

Supplementary Materials

Figure S1

Result of vibration frequency using accelerometer.

		Location A								
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
Frequency (Hz)	1	201	234	211	272	254	244	268	270	251
	2	245	210	169	253	271	227	301	290	233
	3	266	247	183	248	234	213	286	265	237
	4	235	215	179	226	241	235	278	280	254
	5	222	231	210	247	251	208	244	263	242
	6	267	209	201	286	246	246	253	247	251
	7	214	234	198	277	237	237	263	251	238
	8	266	241	179	239	253	254	268	259	245
	9	225	235	192	222	246	216	278	249	231
	10	212	245	195	245	229	223	289	257	245
	Average	235.3	230.1	191.7	251.5	246.2	230.3	272.8	263.1	242.7

Location B										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
Frequency (Hz)	1	129	113	104	167	181	124	189	173	131
	2	123	95	122	188	174	136	196	138	140
	3	111	105	113	170	169	158	135	136	163
	4	136	94	91	163	147	124	180	153	153
	5	119	116	87	128	126	163	149	194	176
	6	100	126	104	138	140	112	200	145	117
	7	122	133	85	142	112	117	118	173	128
	8	139	92	107	150	147	136	183	129	163
	9	138	124	123	133	114	164	181	151	176
	10	118	99	92	180	129	135	159	144	134
	Average	123.5	109.7	102.8	155.9	143.9	136.9	169	153.6	148.1

Location C										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
Frequency (Hz)	1	134	182	124	242	238	253	379	243	274
	2	224	156	160	249	264	214	221	231	311
	3	153	231	174	267	323	222	297	225	228
	4	219	152	132	351	238	274	386	353	214
	5	239	221	231	264	197	312	228	217	276
	6	201	187	112	256	243	253	284	247	235
	7	190	211	196	343	219	206	354	283	243
	8	250	162	144	284	274	219	337	241	266
	9	242	174	216	249	320	224	263	363	289
	10	187	145	163	343	275	211	349	348	315
	Average	203.9	182.1	165.2	284.8	259.1	238.8	309.8	275.1	265.1

Location D										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
Frequency (Hz)	1	673	672	645	760	723	686	764	750	686
	2	692	637	668	676	742	659	866	695	659
	3	702	690	701	730	711	734	738	731	734
	4	684	657	630	747	763	641	770	734	741
	5	728	728	647	683	656	711	728	716	711
	6	691	684	664	725	682	630	692	747	690
	7	675	664	685	681	745	618	780	764	748
	8	656	731	672	755	716	685	635	661	685
	9	731	653	659	747	672	748	708	735	748
	10	741	612	637	697	725	619	794	701	619
	Average	697.3	672.8	660.8	720.1	713.5	673.1	747.5	723.4	702.1

		Location E								
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
Frequency (Hz)	1	264	286	158	333	328	244	350	298	341
	2	242	253	162	312	314	284	370	365	337
	3	296	236	212	287	355	296	387	341	286
	4	243	247	192	321	251	263	390	394	295
	5	238	203	145	293	256	238	377	348	320
	6	271	243	168	354	325	271	387	370	267
	7	302	194	194	369	295	254	352	325	363
	8	257	285	213	328	259	287	337	354	372
	9	247	201	153	375	278	299	349	317	329
	10	299	186	185	342	243	249	339	374	295
	Average	265.9	233.4	178.2	331.4	290.4	268.5	363.8	348.6	320.5

Location F										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
Frequency (Hz)	1	780	701	642	778	753	732	810	838	760
	2	711	724	697	829	796	693	838	826	784
	3	681	650	659	738	721	675	827	762	809
	4	708	649	630	826	735	754	844	748	817
	5	676	685	647	814	759	705	786	864	765
	6	667	651	705	790	711	741	880	736	723
	7	721	741	685	767	737	685	834	832	759
	8	754	742	610	781	753	702	837	758	740
	9	684	649	634	824	795	731	875	743	742
	10	721	738	712	784	726	715	771	884	795
	Average	710.3	693	662.1	793.1	748.6	713.3	830.2	799.1	769.4

Figure S2

One way ANOVA analysis for vibration frequency.

Point A (20°C)						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7074.6	2	3537.3	7.89041	0.002002	3.354131
Within Groups	12104.2	27	448.3037			
Total	19178.8	29				

Point A (22°C)						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5446.067	2	2723.033	15.38308	3.47x10 ⁻⁵	3.354131
Within Groups	4779.4	27	177.0148			
Total	10225.47	29				

Point A (24°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	14149.07	2	7074.533	42.94054	4.15e-09	3.354131
Within Groups	4448.3	27	164.7519		4.1x10 ⁻⁹	
Total	18597.37	29				

Point B (20°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	10972.07	2	5486.033	12.30114	0.000159	3.354131
Within Groups	12041.4	27	445.9778			
Total	23013.47	29				

Point B (22°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	10636.47	2	5318.233	12.94394	0.000114	3.354131
Within Groups	11093.4	27	410.8667			
Total	21729.87	29				

Point B (24°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	11134.47	2	5567.233	16.9057	1.74x10 ⁻⁵	3.354131
Within Groups	8891.4	27	329.3111			
Total	20025.87	29				

Point C (20°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	61282.07	2	30641.03	13.14061	0.000103	3.354131
Within Groups	62958.1	27	2331.781			
Total	124240.2	29				

Point C (22°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	49446.67	2	24723.33	12.57434	0.000138	3.354131
Within Groups	53086.7	27	1966.174			
Total	102533.4	29				

Point C (24°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	53628.87	2	26814.43	20.59474	3.7x10 ⁻⁶	3.354131
Within Groups	35154.1	27	1302.004			
Total	88782.97	29				

Point D (20°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	12635.47	2	6317.733	3.241864	0.054721	3.354131
Within Groups	52617.5	27	1948.796			
Total	65252.97	29				

Point D (22°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	14382.87	2	7191.433	6.156561	0.006268	3.354131
Within Groups	31538.5	27	1168.093			
Total	45921.37	29				

Point D (24°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	8993.267	2	4496.633	2.979701	0.067716	3.354131
Within Groups	40745.4	27	1509.089			
Total	49738.67	29				

Point E (20°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	49748.07	2	24874.03	38.63116	1.2x10 ⁻⁸	3.354131
Within Groups	17384.9	27	643.8852			
Total	67132.97	29				

Point E (22°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	66357.6	2	33178.8	27.15353	3.44x10 ⁻⁷⁷	3.354131
Within Groups	32991.2	27	1221.896			
Total	99348.8	29				

Point E (24°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	103691.3	2	51845.63	68.77227	2.53x10 ⁻¹¹	3.354131
Within Groups	20354.6	27	753.8741			
Total	124045.9	29				

Point F (20°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	75360.87	2	37680.43	33.65816	4.64x10 ⁻⁸	3.354131
Within Groups	30226.6	27	1119.504			
Total	105587.5	29				

Point F (22°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	56329.4	2	28164.7	15.08784	3.99x10 ⁻⁵	3.354131
Within Groups	50401.3	27	1866.715			
Total	106730.7	29				

Point F (24°C)						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	57606.47	2	28803.23	30.02491	1.37x10 ⁻⁷	3.354131
Within Groups	25901.4	27	959.3111			
Total	83507.87	29				

Figure S3

Two way ANOVA analysis for vibration frequency

Location A						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	16660.16	2	8330.078	31.63039	3.109311	yes
Factor B (Air flow rates)	24832.69	2	12416.34	47.14648	3.109311	yes
Factor AB	1837.044	4	459.2611	1.743874	2.484441	no
Error	21331.9	81	263.3568			
Total	64661.79	89				

Location B						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	6384.622	2	3192.311	8.073927	3.109311	yes
Factor B (Air flow rates)	32711.76	2	16355.88	41.36695	3.109311	yes
Factor AB	31.24444	4	7.811111	0.019756	2.484441	no
Within	32026.2	81	395.3852			
Total	71153.82	89				

Location C						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	28587.82	2	14293.91	7.657508	3.109311	yes
Factor B (Air flow rates)	163781.1	2	81890.54	43.87025	3.109311	yes
Factor AB	576.5111	4	144.1278	0.077212	2.484441	no
Error	151198.9	81	1866.653			
Total	344144.3	89				

Location D						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	27882.16	2	13941.08	9.04095	3.109311	yes
Factor B (Air flow rates)	33704.16	2	16852.08	10.92877	3.109311	yes
Factor AB	2307.444	4	576.8611	0.374101	2.484441	no
Error	124901.4	81	1541.993			
Total	188795.2	89				

Location E						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	62813.27	2	31406.63	35.96652	3.109311	yes
Factor B (Air flow rates)	213253.1	2	106626.5	122.1075	3.109311	yes
Factor AB	6543.867	4	1635.967	1.873491	2.484441	no
Error	70730.7	81	873.2185			
Total	353340.9	89				

Location F						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	59414.07	2	29707.03	22.58787	3.109311	yes
Factor B (Air flow rates)	186318.6	2	93159.3	70.83406	3.109311	yes
Factor AB	2978.133	4	744.5333	0.566109	2.484441	no
Error	106529.3	81	1315.177			
Total	355240.1	89				

Figure S4

Result of RMS voltage utilizing piezoelectric sensor

Location A										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
RMS voltage (mV)	1	103.23	53.28	59.94	74.37	58.83	71.04	106.56	138.75	106.56
	2	71.04	57.72	48.84	81.03	75.48	81.03	115.44	116.55	85.47
	3	79.92	67.71	67.71	93.24	71.04	89.91	98.79	74.37	64.38
	4	84.36	43.29	41.07	83.25	79.92	58.83	77.7	132.09	108.78
	5	56.61	69.93	68.82	101.01	104.34	114.33	140.97	93.24	59.94
	6	47.73	63.27	83.25	116.55	96.57	103.23	95.46	79.92	119.88
	7	75.48	82.14	43.29	115.44	92.13	93.24	102.12	72.15	72.15
	8	58.83	52.17	72.15	69.93	87.69	83.25	112.11	81.03	71.04
	9	48.84	81.03	58.83	108.78	99.9	74.37	89.91	99.9	105.45
	10	71.04	69.93	44.4	109.89	115.44	65.49	96.57	94.35	124.32
Average RMS voltage		69.71	64.05	58.83	95.35	88.13	83.47	103.56	98.24	91.80

Location B										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
RMS voltage (mV)	1	21.09	25.53	13.32	26.64	46.62	25.53	48.84	38.85	41.07
	2	24.42	38.85	16.65	35.52	33.3	21.09	65.49	54.39	47.73
	3	41.07	24.42	23.31	41.07	18.87	27.75	44.4	59.94	56.61
	4	14.43	19.98	37.74	21.09	24.42	43.29	41.07	32.19	71.04
	5	18.87	16.65	28.86	28.86	35.52	18.87	68.82	62.16	37.74
	6	19.98	9.99	12.21	43.29	41.07	28.86	74.37	46.62	36.63
	7	27.75	29.97	18.87	49.95	37.74	36.63	65.49	41.07	27.75
	8	32.19	15.54	27.75	27.75	23.31	29.97	44.4	37.74	43.29
	9	26.64	34.41	31.08	31.08	25.53	38.85	58.83	54.39	28.86
	10	36.63	32.19	14.43	39.96	39.96	25.53	49.95	67.71	48.84
Average RMS voltage		26.31	24.75	22.42	34.52	32.63	29.64	56.17	49.51	43.96

Location C										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
RMS voltage (mV)	1	116.55	93.24	95.46	134.31	104.34	113.22	118.77	130.98	83.25
	2	74.37	101.01	72.15	126.54	89.91	86.58	88.8	98.79	97.68
	3	103.23	84.36	81.03	104.34	125.43	71.04	139.86	113.22	113.22
	4	79.92	116.55	91.02	79.92	96.57	93.24	116.55	104.34	130.98
	5	132.09	79.92	93.24	120.99	83.25	103.23	144.3	137.64	113.22
	6	98.79	94.35	83.25	94.35	135.42	126.54	95.46	93.24	81.03
	7	92.13	82.14	97.68	124.32	73.26	71.04	147.63	132.09	71.04
	8	115.44	104.34	82.14	104.34	114.33	86.58	125.43	82.14	94.35
	9	96.57	89.91	73.26	125.43	98.79	94.35	82.14	114.33	108.78
	10	108.78	71.04	92.13	92.13	103.23	87.69	114.33	108.78	78.81
Average RMS voltage		101.79	91.69	86.14	110.67	102.45	93.35	117.33	111.56	97.24

Location D										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
RMS voltage (mV)	1	412.92	356.31	304.14	578.31	406.26	406.26	428.46	503.94	427.35
	2	365.19	265.29	354.09	479.52	479.52	502.83	499.5	473.97	365.19
	3	509.49	426.24	325.23	513.93	427.35	416.25	466.2	416.25	468.42
	4	486.18	362.97	523.92	415.14	564.99	477.3	446.22	455.1	486.18
	5	361.86	478.41	392.94	516.15	516.15	301.92	463.98	438.45	361.86
	6	358.53	314.13	266.4	379.62	385.17	356.31	495.06	467.31	358.53
	7	385.17	346.32	404.04	463.98	456.21	460.65	562.77	429.57	496.17
	8	405.15	396.27	457.32	487.29	502.83	404.04	421.8	478.41	405.15
	9	385.17	428.46	384.06	435.12	445.11	405.15	532.8	430.68	385.17
	10	479.52	446.22	275.28	446.22	401.82	449.55	572.76	589.41	482.85
Average RMS voltage		414.92	382.06	368.74	471.53	458.54	418.03	488.96	468.31	423.69

Location E										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
RMS voltage (mV)	1	139.86	104.34	86.58	115.44	137.64	77.7	139.86	132.09	106.56
	2	113.22	129.87	126.54	169.83	122.1	113.22	146.52	115.44	133.2
	3	105.45	138.75	117.66	124.32	96.57	125.43	157.62	154.29	127.65
	4	81.03	122.1	96.57	103.23	116.55	94.35	117.66	139.86	113.22
	5	95.46	82.14	62.16	96.57	82.14	124.32	129.87	113.22	115.44
	6	124.32	116.55	81.03	137.64	160.95	138.75	133.2	125.43	143.19
	7	118.77	103.23	75.48	154.29	113.22	98.79	164.28	113.22	130.98
	8	136.53	142.08	115.44	118.77	153.18	153.18	112.11	133.2	116.55
	9	104.34	84.36	107.67	157.62	138.75	104.34	142.08	157.62	101.01
	10	126.54	91.02	67.71	142.08	146.52	139.86	156.51	127.65	120.99
Average RMS voltage		114.55	111.44	93.68	131.98	126.76	116.99	139.97	131.20	120.88

Location F										
	Air flow rates	1			2			3		
	Temperature	20°C	22°C	24°C	20°C	22°C	24°C	20°C	22°C	24°C
RMS voltage (mV)	1	557.22	412.92	325.23	388.5	364.08	426.24	520.59	508.38	485.07
	2	469.53	365.19	407.37	513.93	467.31	345.21	491.73	434.01	424.02
	3	365.19	509.49	281.94	476.19	315.24	473.97	531.69	557.22	526.14
	4	467.31	486.18	479.52	465.09	382.95	329.67	499.5	485.07	455.1
	5	455.1	361.86	294.15	426.24	447.33	378.51	490.62	500.61	416.25
	6	525.03	358.53	483.96	557.22	475.08	415.14	453.99	557.22	476.19
	7	463.98	385.17	415.14	536.13	539.46	482.85	561.66	481.74	486.18
	8	424.02	405.15	388.5	475.08	557.22	518.37	480.63	542.79	422.91
	9	379.62	385.17	469.53	503.94	487.29	435.12	530.58	414.03	401.82
	10	398.49	479.52	370.74	399.6	547.23	535.02	547.23	467.31	467.31
Average RMS voltage		450.55	414.92	391.61	474.19	458.32	434.01	510.82	494.84	456.10

Figure S5

Two factors ANOVA analysis for RMS voltage

Location A						
Source of Variation	SS	df	MS	F	F crit	Significant (yes/no)
Factor A (Temperature)	1988.144	2	994.072	3.010586	3.109311	no
Factor B (Air flow rates)	18270.67	2	9135.337	27.66673	3.109311	yes
Factor AB	14.26498	4	3.566245	0.010801	2.484441	no
Error	26745.56	81	330.1922			
Total	47018.65	89				

Location B						
Source of Variation	SS	df	MS	F	F crit	Significant (yes/no)
Factor A (Temperature)	733.8661	2	366.9331	3.641492	3.109311	yes
Factor B (Air flow rates)	10148.01	2	5074.007	50.35511	3.109311	yes
Factor AB	211.401	4	52.85025	0.524493	2.484441	no
Error	8161.923	81	100.7645			
Total	19255.2	89				

Location C						
Source of Variation	SS	df	MS	F	F crit	Significant (yes/no)
Factor A (Temperature)	4705.171	2	2352.585	7.662239	3.109311	yes
Factor B (Air flow rates)	3634.065	2	1817.033	5.917974	3.109311	yes
Factor AB	194.6444	4	48.66111	0.158486	2.484441	no
Error	24869.94	81	307.0363			
Total	33403.82	89				

Location D						
Source of Variation	SS	df	MS	F	F crit	Significant (yes/no)
Factor A (Temperature)	45913.06	2	22956.53	6.352493	3.109311	yes
Factor B (Air flow rates)	89625.5	2	44812.75	12.40051	3.109311	yes
Factor AB	3217.095	4	804.2738	0.222557	2.484441	no
Error	292716.4	81	3613.783			
Total	431472.1	89				

Location E						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	5270.951	2	2635.476	6.219239	3.109311	yes
Factor B (Air flow rates)	9606.793	2	4803.397	11.33513	3.109311	yes
Factor AB	248.0354	4	62.00885	0.14633	2.484441	no
Error	34324.7	81	423.7618			
Total	49450.48	89				

Location F						
<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>F crit</i>	<i>Significant (yes/no)</i>
Factor A (Temperature)	39645.47	2	19822.74	5.546305	3.109311	yes
Factor B (Air flow rates)	69938.05	2	34969.02	9.784162	3.109311	yes
Factor AB	2005.339	4	501.3346	0.140271	2.484441	no
Error	289497.5	81	3574.044			
Total	401086.4	89				