LIST OF APPENDICES

Simulation & Experimental Data

Appendix I High Work Function Materials Voltage Output

Emitter Tempermature (^{0}c)	**Output Voltage (V)**					
	Molybdenum (Mo)	**Aluminum (Al)**	**Tungsten (W)**	**Mild Steel (MS)**	**Beryllium (Be)**	**Brass**
	4.15 eV	4.26 eV	4.54 eV	4.81 eV	4.98 eV	5.10 eV
1000	3.7114E-8	2.66577E-8	1.92461E-9	3.78297E-10	6.74721E-11	3.0622E-11
1150	2.9460E-6	2.36448E-6	2.26447E-7	5.84504E-8	4.5099E-10	6.34006E-9
1300	8.6955E-5	7.60096E-5	9.04677E-6	2.87964E-6	6.95735E-7	3.91209E-7
1450	0.0012945	0.0012109	0.00017123	6.43625E-5	1.7266E-5	1.0453E-5
1600	0.0117672	0.0116293	0.00189178	0.000813881	0.000237712	0.00015281
1750	0.0740562	0.0766022	0.0139945	0.00673359	0.00211026	0.00142579
1900	0.351748	0.378081	0.0761628	0.0402679	0.0133911	0.00943463
2050	1.34037	1.48872	0.325988	0.18679	0.0653445	0.0477139
2200	4.28434	4.89512	1.16106	0.707568	0.258596	0.194745
2350	11.8752	13.9073	3.48512	2.27439	0.863554	0.668088
2500	29.2742	35.0368	9.27939	6.38746	2.50806	1.9869

Appendix II Low Work Function Coating Materials Voltage Output

Emitter Temperature (^{0}c)	Output Voltage (V)			
	Graphene	**CsI**	**Diamond**	**Carbon Nanotube**
100	1.76005E-32	7.01121E-83	1.46412E-42	4.03187E-29
200	1.33906E-13	8.45149E-39	1.22131E-18	6.409E-12
300	3.32318E-7	5.26798E-24	1.45068E-10	4.38075E-6
400	0.000586304	1.47296E-16	1.77066E-6	0.00405619
500	0.0556322	4.62786E-12	0.00053621	0.26141
600	1.2103	4.81881E-9	0.0252874	4.39432
700	11.2759	7.11526E-7	0.409412	34.0526
800	61.5845	3.08678E-5	3.38437	161.983
900	234.966	0.000590249	17.8243	555.056
1000	696.113	0.00634902	68.3416	1508.96

Appendix III Power output and efficiency

Material	Parameter	Analytical Result	Simulation Result
Tungsten	P_{out}	4.4 W	4.110 W
	η (%)	1.7	1.631
Molybdenum	P_{out}	35 W	32.982 W
	η (%)	14	13.088
Graphene	P_{out}	30 W	27.860 W
	η (%)	12	11.055
CsI	P_{out}	5.17 W	4.837 W
	η (%)	2	1.9195
Carbon nanotube	P_{out}	28 W	25.831 W
	η (%)	11	10.250
Diamond	P_{out}	60 W	55.114 W
	η (%)	24	21.870

Appendix IV Results for Aluminium as Emitter

Deg C	Voltage	Deg C	Voltage
93	0.01	384.25	0.11
92.25	0.01	432.5	0.12
185	0.01	435.5	0.12
189.5	0.01	382.25	0.12
437.25	0.01	44.25	0.14
424.25	0.01	327.75	0.14
371.25	0.01	380.75	0.14
87.75	0.02	375.25	0.14
116.25	0.02	431	0.15
142.5	0.02	369.75	0.16
319.25	0.02	385.75	0.17
379.75	0.02	114.25	0.18
423.25	0.02	388.75	0.18
435	0.02	372.75	0.18
436.25	0.02	35.5	0.19
416.25	0.02	108.5	0.19
383.75	0.02	238.75	0.19
39.5	0.03	272.75	0.19
43	0.03	434.5	0.19
391.25	0.03	424.75	0.19
435	0.03	92.75	0.2
434.25	0.03	146.25	0.2
432.75	0.03	386.25	0.2
429.5	0.04	35	0.21
35.5	0.05	35.25	0.21
56.25	0.05	436.75	0.22
65.25	0.05	179	0.23
213.5	0.05	93	0.24
416.75	0.05	385.25	0.25
385	0.05	420.75	0.25
383	0.05	92.5	0.26
40.5	0.06	369.5	0.28
435.5	0.06	128.25	0.29
378	0.07	434	0.29
367.75	0.07	435.25	0.29
417.75	0.08	402.75	0.3
421.5	0.08	392.25	0.3
419	0.08	37	0.31

Deg C	Voltage
403.5	0.34
433	0.35
92	0.36
100	0.36
262	0.37
424.5	0.38
413.5	0.38
374	0.38
423	0.39
427.5	0.4
416	0.41
35.5	0.42
374	0.42
35	0.43
431	0.43
416	0.46
410.75	0.46
372.5	0.48
409	0.49
417.25	0.49
430.75	0.49
197	0.52
379.25	0.52
200	0.54
433	0.54
382.5	0.56
426.75	0.56
421.25	0.56
424.75	0.57
434	0.57
34.75	0.59
426.75	0.59
285.5	0.6
62	0.61
378.5	0.61
418.5	0.62
322.5	0.63
403.5	0.63
426	0.64
45.25	0.66
413.25	0.66
370.5	0.67

Deg C	Voltage
433.75	0.7
373.25	0.71
54.5	0.72
418.5	0.72
410.25	0.73
407.25	0.74
139.5	0.75
35.25	0.78
409	0.78
46.5	0.79
431	0.79
430.5	0.8
410.5	0.81
411	0.82
404.75	0.82
34.75	0.83
38.75	0.83
435.75	0.83
406.25	0.83
290.75	0.88
425	0.92
404	0.92
38.5	0.95
82.5	0.95
397.25	0.97
434.25	0.98
433.25	1
431	1
429	1.03
246.25	1.04
419.75	1.04
369.75	1.04
76.5	1.05
126.75	1.06
431.5	1.06
94.75	1.1
398.75	1.1
64.25	1.12
433.75	1.12
399.5	1.13
428.5	1.13
420.25	1.14

Deg C	Voltage
413	1.18
263.25	1.19
85.5	1.21
411.5	1.21
429.5	1.21
428.25	1.22
36.5	1.23
402.5	1.23
431.5	1.24
384.75	1.25
92.5	1.29
367.25	1.29
309	1.31
432	1.31
403.75	1.32
412	1.35
433	1.37
343.5	1.38
432.75	1.41
400.25	1.43
432.5	1.45
429.5	1.46
36.75	1.48
430.25	1.52
244.75	1.53
172.5	1.59
401.75	1.67
339.25	1.74
162.25	2
45.75	2.04
41	2.12
365.5	2.13
93.25	2.19
38.25	2.25
278	2.27
286.75	2.32
37	2.64
35.25	2.86
313.75	3.08
234.5	3.52
35.25	3.65
35.75	4.03
35	4.2
240.25	4.42

Deg C	Voltage
216.25	4.75
70.5	4.93
92.5	4.96
35	5
36	5
37.5	5
75.5	5
201.75	5
206.25	5
207.25	5
212	5
218	5
223	5
223.75	5
228.75	5
229	5
251.5	5
256.75	5
271.5	5
276.75	5
282.5	5
309.75	5
314	5
318.25	5
322	5
327	5
335.5	5
348	5
352	5
360.25	5
364.75	5
370.75	5
379.25	5

Appendix V Results for Brass as Emitter			
Deg C	Voltage	Deg C	Voltage
76.5	0.01	291.75	0.08
155.5	0.01	361	0.08
176	0.01	370.25	0.08
376.5	0.01	384	0.08
384.25	0.01	384.25	0.08
376	0.01	369.75	0.08
374	0.01	77.25	0.09
86.75	0.02	382.25	0.09
189.75	0.02	356	0.1
195.5	0.02	384.5	0.1
330.75	0.02	383.5	0.11
336.5	0.02	363.25	0.11
379.5	0.02	366.5	0.12
377.25	0.02	362.25	0.12
346.5	0.02	381.25	0.14
177.5	0.03	368.5	0.14
208.5	0.03	107.75	0.15
350.5	0.03	267.5	0.15
365.75	0.03	318.75	0.15
360.75	0.03	371.75	0.15
326	0.04	371.25	0.15
356.75	0.04	308.5	0.15
362	0.04	72.75	0.16
383.25	0.04	339.5	0.16
378.25	0.04	380.25	0.16
77	0.05	370.5	0.16
281.5	0.05	334.25	0.16
382	0.05	206.75	0.17
378.5	0.05	384.25	0.17
376	0.05	377.25	0.17
371.75	0.05	373.25	0.17
373.75	0.06	313	0.17
382.75	0.06	382.25	0.18
375	0.06	86.75	0.19
79.25	0.07	72	0.2
91	0.07	140	0.2
380	0.07	381	0.2
385	0.07	374.5	0.2
372.75	0.07	348.25	0.2
317.5	0.07	76.75	0.21
71.5	0.08	384	0.21
71.25	0.08	213.25	0.22

Deg C	Voltage
274.5	0.22
381.25	0.22
385	0.23
382	0.23
77	0.25
383.5	0.25
383.75	0.26
355.5	0.26
142	0.28
375.25	0.28
383	0.29
340.5	0.29
71.75	0.3
308.5	0.3
369.5	0.31
384.75	0.32
367.75	0.32
367	0.32
384.25	0.33
366.5	0.34
377.75	0.35
305	0.36
351.5	0.36
282.5	0.39
384.25	0.39
90.75	0.41
333	0.41
369.25	0.41
290.5	0.42
384.25	0.42
375.75	0.44
301.5	0.46
253	0.47
365.75	0.47
335.75	0.5
329.5	0.51
87.75	0.52
326.5	0.52
76	0.53
372.75	0.54
295.25	0.55
288.75	0.56

Deg C	Voltage
365.75	0.61
87.5	0.62
336.25	0.63
345.5	0.65
77.5	0.66
86.25	0.66
84	0.67
322.25	0.67
71.75	0.68
71.75	0.68
77.5	0.7
154.25	0.7
321.5	0.7
260.25	0.72
315.5	0.72
325.5	0.73
180.5	0.79
364.5	0.83
351.75	0.83
74.75	0.84
363.75	0.86
93.25	0.91
336.25	0.91
338.5	1.05
104.75	1.08
319.5	1.12
36.75	1.14
187	1.27
46.25	1.34
44.75	1.38
362.5	1.45
315.25	1.47
138	1.48
188.5	1.51
359.75	1.52
328.25	1.54
221	1.57
227.5	1.6
361	1.64
310.5	1.68
350.75	1.72
358	1.73

Deg C	Voltage
349	2.06
58.5	2.1
355	2.1
353.5	2.1
222.25	2.14
35.75	2.19
356.75	2.22
338	2.25
351.5	2.28
71	2.49
284	2.49
337	2.61
326.75	3.44
344.75	3.47
309	4.46
37.25	4.48

Appendix VI Results for MS as Emitter

Deg C	Voltage
335.75	0.01
335.5	0.01
334.25	0.01
327	0.01
326.25	0.01
325.75	0.01
338	0.02
282.5	0.03
339.25	0.03
332	0.03
287.75	0.04
291	0.05
335.25	0.05
332.75	0.05
335.5	0.06
333.25	0.06
330	0.06
324.5	0.06
283.25	0.07
333.25	0.07
329.75	0.07

Deg C	Voltage
335.75	0.19
339.5	0.2
325.75	0.2
337.5	0.21
331.25	0.22
302.25	0.24
332.5	0.24
283.75	0.25
326.75	0.25
289.5	0.27
286.75	0.29
337.25	0.3
338.75	0.31
292.25	0.36
286.25	0.38
297.75	0.43
299.25	0.46
302.75	0.47
336.25	0.49
293.5	0.51
296.75	0.51

288.75	0.08
335.5	0.08
329.25	0.08
332	0.09
326	0.1
325.25	0.1
334.5	0.11
336.25	0.12
334	0.12
328.5	0.12
284.5	0.13
338.5	0.13
47.5	0.14
330.75	0.14
336	0.15
325.75	0.15
337	0.16
327.75	0.16
325.5	0.17
335.5	0.18
328	0.18

305.5	0.51
309.25	0.51
320.5	0.51
151.75	0.54
314	0.55
293	0.56
296	0.57
307	0.57
311.5	0.57
323	0.58
326	0.58
49.25	0.59
305.25	0.6
313	0.6
329.25	0.63
294.5	0.66
294.75	0.66
318.25	0.67
324	0.67
293.75	0.69
316.75	0.69

Deg C	**Voltage**
321.5	0.69
330.75	0.69
306.5	0.71
319	0.71
333	0.71
51	0.72
334.25	0.73
305.75	0.74
327.5	0.74
315.25	0.75
331.75	0.75
332.75	0.75
335	0.76
308	0.77
329.75	0.77
323.25	0.8
305.75	0.81
311.5	0.82
305.5	0.83
333.75	0.83
312.75	0.84

Deg C	**Voltage**
328.5	1.1
60.75	1.13
89	1.13
330.75	1.13
331.75	1.17
50.5	1.26
175.5	1.47
203	1.84
76.25	1.95
84	2.07
221	2.27
48.25	2.37
74	2.37
227.75	2.46
201	2.8
104.25	3.07
212.25	3.46
278	3.59
93.5	3.71
129	3.71
153	3.84

334	0.84
306.75	0.85
324.5	0.85
322.25	0.86
69	0.87
312	0.87
327.25	0.88
305.5	0.89
300.75	0.9
309.5	0.9
326.25	0.9
315.25	0.91
317.75	0.91
293.5	0.92
333	0.92
325.5	0.94
304.5	0.96
308.5	0.96
310.5	0.96
320	0.98
313.75	0.99
335.25	1.02

48.5	3.85
87	4.16
75	4.18
122.5	4.23
50.25	4.42
50.5	4.44
168	4.49
127	4.54
88.5	4.61
149.25	4.63
264.25	4.63
213.75	4.67
257.5	4.7
253	4.76
129.75	4.83
49	4.89
171.75	4.89
80.5	4.9

Appendix VII Thermionic Emission Analysis Data

Thermionic Emission Analysis Data							
Sr No.	Temperature	Conversion Efficiency					
		SS400	SUH409L	SUS439L	SA1D	Tungsten	Coated Graphene
1	200	0.123	0.16	0.21	0.098	3.24	6.06
2	250	0.64	0.222	0.64	0.16	3.68	8.37
3	300	1.157	0.284	1.07	0.222	4.12	9.34
4	350	1.674	0.82	1.5	0.284	4.56	11.2
5	400	2.191	0.882	1.42	0.82	5	12.84
6	450	2.19	1.0862	1.34	1.356	5.2	14.4
7	500	2.54	1.2904	1.26	1.67	5.23	16.12
8	550	2.79	1.4946	1.76	1.984	5.28	17.76
9	600	3.05	1.6988	2.26	2.298	5.67	19.4
10	650	3.05	1.903	2.76	2.612	6.06	21.04
11	700	3.07	2.09	3.26	2.926	8.37	21.04
12	750	3.12	2.277	3.42	3.76	9.34	23.58
13	800	3.24	2.16	3.68	4.56	14.3	26.37

Appendix VIII Thermal Stress & Strain Analysis Data

Thermal Stress & strain Analysis Data				
Pipe Material	Stress (Mpa)		Strain	
	Numerical Result	Simulation Result	Numerical result	Simulation result
SS400	2.6	2.7489	0.0018	0.00191688
SUH409L	1.74	1.694	0.00016	0.000133735
SUS439L	1.8	1.93193	0.00028	0.000275533
SA1D	2.14	2.002	0.0004	0.000335176
Tungsten	2.3	2.3177	0.00083	0.000749955
Molybdenum	1.3	1.26773	2.90E-05	2.72E-05

Appendix IX Experiment Vs Simulation Data

Experiment Vs Simulation Data			
Sr No.	Temperature	Simulation Results	Experimental results
1	200	3.24	2.76
2	250	3.68	3.24
3	300	4.12	3.68
4	350	4.56	4.21
5	400	5	4.87
6	450	5.2	5
7	500	5.23	4.78
8	550	5.28	5.1
9	600	5.67	5.32
10	650	6.06	5.83
11	700	8.37	7.97
12	750	9.34	9.11
13	800	14.3	9.67

Appendix X List of Paper Presented and Published

1. Kodihal, K., & Sagar, A. (2019). A review on opportunities of thermionic regeneration system in hybrid electric vehicle. Journal of Physics: Conference Series, 1230, 012083, 1–9. https://doi.org/10.1088/1742-6596/1230/1/012083
2. Kodihal, K., & Sagar, A. (2019). A review on methods and materials for optimizing thermionic regeneration system. AIP Conference Proceedings, 2148(1), 030039, 1–7. https://doi.org/10.1063/1.5123961
3. Kodihal, K., & Sagar, A. (2019). A Study and mathematical analysis of thermionic energy conversion materials based on their solid state emission properties. SAE Technical Paper, 2019-28–0084, 1–5. https://doi.org/10.4271/2019-28-0084
4. Kodihal, K., & Sagar, A. (2019). Prototype design of a small scale thermionic energy generator for waste heat recovery in hybrid electric vehicle. SAE Technical Paper, 2019-28–0027, 1–5. https://doi.org/10.4271/2019-28-0027
5. Kodihal, K., & Sambhare. (2018). Experimental Study of Compression Ignition Engine with Change in Intake Manifold Temperature. International Journal of Engineering Technology Science and Research IJETSR, 5(3), 1039–1044.

Appendix XI List of Paper Communicated

1. A Paper Titled “Thermionic Conversion Analysis of a Waste Heat Recovery System Designed for a Hybrid Electric Vehicle,” is submitted to International Journal of Transportation Science and Technology.
2. A paper titled, “Control Algorithm for Hybrid Electric Vehicle equipped with Thermionic Regeneration System,” is submitted to Transportation Research Part C

Appendix XII Copy of Acknowledgements

International Journal of Transportation Science and Technology

THERMIONIC CONVERSION ANALYSIS OF A WASTE HEAT RECOVERY SYSTEMDESIGNED FOR A HYBRID ELECTRIC VEHICLE.

--Manuscript Draft--

Manuscript Number:	IJTST-S-22-00048
Article Type:	Research Paper
Keywords:	Thermionic Emission; Waste Heat Recovery; Hybrid Electric Vehicle
Corresponding Author:	kantaprasad Kodihal INDIA
First Author:	kantaprasad Kodihal
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Abstract:	Vehicular emissions have a serious impact on environment and human health. Harmful gases are formed through hydrocarbon combustion. Technology and systems are getting developed, resulting in reduction of pollutants emitting from a vehicle. Thermionic emission stands different in comparison with these toxic emissions. Even though it has an impact on vehicle performance and energy utilization. IC engine's waste heat is a significance of thermionic emission. Waste heat recovery is considered as a sustainable solution to improve the efficiency of any thermodynamic system. Various methods are developed to utilize waste heat in another useful energy. Automotive vehicles are being designed with hybrid architectures so that the emission standards will be followed. More of them use electric with IC engine combinations. These combinations are referred as hybrid electric vehicle architectures differentiated as micro, mild, full and plug-in hybrids. In case of hybrid electric vehicle the demand of electric energy increases. This paper introduces a recent approach to convert heat to electricity using thermionic emission.
Suggested Reviewers:	
Opposed Reviewers:	

Transportation Research Part C

Control Algorithm for Hybrid Electric Vehicle equipped with Thermionic RegenerationSystem.

--Manuscript Draft--

Manuscript Number:	TRC-S-22-00275
Article Type:	Research Paper
Keywords:	Thermionic Regeneration System, Hybrid Electric Vehicle, Fuel Consumption
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Abstract:	Waste heat recovery have been considered as an effective method to improve overall efficiency of an automotive energy generation system. Researchers are exploring use of such waste heat recovery system in Hybrid Electric Vehicles (HEV). In case of hybrid electric vehicles the IC engine and electric motor in combination or individually drive the wheels. The control strategy plays a vital role in HEV for mode selection and energy management. This research paper shows the development and analysis of a control algorithm designed for a series/parallel HEV equipped with thermionic regeneration system. Thermionic regeneration have shown highest energy conversion efficiency for direct heat to electricity conversion.
Suggested Reviewers:	Anders Grauers anders.grauers@chalmers.se The reviewer has done eminent research on hybrid electric vehicles
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Appendix IV Biodata of Researcher

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Academic Qualifications:

Course	Institute	University	Percentage	Year of Passing
PhD	SAS	BSDU	-	2021
M.Voc	DDUKK	Dr. B.A.M U	7.99 (CGPA)	2018
B.E	GCOEARA Pune	SPPU	75.06%	2016
Diploma	GP Aurnagabad	Autonomous	89.10%	2013
S.S.C.	SDV Latur	State Board	92.00%	2010

Software Skills

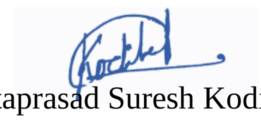
- CAD Designing using Autocad, Catia, Solidworks
- Simulations using COMSOL Multiphysics, LABVIEW, MATLAB

Achievements:

- Best Paper Award at International Conference on Advances in Design, Materials, Manufacturing and Surface Engineering for Mobility 2019.
- Best Poster Award at NuGen Mobility Summit 2019, ICAT, Manesar
- Secured second prize in University level Research competition held at Dr. B.A.M. University, Aurangabad

Declaration:

I hereby inform you that all the statements made above are true the best of my knowledge and belief.



(Kantaprasad Suresh Kodihal)