6x6x3/16 plates	Facilities				\$0.00			
	Graphit Sheets	P14965-ND	PGS SHEET 115X180MM W/POLYESTER	digikey.com			\$10.68	\$106.80			
Module	Nuts	91841A005	18-8 Stainless hex nut	mcmaster.com	1	100	\$2.61	\$2.61			
	Lock washer	95584A200	18 -8 Stainless Steel #4	mcmaster.com	1	100	\$2.03	\$2.03			
	Screws	91251A115	4-40 1" Steel cap screws	mcmaster.com	2	100	\$5.40	\$10.80			
Fan	Fan	RP7075	Panaflo Case Cooling Fan, 12Vdc, High	/www.skycraftsurplus.com	6		\$9.95	\$59.70			
Radio Charger	Battery Charger		EV-Peak R1 200W 20Amp Touch Screen NiMH / LiPO Battery Balance Charger	getfpv.com	1		\$69.99	\$69.99			
	Barrel Jack	CP3-1000-ND	CONN PWR PLUG 2.1X5.5MM SOLDER	digikey.com	10		\$0.91	\$9.10			
Transmission of Electricity	8 AWG 3 conductor cable			mcmaster.com	60	feet	\$2.51	\$150.60			
	12 circuit terminal block	7527K33	16-6 AWG wire, 12 circuit terminal block	mcmaster.com	1		\$24.50	\$24.50			
	20 circuit terminal block	7527K41	22-12 AWG wire, 20 cicurit terminal block	mcmaster.com	1		\$7.67	\$7.67			
	Voltage Regulator	HVI-FN-12	TEG Power Thermoelectric Generator Fan Drive Module	Tegmart.com	1		\$13.99	\$13.99			
							Total	\$2,077.79			

Final Product

- 6 modules
- Producing 48 watts of usable power from 2000 watts of waste heat
- Power generated will be used to charge 2 way radios at the steam plant.



Questions???