Report on a blind trial of the Sonobotics Evo system for thickness measurement in the BP Naperville test facility

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Executive Summary

A blind trial of the thickness measurement performance of the Sonobotics Evo EMAT system was performed at the BP Naperville test facility. The system was used to perform measurements on 9 carbon steel components of varying condition and thicknesses that were unknown to the inspector. On 8 out of the 9 test specimens the EMAT system was able to achieve sufficient SNR to produce a thickness reading, on the 9th specimen the signal did not achieve a high enough SNR to return a usable thickness measurement. For the 8 other specimens the thicknesses ranged from 6.5 – 32mm and the components were covered by different paints and coatings and had different levels of surface roughness. The mean difference between reference measurements and the Sonobotics Evo thickness measurements was ~0.13mm or 0.2% of the overall thickness showing very good agreement between the two techniques. This demonstrates the robust measurement performance of the Sonobotics Evo on a range of different samples that are representative of components in the oil and gas sector.

1. Introduction and purpose of the work

The purpose of this work was to perform a blind trial at an independent test facility to verify the thickness measurement performance of the Sonobotics Evo EMAT acquisition system on test specimens of unknown thickness that are representative of components that will be encountered in the field. The tests were performed at the BP drone test facility at Naperville in July 2022. Since the Sonobotics Evo can be mounted on any robotic manipulator, the robotic system was removed from the tests and a human operator manipulated the Sonobotic Evo EMAT linearly polarized shear wave probe and a manual ultrasonic test equipment (Olympus 38DL Plus) using coupling gel and longitudinal waves was used as independent reference measurement technique.

2. Description of the work

The BP drone testing facility consists of a mock up cross section of an FPSO hull. This is to mimic the different limited access conditions in which a robot would need to navigate to perform thickness measurements in a realistic environment. Test components (mainly carbon steel pipes and plates) of varying thickness, condition and with different surface coatings are mounted in different orientations on the surfaces of the facility. A picture that that shows the FPSO mock up and some of the test samples in the facility is shown in figure 1.

Figure 1: Pictures left to right: illustration of FPSO hull mock up showing red locations of test samples with thicknesses unknow to the inspector, picture of actual FPSO mock up structure (wooden structure with changeable steel test samples), EMAT probe on steel sample and EMAT probe on pipe sample.

For this work 9 locations in the test facility were chosen and the Sonobotics Evo system and a standard manual ultrasonic thickness gauge (Olympus 38DL Plus) were used to measure the thickness of each component. The manual ultrasonic thickness gauge was operated by an ASNT Level III Inspection specialist, while the Sonobotics EVO system was handled by an operator (Research Student/Engineering Graduate) who had been provided with the system for the first time 1 day prior to the tests and had been given one hour's worth of introduction before using it in the field. This was deliberate as the Sonobotics Evo system is meant to be robot mounted with minimum user input required. Essentially, it needs to be switched on and to receive information about the velocity of sound in the test sample as well as a desired minimum level of signal to noise ratio SNR that needs to be exceeded for a thickness to be extracted from an A-scan.

The Sonobotics Evo system has an automatic thickness calculation routine that determines the arrival time of the first two consecutive echoes that are above an SNR threshold and computes the thickness using the arrival time difference and the ultrasonic velocity in the material. In the manual ultrasonic tests a similar approach was followed but time gates had to be set for the first and second echo arrival. 5 measurements were acquired on each specimen and average to produce the overall test results for each specimen. There was no direct control of the measurement location, meaning that both transducers (the EMAT probe and the reference measurement probe) could have been slightly offset, introducing additional variability.

3. Results

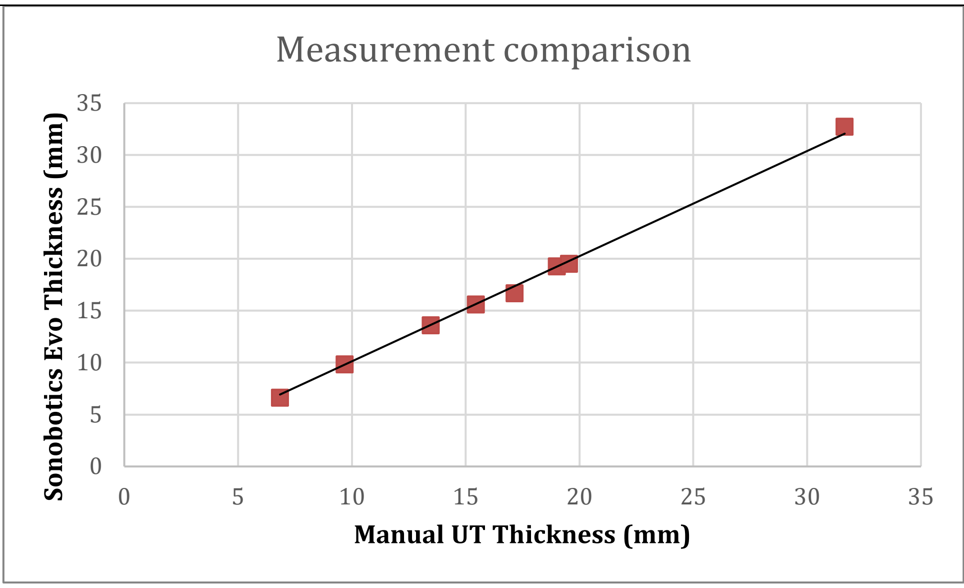

Figure 2: Graphical results showing Manual UT thickness measurements vs Sonobotics Evo thickness measurements

Location	Thickness (mm) L1	L2	L3	L4	L5	L6	L7	L8	L9
Descriptor	rough plate	rough plate	rough plate	coated plate	coated plate	coated plate	pipe	rough surface	pipe
Manual UT	15.45	19	31.65	9.68	17.15	19.54	13.46	6.84	[redacted]
Sonobotics Evo	15.59	19.26	32.71	9.83	16.67	19.53	13.58	6.62	[redacted]
Difference (mm)	0.14	0.26	1.06	0.15	-0.48	-0.01	0.12	-0.22	[redacted]
Difference (% of thickness)	0.90	1.35	3.24	1.53	-2.88	-0.05	0.88	-3.32	[redacted]
Mean difference (mm)	0.1275								
Mean difference (% of thickness)	0.21								

Table 1: Thickness measurement results and differences

Figure 1 shows the overall results that are tabulated in Table 1. The measured thicknesses ranged from 6.6 to 32.7 mm. The maximum over-estimate was 1.06mm and the minimum underestimate was -0.48mm. The mean difference between the two measurements was computed to be 0.1275mm or 0.21% of the measured thickness.

4. Discussion

The results show very good agreement between the two measurements with a mean difference of ~0.13mm or 0.2% of the actual measured thickness. This is a very good result considering the fact that the samples also presented additional challenges such as the presence of coatings, curvature and rough surfaces which introduce uncertainties into any ultrasonic measurement. It is also worthwhile noting that the error is dominated by the results at location L3 and L5 which show the biggest difference in measurements. In these locations the signal variability was higher and this could be due to the more challenging nature of the geometry and specimen and might be something to further report on the future and reporting of the variability might be a way to improve the measurement outcomes. The extreme case of this being the 9th measurement location at which the signals were to variable and hence a result is not reported.

5. Conclusion

This report summaries the outcomes of the blind tests that were performed at the BP Naperville test facility to compare the measurement outcomes of the Sonobotics Evo EMAT thickness measurement tool with a standard manual ultrasonic thickness gauge. The results show that when a good signal is obtained the Sonobotics Evo system can reliably determine the thickness of the test component and the reported result on average lies within 0.2% of the thickness that the reference manual testing equipment returned.