Signal Strength Evaluation for 3D Printed Sand Casting Molds

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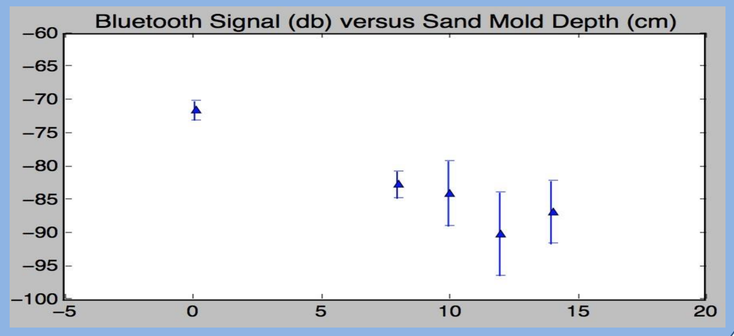
Abstract

Sand Casting is an ancient art of preparing a patterned mold for casting metals such as steel, nickel and titanium. 3D printing is revolutionizing this art through binder jetting of geometrically complex sand molds not possible with traditional methods. One new advantage of 3D printed molds is that the sand structures can be instrumented to assure quality and improve yield. Unfilled sections of the cavity may occur from premature freezing of the metal in thin cavities sections. Porosity can occur when the melting temperature is too high due to a non-uniform cooling rate, or if the sand used has a low permeability. Hot tearing also comes from a non-uniform cooling rate. The use of printed sand molds enables the collection of data by using Bluetooth embedded sensors. For instance a RedBear Nano board that costs less than $20 USD can be programmed to send data via Bluetooth to an external computer. This project has focused on creating and validating the use of a Bluetooth disposable sensor within a sand mold with the driving hypothesis that yield, performance and quality can be improved through the comprehensive collection of data not possible previously.

Results

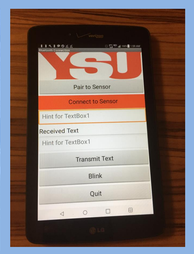
For the testing process, three sets of data were collected. In each set a RedBear Nano chip was placed inside a sand mold sphere and the strength was recorded of the received signal strength (recorded in dB) through the nRF connect app on a variety of Bluetooth enabled phones.

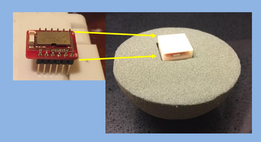
On the first test we used four spheres of different sizes taking eight measurements in each sphere. The results from the data set were not very conclusive of a definitive relationship between sand mold thickness and signal loss but generally show a minor attenuation of the signal with distance to the surface of the mold. The only thing it told was that there was some signal loss through the mold but that the concept was feasible.

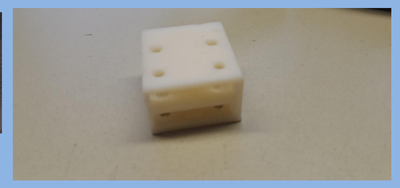


Methodology

Four 3D printed sand molds spheres were printed with a cavity specifically built for the Red Board Nano Bluetooth radio. In each case, the radio was inserted into the sphere half, the sphere halves were combined and radio signal strength was measured to determine the amount of attenuation of the signal through the inkjet glued sand. Several phones were used with a specific app that could read the RSSI – Radio Signal Strength Index. Measurements were recorded for three phones.







Data

BLE RSSI

Sphere Size	Small	Original	Medium	Large	units of (db)
Measurement					
#1	-68	-59	-58	-61	
#2	-75	-55	-58	-62	
#3	-71	-47	-56	-63	
#4	-75	-51	-57	-65	
#5	-72	-52	-56	-59	
#6	-73	-54	-56	-58	
#7	-71	-55	-59	-56	
#8	-69	-51	-55	-57	
					Outside of sphere
Average	-71.75	-53	-56.875	-60.125	-50

Test Data #1

	Out of Case	Small sphere
Measurement		
#1	-48	-66
2	-43	-65
3	-50	-65
4	-45	-83
5	-45	-65
6	-42	-71
7	-41	-72
8	-44	-62
9	-45	-59
10	-42	-80
11	-46	-62
12	-50	-58
13	-42	-60
14	-45	-63
15	-45	-62
16	-42	-62
17	-44	-63
18	-47	-63
19	-42	-62
20	-49	-76
AVG	-44.85	-65.95

Test Data #2

Sphere Size	Small			Original		Medium			Large		Out of Sphere
Sphere Number	1	2	3	1	2	1	2	3	1	2	N/A
RSSI Value #1	-76	-82	-79	-78	-85	-78	-85	-70	-89	-81	-72
2	-80	-77	-76	-78	-72	-73	-82	-74	-81	-86	-71
3	-82	-77	-81	-82	-84	-79	-85	-75	-83	-87	-68
4	-80	-83	-79	-79	-76	-82	-77	-74	-78	-75	-68
5	-83	-84	-78	-83	-72	-83	-88	-77	-77	-77	-70
6	-82	-87	-81	-71	-83	-75	-74	-71	-77	-81	-72
7	-82	-81	-78	-71	-82	-80	-96	-74	-90	-75	-70
Average RSSI	-80.71	-81.57	-78.86	-77.43	-79.14	-78.57	-83.86	-73.57	-82.14	-80.29	-70.14
Difference from Out of Sphere	10.57	11.43	8.71	7.29	9.00	8.43	13.71	3.43	12.00	10.14	
Average Difference	9.47										
Average of sphere sizes		10.24			8.14		8.52			11.07	

Test Data #3

Conclusions

The experiment demonstrates the feasibility of the approach in which data can be collected during a sand mold casting. Although some attenuation was recorded, the distance used in most molds would be less than the radii of the spheres used in this study. Disposable Internet of Thing sensors are a possible mechanism to measure temperature, pressure, and chemistry during a casting.

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