This data article reports the data for reflection and transmission coefficients of the SH0 and SH1 ultrasonic guided waves modes due to their interaction with tapered wall thinning in aluminium plates. Several thinning depths and edge taper angles were machined, at the total of 35 different samples. Periodic permanent magnet array electromagnet acoustic transducers were used to generate and receive the waves. Both modes were individually generated and separated in the received signal by means of effective post-processing technique. Reflection and transmission coefficients were calculated at both the leading and trailing edges of the thinning region for mode-converted and non-mode converted signals; therefore, eight coefficients were calculated for each generated mode, at the total of sixteen coefficients for each sample. Additional finite-element model was used in order to obtain numerical values for the coefficients. These data were used in order to analyze the interaction of the SH0 and SH1 modes with wall thinning and the capabilities of using them in non-destructive evaluation of corrosion-like defects in the research paper entitled “Interaction of SH guided waves with wall thinning” (Kubrusly et al., 2019). © 2018 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
Specifications table

| Subject area          | Physics                                                                 |
|-----------------------|-------------------------------------------------------------------------|
| More specific subject area | Non-destructive testing, ultrasonic wave propagation                     |
| Type of data          | Tables, Figures                                                         |
| How data were acquired| Ultrasonic SH guided wave signals on machined aluminium plates. Ultrasound equipment: RITEC RPR-4000 Pulser/Receiver with ultrasound transducers: 10 mm pitch PPM EMATs from Sonemat Ltd. Additional finite element simulations performed with PZFlex© solver. Filtered. |
| Data format           | Aluminiум plates, 8 mm thick, 800 mm long, 250 mm wide, with machined thinning sections, 150 mm long all width wide, several depths and taper angles. |
| Experimental factors  | Ultrason transducer positioned at the sample surface in specific positions in order to measure reflected and transmitted waves due to interaction with thinning region in the samples. |
| Experimental features | Ultrason transducer positioned at the sample surface in specific positions in order to measure reflected and transmitted waves due to interaction with thinning region in the samples. |
| Data source location  | Ultrasonics Group, Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom. |
| Data accessibility    | Data are with this article                                              |
| Related research article | A. C. Kubrusly, M. A. Freitas, J. P. von der Weid, and S. Dixon, "Interaction of SH guided waves with wall thinning," NDT &E International, 101 (2019), pp. 94–103 [1] |

Value of the data

- The data allow investigation on the interaction of the SH0 and SH1 guided wave modes with thinning regions that simulate wall loss due to corrosion in metallic plates, which is important for non-destructive tests of plates and pipes.
- Up to now, detailed experimental data on the reflection and transmission coefficients for mode-converted and non-mode converted waves of the SH0 and SH1 guided wave modes were not reported.
- The data allow one to address the capabilities and limitation on the use of ultrasonic SH guided wave to estimate and detect wall thinning.
- The data can be used for developing and evaluating novel techniques in order to assess the amount and severity of wall loss by means of reflected and transmitted SH guided waves.

1. Data

The dataset within this data article provides the reflection and transmission coefficients of shear horizontal (SH) guided wave modes at both the leading and trailing edges of linearly tapered thinning regions. Each experimental sample had a different thinning depth and taper angle, 35 different samples were machined and experimentally analyzed. Coefficients for reflection at the leading edge, transmission to the thinning region, reflection at the trailing edge, and transmission out of the thinning region, were calculated. Either the SH0 or SH1 modes were individually generated; both modes were received in each generation case for each coefficient in order to obtain data on mode-converted and non-mode converted waves, therefore giving rise to a total of 16 different coefficients for each sample. Additional numerical data were obtained by means of a finite-element model for a wider collection of thinning geometry. The coefficient data are reported in Tables 1–8 and in Tables 9–16, for generation of the SH0 and SH1 mode, respectively.
2. Experimental design, materials and methods

Aluminium plates were used as test samples with dimension of 8 mm thick, 800 mm long and 250 mm wide. A tapered thinner section was machined in each sample starting at position \( \ell_a = 182 \) mm with a total length of \( \ell_d = 150 \) mm, several different depths, \( d \), and edge angles, \( \alpha \), of the thinned region were machined in order to analyze the coefficients as a function of \( d \) and \( \alpha \). Specimens were prepared at edge angles of 10°, 45°, 55°, and 90°; for each of these angles, depths from 1 mm down to 7 mm were machined in 1 mm step. Additional specimens were prepared with 6 mm and 7 mm depth at edge angles of 25°, 30° and 35° and 25°, 30° and 65°, respectively. Therefore, a total of 34 samples were machined plus one non-machined reference sample, all of which were experimentally evaluated. Fig. 1 shows the sample and machined thinning region drawing with dimension and Fig. 2 shows one machined test sample.

### Table 1

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|---------------------|----|----|----|----|----|----|----|----|
| Relative depth (%)  | 0  | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 | 0.0054 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 0  | 0.0342 | 0.0342 | 0.0342 | 0.0342 | 0.0342 | 0.0342 | 0.0342 |
| 12.5                |    | 0.0938 | 0.0850 | 0.0794 | 0.0783 | 0.0728 | 0.0648 | 0.0619 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 25 | 0.2266 | 0.1895 | 0.1735 | 0.1511 | 0.1122 | 0.0811 | 0.0417 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 37 | 0.3799 | 0.3287 | 0.2941 | 0.2469 | 0.1922 | 0.1736 | 0.1684 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 50 | 0.5104 | 0.4609 | 0.3980 | 0.3152 | 0.1941 | 0.1478 | 0.1203 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 62.5 | 0.6210 | 0.5355 | 0.4058 | 0.2558 | 0.1378 | 0.1439 | 0.1587 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 75 | 0.7243 | 0.5615 | 0.3373 | 0.1952 | 0.2358 | 0.1904 | 0.0745 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 87.5 | 0.8450 | 0.4515 | 0.2628 | 0.3955 | 0.2381 | 0.0542 | 0.2358 |
|                     |    | Exp. |     |     |     |     |     |     |

### Table 2

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|---------------------|----|----|----|----|----|----|----|----|
| Relative depth (%)  | 0  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 0  | 0.0223 | 0.0223 | 0.0223 | 0.0223 | 0.0223 | 0.0223 | 0.0223 |
| 12.5                |    | 0.1311 | 0.1194 | 0.1126 | 0.1122 | 0.1041 | 0.0950 | 0.0925 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 25 | 0.2054 | 0.1728 | 0.1373 | 0.1374 | 0.1374 | 0.1374 | 0.1374 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 37 | 0.3259 | 0.2805 | 0.2265 | 0.2265 | 0.2265 | 0.2265 | 0.2265 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 50 | 0.5104 | 0.4609 | 0.3980 | 0.3152 | 0.1941 | 0.1478 | 0.1203 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 62.5 | 0.6210 | 0.5355 | 0.4058 | 0.2558 | 0.1378 | 0.1439 | 0.1587 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 75 | 0.7243 | 0.5615 | 0.3373 | 0.1952 | 0.2358 | 0.1904 | 0.0745 |
|                     |    | Exp. |     |     |     |     |     |     |
|                     | 87.5 | 0.8450 | 0.4515 | 0.2628 | 0.3955 | 0.2381 | 0.0542 | 0.2358 |
|                     |    | Exp. |     |     |     |     |     |     |
The machined samples were experimentally evaluated using a RITEC RPR-4000 Pulser/Receiver and periodic permanent magnet array electromagnet acoustic transducers (PPM EMATs) from Sonemat Ltd. (3cycle, 10 mm nominal wavelength) as transmitter and receiver. PPM EMATs are able to generate shear horizontal guided waves in metallic plates [2]. In order to generate either the SH0 or the SH1 mode an 8 cycle tone burst at 311 kHz or 367 kHz, respectively, were applied to the transmitter PPM EMAT according to dispersion curve of each mode [1]. Dual excitation and reception on both plate's surfaces was adopted in order to ensure that a single mode was generated and then to separate the two possible received modes due to mode conversion. Details on the dual transduction procedure and experimental setup are described in Refs. [3] and [1], respectively.

Transmitters were placed at position O whereas receiver was positioned at positions (1), (2) or (3), see Fig. 1, in order to receive signals before, at and after the thinning region, respectively. Signals acquired by the oscilloscope were averaged in order to diminish the noise level, also a digital low-pass

### Table 3

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|----------------------|----|----|----|----|----|----|----|----|
| Relative depth (%)   |    |    |    |    |    |    |    |    |
| 0                    | FEM 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 |
| Exp. 0.9918 | 0.9918 | 0.9918 | 0.9918 | 0.9918 | 0.9918 | 0.9918 | 0.9918 | 0.9918 |
| 12.5                 | FEM 0.9917 | 0.9839 | 0.9855 | 0.9854 | 0.9868 | 0.9881 | 0.9893 | 0.9945 |
| Exp. 0.9627 | 0.9851 | 0.9807 | 0.9761 | 0.9761 | 0.9769 | 0.9791 | 0.9817 | 0.9871 |
| 25                  | FEM 0.9099 | 0.9326 | 0.9395 | 0.9472 | 0.9579 | 0.9638 | 0.9695 | 0.9796 |
| Exp. 0.9092 | 0.9088 | 0.9205 | 0.9205 | 0.9205 | 0.9205 | 0.9205 | 0.9205 | 0.9205 |
| 37                  | FEM 0.7957 | 0.8328 | 0.8521 | 0.8727 | 0.8954 | 0.9051 | 0.9124 | 0.9867 |
| Exp. 0.7977 | 0.8269 | 0.8709 | 0.8709 | 0.8709 | 0.8709 | 0.8709 | 0.8709 | 0.8709 |
| 50                  | FEM 0.6992 | 0.7467 | 0.7869 | 0.8326 | 0.8915 | 0.9162 | 0.9331 | 0.9918 |
| Exp. 0.7407 | 0.7692 | 0.8105 | 0.8105 | 0.8105 | 0.8105 | 0.8105 | 0.8105 | 0.8105 |
| 62.5                | FEM 0.6276 | 0.6969 | 0.7607 | 0.8304 | 0.9109 | 0.9384 | 0.9505 | 0.9912 |
| Exp. 0.6306 | 0.7437 | 0.7999 | 0.7999 | 0.7999 | 0.7999 | 0.7999 | 0.7999 | 0.7999 |
| 75                  | FEM 0.5677 | 0.6501 | 0.7438 | 0.8395 | 0.9193 | 0.9374 | 0.9533 | 0.9917 |
| Exp. 0.5420 | 0.7155 | 0.7699 | 0.7699 | 0.7699 | 0.7699 | 0.7699 | 0.7699 | 0.7699 |
| 87.5                | FEM 0.4733 | 0.6099 | 0.7277 | 0.8371 | 0.9171 | 0.9374 | 0.9533 | 0.9917 |
| Exp. 0.4066 | 0.5450 | 0.6579 | 0.7288 | 0.7640 | 0.7787 | 0.8235 | 0.8235 | 0.8235 |

### Table 4

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|----------------------|----|----|----|----|----|----|----|----|
| Relative depth (%)   |    |    |    |    |    |    |    |    |
| 0                    | FEM 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp. 0.0486 | 0.0486 | 0.0486 | 0.0486 | 0.0486 | 0.0486 | 0.0486 | 0.0486 | 0.0486 |
| 12.5                 | FEM 0.0657 | 0.0624 | 0.0596 | 0.0616 | 0.0601 | 0.0601 | 0.0596 | 0.0630 |
| Exp. 0.1186 | 0.0837 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 |
| 25                  | FEM 0.0713 | 0.0694 | 0.0706 | 0.0734 | 0.0776 | 0.0816 | 0.0862 | 0.0748 |
| Exp. 0.0906 | 0.0835 | 0.0961 | 0.0961 | 0.0961 | 0.0961 | 0.0961 | 0.0961 | 0.0961 |
| 37                  | FEM 0.0333 | 0.0361 | 0.0444 | 0.0573 | 0.0643 | 0.0645 | 0.0611 | 0.0368 |
| Exp. 0.0424 | 0.0454 | 0.0377 | 0.0377 | 0.0377 | 0.0377 | 0.0377 | 0.0377 | 0.0377 |
| 50                  | FEM 0.0045 | 0.0040 | 0.0034 | 0.0027 | 0.0021 | 0.0020 | 0.0017 | 0.0007 |
| Exp. 0.0039 | 0.0020 | 0.0035 | 0.0035 | 0.0035 | 0.0035 | 0.0035 | 0.0035 | 0.0035 |
| 62.5                | FEM 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp. 0.0033 | 0.0042 | 0.0471 | 0.0471 | 0.0471 | 0.0471 | 0.0471 | 0.0471 | 0.0471 |
| 75                  | FEM 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp. 0.0306 | 0.0552 | 0.0586 | 0.0586 | 0.0586 | 0.0586 | 0.0586 | 0.0586 | 0.0586 |
| 87.5                | FEM 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp. 0.0462 | 0.0437 | 0.1001 | 0.0813 | 0.0813 | 0.0813 | 0.0813 | 0.0813 | 0.0813 |
filter at 400 kHz 3 dB cut-off frequency was applied to the raw signals. Signals acquired at both surfaces were combined following [3] in order to separate mode-converted and non-mode converted signals for each generation.

Four coefficients were calculated, namely $R_{ij}$, $T_{ij}$, $TR_{ij}$, $TT_{ij}$, which denote the reflection at the thinning region leading edge, transmission to the region, reflection at the thinning region trailing edge, and transmission out of the far end of the region, respectively. The first subscript, $i$, denotes the generated mode, whereas the second one, $j$, denotes the received mode. Either $i$ or $j$ can be 0 or 1, here, corresponding to the SH0 or SH1 modes, respectively. These coefficients are defined by:

$$R_{ij} = \frac{A^{(1)}_{ij}}{A^{(1)}_i},$$

(1a)

Table 5

$TR_{00}$ coefficient.

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|----------------------|----|----|----|----|----|----|----|----|
| Relative depth (%)   |    |    |    |    |    |    |    |    |
| 0 FEM                | 0.0028 | 0.0028 | 0.0028 | 0.0028 | 0.0028 | 0.0028 | 0.0028 | 0.0028 |
| Exp.                 | 0.0190 | 0.0190 | 0.0190 | 0.0190 | 0.0190 | 0.0190 | 0.0190 | 0.0190 |
| 12.5 FEM             | 0.0622 | 0.0539 | 0.0533 | 0.0506 | 0.0471 | 0.0452 | 0.0399 | 0.0116 |
| Exp.                 | 0.0579 | 0.0497 | 0.0533 | 0.0533 | 0.0533 | 0.0533 | 0.0533 | 0.0533 |
| 25 FEM               | 0.0854 | 0.0755 | 0.0674 | 0.0539 | 0.0323 | 0.0237 | 0.0106 | 0.0188 |
| Exp.                 | 0.0888 | 0.0514 | 0.0517 | 0.0517 | 0.0517 | 0.0517 | 0.0517 | 0.0517 |
| 37 FEM               | 0.0451 | 0.0305 | 0.0201 | 0.0202 | 0.0275 | 0.0366 | 0.0419 | 0.0216 |
| Exp.                 | 0.0483 | 0.0424 | 0.0367 | 0.0367 | 0.0367 | 0.0367 | 0.0367 | 0.0367 |
| 50 FEM               | 0.0253 | 0.0207 | 0.0324 | 0.0481 | 0.0630 | 0.0558 | 0.0223 | 0.0264 |
| Exp.                 | 0.0424 | 0.0549 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 |
| 62.5 FEM             | 0.0462 | 0.0749 | 0.0917 | 0.0987 | 0.0541 | 0.0325 | 0.0709 | 0.0225 |
| Exp.                 | 0.0616 | 0.0961 | 0.0928 | 0.0928 | 0.0928 | 0.0928 | 0.0928 | 0.0928 |
| 75 FEM               | 0.1214 | 0.1495 | 0.1661 | 0.1263 | 0.0787 | 0.1301 | 0.0634 | 0.0279 |
| Exp.                 | 0.1229 | 0.1410 | 0.0958 | 0.0684 | 0.0897 | 0.0694 | 0.0552 |
| 87.5 FEM             | 0.2318 | 0.2557 | 0.2080 | 0.1839 | 0.2118 | 0.1591 | 0.1760 | 0.0709 |
| Exp.                 | 0.1765 | 0.1834 | 0.1385 | 0.0865 | 0.0863 | 0.1327 | 0.0462 |

Table 6

$TR_{01}$ coefficient.

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|----------------------|----|----|----|----|----|----|----|----|
| Relative depth (%)   |    |    |    |    |    |    |    |    |
| 0 FEM                | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp.                 | 0.0409 | 0.0409 | 0.0409 | 0.0409 | 0.0409 | 0.0409 | 0.0409 | 0.0409 |
| 12.5 FEM             | 0.0688 | 0.0603 | 0.0590 | 0.0568 | 0.0539 | 0.0514 | 0.0468 | 0.0080 |
| Exp.                 | 0.0688 | 0.0619 | 0.0655 | 0.0655 | 0.0655 | 0.0655 | 0.0655 | 0.0655 |
| 25 FEM               | 0.0855 | 0.0775 | 0.0702 | 0.0584 | 0.0428 | 0.0335 | 0.0208 | 0.0141 |
| Exp.                 | 0.0844 | 0.0549 | 0.0602 | 0.0602 | 0.0602 | 0.0602 | 0.0602 | 0.0602 |
| 37 FEM               | — | — | — | — | — | — | — | — |
| Exp.                 | — | — | — | — | — | — | — | — |
| 50 FEM               | — | — | — | — | — | — | — | — |
| Exp.                 | — | — | — | — | — | — | — | — |
| 62.5 FEM             | — | — | — | — | — | — | — | — |
| Exp.                 | — | — | — | — | — | — | — | — |
| 75 FEM               | — | — | — | — | — | — | — | — |
| Exp.                 | — | — | — | — | — | — | — | — |
| 87.5 FEM             | — | — | — | — | — | — | — | — |
| Exp.                 | — | — | — | — | — | — | — | — |
\[ T_{ij} = \frac{A_2}{A_1^{(1)+}} \sqrt{\frac{h - d}{h}} \]  \hspace{1cm} (1b)

\[ TR_{ij} = \frac{A_2^{(2)-}}{A_1^{(1)+}} \sqrt{\frac{h - d}{h}} \]  \hspace{1cm} (1c)

\[ TT_{ij} = \frac{A_3}{A_1^{(1)+}} \]  \hspace{1cm} (1d)

where \( A \) is the peak-to-peak of the received signal inside a time gate in which the mode is expected to arrive, the superscripts + and − mean the forward and backward propagating waves, and (1), (2) and

### Table 7

| Taper angle (degree) | 90   | 65   | 55   | 45   | 35   | 30   | 25   | 10   |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Relative depth (%)   |     |     |     |     |     |     |     |     |
| 0 FEM                | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 | 0.9999 |
| Exp.                | 1.0218 | 1.0218 | 1.0218 | 1.0218 | 1.0218 | 1.0218 | 1.0218 | 1.0218 |
| 12.5 FEM             | 0.9636 | 0.9704 | 0.9714 | 0.9729 | 0.9750 | 0.9769 | 0.9790 | 0.9903 |
| Exp.                | 0.9840 | 1.0085 | 1.0100 | -- | -- | -- | 1.0062 |     |
| 25 FEM               | 0.8280 | 0.8646 | 0.8796 | 0.8980 | 0.9179 | 0.9282 | 0.9390 | 0.9575 |
| Exp.                | 0.8523 | 0.8832 | 0.9168 | -- | -- | -- | 0.9768 |     |
| 37 FEM               | 0.6327 | 0.6956 | 0.7289 | 0.7632 | 0.8021 | 0.8202 | 0.8326 | 0.9729 |
| Exp.                | 0.6546 | 0.7330 | 0.7978 | -- | -- | -- | 0.9565 |     |
| 50 FEM               | 0.4885 | 0.5638 | 0.6205 | 0.7017 | 0.7947 | 0.8397 | 0.8741 | 0.9822 |
| Exp.                | 0.5171 | 0.6507 | 0.7324 | -- | -- | -- | 0.9780 |     |
| 62.5 FEM             | 0.3942 | 0.4819 | 0.5748 | 0.6986 | 0.8297 | 0.8812 | 0.9055 | 0.9835 |
| Exp.                | 0.4097 | 0.6196 | 0.7013 | -- | -- | -- | 0.9888 |     |
| 75 FEM               | 0.3223 | 0.4259 | 0.5524 | 0.7120 | 0.8442 | 0.8771 | 0.9102 | 0.9824 |
| Exp.                | 0.3232 | 0.6193 | 0.7144 | 0.8446 | 0.8646 | 0.9094 | 0.9745 |     |
| 87.5 FEM             | 0.2243 | 0.3699 | 0.5331 | 0.7049 | 0.8035 | 0.8688 | 0.8849 | 0.9778 |
| Exp.                | 0.2449 | 0.3837 | 0.6299 | 0.7267 | -- | 0.9013 | 0.8558 | 0.9882 |

### Table 8

| Taper angle (degree) | 90   | 65   | 55   | 45   | 35   | 30   | 25   | 10   |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Relative depth (%)   |     |     |     |     |     |     |     |     |
| 0 FEM                | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp.                | 0.0045 | 0.0458 | 0.0458 | 0.0458 | 0.0458 | 0.0458 | 0.0458 | 0.0458 |
| 12.5 FEM             | 0.1307 | 0.1276 | 0.1305 | 0.1258 | 0.1253 | 0.1263 | 0.1221 | 0.115 |
| Exp.                | 0.1000 | 0.1920 | 0.1432 | -- | -- | -- | 0.0968 |     |
| 25 FEM               | 0.3152 | 0.2912 | 0.2784 | 0.2598 | 0.2519 | 0.2473 | 0.2416 | 0.2248 |
| Exp.                | 0.3429 | 0.2599 | 0.2739 | -- | -- | -- | 0.2321 |     |
| 37 FEM               | 0.4622 | 0.4411 | 0.4278 | 0.4130 | 0.3921 | 0.3779 | 0.3717 | 0.1643 |
| Exp.                | 0.4469 | 0.4082 | 0.4167 | -- | -- | -- | 0.2004 |     |
| 50 FEM               | 0.4932 | 0.4840 | 0.4780 | 0.4430 | 0.3988 | 0.3632 | 0.3297 | 0.1288 |
| Exp.                | 0.5096 | 0.4329 | 0.4392 | -- | -- | -- | 0.1642 |     |
| 62.5 FEM             | 0.4796 | 0.4904 | 0.4826 | 0.4344 | 0.3723 | 0.3238 | 0.2819 | 0.1272 |
| Exp.                | 0.5014 | 0.4248 | 0.4310 | -- | -- | -- | 0.1753 |     |
| 75 FEM               | 0.4415 | 0.4592 | 0.4639 | 0.4242 | 0.3548 | 0.3036 | 0.2777 | 0.1273 |
| Exp.                | 0.4577 | 0.4193 | 0.4256 | 0.3387 | 0.3230 | 0.2619 | 0.1652 |     |
| 87.5 FEM             | 0.3396 | 0.4054 | 0.4433 | 0.4136 | 0.3354 | 0.3013 | 0.2703 | 0.1260 |
| Exp.                | 0.3595 | 0.3975 | 0.4022 | 0.4061 | -- | 0.2647 | 0.2749 | 0.1585 |
(3) indicate the reading positions according to Fig. 1. All coefficients are related to the incident wave, \( A_i^{(1)+} \). Since the wave amplitude is increased when it is transmitted to a thinner region, due to the energy distribution across the thickness, it is necessary to include the square root in Eq. (1b) and (1c) in order to compensate it, where \( h \) is the plate’s original thickness, and therefore \( h - d \) is the remaining thickness in the thinner region.

The time gate to select the amplitude \( A_i^{(1)+} \) of the incident mode \( i \) before the thinning region, starts and ends, respectively at:

\[
t_{1i}^{(1)+} = \frac{X_i^{(1)}}{c_0} - \Delta_i, \quad (2a)
\]

\[
t_{2i}^{(1)+} = \frac{X_i^{(1)}}{c_0} + \frac{N}{f_c} + \Delta_i, \quad (2b)
\]

### Table 9

\( R_{11} \) coefficient.

| Taper angle (degree) | 90  | 65  | 55  | 45  | 35  | 30  | 25  | 10  |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Relative depth (%)   | FEM | Exp. | FEM | Exp. | FEM | Exp. | FEM | Exp. |
| 0                    | 0.0093 | 0.0093 | 0.0093 | 0.0093 | 0.0093 | 0.0093 | 0.0093 | 0.0093 |
| 12.5                 | 0.2104 | 0.1791 | 0.1760 | 0.1675 | 0.1520 | 0.1384 | 0.1224 | 0.0192 |
| 25                   | 0.4484 | 0.3523 | 0.3071 | 0.2539 | 0.1769 | 0.1218 | 0.0628 | 0.0277 |
| 37                   | 0.5254 | 0.4055 | 0.3325 | 0.2295 | 0.0918 | 0.1164 | 0.1779 | 0.1222 |
| 50                   | 0.5261 | 0.5235 | 0.5004 | 0.5261 | 0.5827 | 0.6194 | 0.6949 | 0.9014 |
| 62.5                 | 0.4801 | 0.4968 | 0.5179 | 0.5095 | 0.6167 | 0.5709 | 0.8474 | 0.9786 |
| 75                   | 0.5512 | 0.4369 | 0.4686 | 0.5275 | 0.6927 | 0.7762 | 0.8562 | 0.9794 |
| 87.5                 | 0.7193 | 0.2709 | 0.4839 | 0.6566 | 0.7045 | 0.8721 | 0.8770 | 0.9772 |

### Table 10

\( R_{10} \) coefficient.

| Taper angle (degree) | 90  | 65  | 55  | 45  | 35  | 30  | 25  | 10  |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Relative depth (%)   | FEM | Exp. | FEM | Exp. | FEM | Exp. | FEM | Exp. |
| 0                    | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 12.5                 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 | 0.0080 |
| 25                   | 0.0681 | 0.0577 | 0.0568 | 0.0537 | 0.0483 | 0.0433 | 0.0375 | 0.0091 |
| 37                   | 0.0392 | 0.0399 | 0.0381 | 0.0381 | 0.0381 | 0.0381 | 0.0381 | 0.0072 |
| 50                   | 0.1598 | 0.1235 | 0.1071 | 0.0858 | 0.0553 | 0.0329 | 0.0136 | 0.0160 |
| 62.5                 | 0.1598 | 0.1235 | 0.1071 | 0.0858 | 0.0553 | 0.0329 | 0.0136 | 0.0160 |
| 75                   | 0.2087 | 0.1538 | 0.1221 | 0.0788 | 0.0410 | 0.0646 | 0.0796 | 0.0218 |
| 87.5                 | 0.1530 | 0.1328 | 0.1052 | 0.0875 | 0.0593 | 0.0329 | 0.0136 | 0.0178 |
| 90                   | 0.2298 | 0.2023 | 0.1900 | 0.2007 | 0.2076 | 0.2130 | 0.1996 | 0.0435 |
| 100                  | 0.2146 | 0.2066 | 0.2076 | 0.2060 | 0.2216 | 0.2163 | 0.1757 | 0.0713 |
| 112.5                | 0.1740 | 0.2246 | 0.2380 | 0.2200 | 0.1972 | 0.1845 | 0.1777 | 0.0702 |
| 125                  | 0.1052 | 0.1813 | 0.1437 | 0.1469 | 0.1332 | 0.1399 | 0.0869 | 0.0767 |
| 137.5                | 0.0582 | 0.2069 | 0.1560 | 0.1182 | 0.1555 | 0.1164 | 0.0886 | 0.0767 |
where $x^{(1)}$ is the longitudinal coordinate of position (1), $c_g$ is the group velocity of the generated mode, and $i$, at its working frequency, $f_c$, $N$ is the number of cycles used in the exciting signal and $\Delta_i$ is a time margin which ensures that the whole signal is included in the time gate, empirically $\Delta_i = 2^i N / 4f_c$. The group velocities for the SH0 and SH1 modes in an 8 mm aluminium plate are $c_{g0} = 3111$ m/s and $c_{g1} = 2428$ m/s, respectively at 311 kHz and 367 kHz. The time gates to select the other amplitudes, namely, $A_j^{(1)-}$, $A_j^{(2)+}$, $A_j^{(2)-}$ and $A_j^{(3)+}$ due to the incident mode $i$, start and end instants are, respectively:

$$t_{1j}^{(1)-} = \frac{c_a}{c_{g0}} + \frac{c_a - x^{(1)}}{c_g} - \Delta_i,$$

(3a)

| Taper angle (degree) | 90  | 65  | 55  | 45  | 35  | 30  | 25  | 10  |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Relative depth (%)   | 0   | 1.0123 | 1.0123 | 1.0123 | 1.0123 | 1.0123 | 1.0123 | 1.0123 |
| Exp.                 | 0.9617 | 0.9617 | 0.9617 | 0.9617 | 0.9617 | 0.9617 | 0.9617 | 0.9617 |
| 12.5 FEM             | 0.9426 | 0.9588 | 0.9596 | 0.9625 | 0.9684 | 0.9722 | 0.9761 | 0.9894 |
| Exp.                 | 0.9153 | –     | 0.9410 | 0.9192 | –     | –     | –     | 0.9463 |
| 25 FEM               | 0.5191 | 0.6274 | 0.6614 | 0.6903 | 0.7195 | 0.7321 | 0.7379 | 0.7449 |
| Exp.                 | 0.4953 | –     | 0.5632 | 0.6268 | –     | –     | –     | 0.6685 |
| 37 FEM               | 0.0825 | 0.1447 | 0.1632 | 0.1781 | 0.1855 | 0.1858 | 0.1863 | 0.2092 |
| Exp.                 | 0.1000 | –     | 0.1734 | 0.1785 | –     | –     | –     | 0.2182 |
| 50 FEM               | 0.0060 | 0.0157 | 0.0183 | 0.0202 | 0.0215 | 0.0229 | 0.0264 | 0.0354 |
| Exp.                 | 0.0149 | –     | 0.0105 | 0.0233 | –     | –     | –     | 0.0221 |
| 62.5 FEM             | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp.                 | 0.0211 | –     | 0.0145 | 0.0193 | –     | –     | –     | 0.0059 |
| 75 FEM               | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp.                 | 0.0206 | –     | 0.0196 | 0.0217 | 0.0223 | 0.0130 | 0.0114 | 0.0077 |
| 87.5 FEM             | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Exp.                 | 0.0272 | 0.0227 | 0.0259 | 0.0235 | –     | 0.0098 | 0.0103 | 0.0106 |

Table 11
$T_{1i}$ coefficient.

| Taper angle (degree) | 90  | 65  | 55  | 45  | 35  | 30  | 25  | 10  |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Relative depth (%)   | 0   | 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 |
| Exp.                 | 0.0563 | 0.0563 | 0.0563 | 0.0563 | 0.0563 | 0.0563 | 0.0563 | 0.0563 |
| 12.5 FEM             | 0.0727 | 0.0634 | 0.0628 | 0.0615 | 0.0579 | 0.0565 | 0.0549 | 0.0494 |
| Exp.                 | 0.0989 | –     | 0.0792 | 0.0910 | –     | –     | –     | 0.0717 |
| 25 FEM               | 0.1850 | 0.1516 | 0.1396 | 0.1306 | 0.1187 | 0.1151 | 0.1119 | 0.0979 |
| Exp.                 | 0.1495 | –     | 0.0995 | 0.1122 | –     | –     | –     | 0.0790 |
| 37 FEM               | 0.2673 | 0.2271 | 0.2135 | 0.2063 | 0.1963 | 0.1958 | 0.1909 | 0.1133 |
| Exp.                 | 0.2267 | –     | 0.1689 | 0.1811 | –     | –     | –     | 0.1023 |
| 50 FEM               | 0.3183 | 0.3027 | 0.2903 | 0.2863 | 0.2756 | 0.2635 | 0.2318 | 0.0510 |
| Exp.                 | 0.2936 | –     | 0.2186 | 0.2476 | –     | –     | –     | 0.0811 |
| 62.5 FEM             | 0.3426 | 0.3379 | 0.3179 | 0.3000 | 0.2627 | 0.2354 | 0.1853 | 0.0722 |
| Exp.                 | 0.3033 | –     | 0.2177 | 0.2438 | –     | –     | –     | 0.0730 |
| 75 FEM               | 0.3395 | 0.3450 | 0.3163 | 0.2873 | 0.2408 | 0.2182 | 0.1760 | 0.0715 |
| Exp.                 | 0.2908 | –     | 0.2021 | 0.2232 | 0.1709 | 0.1405 | 0.1122 | 0.0695 |
| 87.5 FEM             | 0.3001 | 0.3371 | 0.3086 | 0.2716 | 0.2376 | 0.2147 | 0.1761 | 0.0717 |
| Exp.                 | 0.2126 | 0.2126 | 0.1607 | 0.1839 | –     | 0.1245 | 0.1023 | 0.0562 |

Table 12
$T_{10}$ coefficient.
\[ t_{ij}^{(1)-} = \frac{\ell_a + d \cot(\alpha)}{c_{g_i}} + \frac{\ell_a + d \cot(\alpha) - x^{(1)}}{c_{g_i}} + \frac{N}{f_c} + \Delta_i, \]  

(3b)

\[ t_{ij}^{(2)+} = \frac{\ell_a}{c_{g_i}} + \frac{x^{(2)} - \ell_a}{c_{g}(\bar{h} - d)} - \Delta_i, \]  

(4a)

\[ t_{ij}^{(2)+} = \frac{\ell_a}{c_{g_i}} + \frac{x^{(2)} - \ell_a}{c_{g}(\bar{h} - d)} + \frac{N}{f_c} + \Delta_i, \]  

(4b)

\[ t_{ij}^{(2)-} = \frac{\ell_a}{c_{g_i}} + \frac{2\ell_d + \ell_a - x^{(2)}}{\max(c_{g_i}(\bar{h} - d), c_{g}(\bar{h} - d))} - \Delta_i, \]  

(5a)
The maximum of the two possible modes within the thinner region length, in Eqs. (5a) and (5b) is considered.

\[
\ell_{2ij}^{(2)} = \frac{\ell_a}{c_{g_i}} + \frac{2\ell_d + \ell_a - x^{(2)}}{\min[c_{g_i}(h-d),c_{g_i}(h-d)]} + \frac{N}{f_c} + \Delta_i, \\
\ell_{1ij}^{(3)} = \frac{\ell_a}{c_{g_i}} + \frac{\ell_d}{\max[c_{g_i}(h-d),c_{g_i}(h-d)]} + \frac{x^{(3)} - \ell_a - \ell_d}{c_{g_i}} - \Delta_i, \\
\ell_{2ij}^{(3)} = \frac{\ell_a}{c_{g_i}} + \frac{\ell_d}{\min[c_{g_i}(h-d),c_{g_i}(h-d)]} + \frac{x^{(3)} - \ell_a - \ell_d}{c_{g_i}} + \frac{N}{f_c} + \Delta_i, 
\]

where \(c_{g_i}\) is the group velocity of the received mode, \(j\), \(c_{sw}(h-d)\) is the group velocity within the thinning region. It is necessary to consider velocity change at the thinning region because the SH1 mode is dispersive and its velocity is a function of the plate's thickness [4]. The minimum and maximum of the two possible modes within the thinner region length, in Eqs. (5a)–(6b), is considered.

**Table 15**

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|---------------------|---|---|---|---|---|---|---|---|
| Relative depth (%)  | 0 | FEM 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 | 0.0018 |
|                     |   | Exp. 0.0193 | 0.0193 | 0.0193 | 0.0193 | 0.0193 | 0.0193 | 0.0193 | 0.0193 |
|                     | 12.5 | FEM 0.0921 | 0.0845 | 0.0846 | 0.0831 | 0.0802 | 0.0795 | 0.0795 | 0.0825 |
|                     |   | Exp. 0.0519 | 0.0755 | 0.0755 | 0.0755 | 0.0755 | 0.0755 | 0.0755 | 0.0585 |
|                     | 25 | FEM 0.1594 | 0.1375 | 0.1291 | 0.1220 | 0.1118 | 0.1154 | 0.1179 | 0.0996 |
|                     |   | Exp. 0.1383 | 0.0989 | 0.1163 | 0.1163 | 0.1163 | 0.1163 | 0.1163 | 0.0810 |
|                     | 37 | FEM 0.2070 | 0.1926 | 0.1860 | 0.1831 | 0.1755 | 0.1750 | 0.1714 | 0.1094 |
|                     |   | Exp. 0.1755 | 0.1490 | 0.1649 | 0.1649 | 0.1649 | 0.1649 | 0.1649 | 0.0956 |
|                     | 50 | FEM 0.2307 | 0.2286 | 0.2244 | 0.2202 | 0.2187 | 0.2161 | 0.2012 | 0.0510 |
|                     |   | Exp. 0.2097 | 0.1749 | 0.2009 | 0.2009 | 0.2009 | 0.2009 | 0.2009 | 0.0827 |
|                     | 62.5 | FEM 0.2232 | 0.2238 | 0.2192 | 0.2146 | 0.2116 | 0.2016 | 0.1707 | 0.0716 |
|                     |   | Exp. 0.1942 | 0.1696 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.0715 |
|                     | 75 | FEM 0.1884 | 0.2010 | 0.2120 | 0.2102 | 0.2003 | 0.1919 | 0.1634 | 0.0710 |
|                     |   | Exp. 0.1628 | 0.1702 | 0.1856 | 0.1625 | 0.1513 | 0.1290 | 0.0679 |
|                     | 87.5 | FEM 0.1316 | 0.1944 | 0.2097 | 0.1942 | 0.1975 | 0.1866 | 0.1632 | 0.0710 |
|                     |   | Exp. 0.1194 | 0.1495 | 0.1543 | 0.1609 | 0.1400 | 0.1218 | 0.0674 |

**Table 16**

| Taper angle (degree) | 90 | 65 | 55 | 45 | 35 | 30 | 25 | 10 |
|---------------------|---|---|---|---|---|---|---|---|
| Relative depth (%)  | 0 | FEM 1.0198 | 1.0198 | 1.0198 | 1.0198 | 1.0198 | 1.0198 | 1.0198 | 1.0198 |
|                     |   | Exp. 0.9868 | 0.9868 | 0.9868 | 0.9868 | 0.9868 | 0.9868 | 0.9868 | 0.9868 |
|                     | 12.5 | FEM 0.9207 | 0.9454 | 0.9443 | 0.9498 | 0.9617 | 0.9703 | 0.9752 | 0.9985 |
|                     |   | Exp. 0.9227 | 0.9460 | 0.9361 | 0.9361 | 0.9361 | 0.9361 | 0.9361 | 0.9790 |
|                     | 25 | FEM 0.5001 | 0.6831 | 0.7545 | 0.8051 | 0.8751 | 0.9021 | 0.9174 | 0.9411 |
|                     |   | Exp. 0.5163 | 0.7294 | 0.7882 | 0.7882 | 0.7882 | 0.7882 | 0.7882 | 0.9366 |
|                     | 37 | FEM 0.3338 | 0.3937 | 0.4888 | 0.5659 | 0.5983 | 0.5905 | 0.5834 | 0.7127 |
|                     |   | Exp. 0.3072 | 0.4294 | 0.5354 | 0.5354 | 0.5354 | 0.5354 | 0.5354 | 0.6460 |
|                     | 50 | FEM 0.4868 | 0.4430 | 0.4174 | 0.4137 | 0.3848 | 0.3412 | 0.2615 | 0.0106 |
|                     |   | Exp. 0.4939 | 0.3760 | 0.3948 | 0.3948 | 0.3948 | 0.3948 | 0.3948 | 0.0234 |
|                     | 62.5 | FEM 0.5626 | 0.5582 | 0.5103 | 0.4675 | 0.3623 | 0.2767 | 0.1657 | 0.0242 |
|                     |   | Exp. 0.5675 | 0.4187 | 0.4410 | 0.4410 | 0.4410 | 0.4410 | 0.4410 | 0.0421 |
|                     | 75 | FEM 0.5429 | 0.5831 | 0.5084 | 0.4296 | 0.3095 | 0.2387 | 0.1483 | 0.0238 |
|                     |   | Exp. 0.5402 | 0.4087 | 0.4316 | 0.2897 | 0.2242 | 0.1379 | 0.0381 |
|                     | 87.5 | FEM 0.4154 | 0.5717 | 0.4820 | 0.3788 | 0.3009 | 0.2302 | 0.1493 | 0.0238 |
|                     |   | Exp. 0.4570 | 0.5375 | 0.3992 | 0.3886 | 0.1846 | 0.1309 | 0.0369 |
because, at first, both modes can propagate in the thinning region due to mode conversion of any incident mode at the leading edge, and the coefficients $T_{Rij}$ and $T_{Tij}$ consider the two possible modes, SH0 or SH1, propagating inside the thinning region. This, however, only holds when the region remaining thickness is above the SH1 mode cut-off thickness. Otherwise, its group velocity is not defined and this mode cannot propagate inside the thinning. Thus, either $\min\{c_{g_0}(h-d), c_{g_1}(h-d)\}$ or $\max\{c_{g_0}(h-d), c_{g_1}(h-d)\}$ should read $c_{g_0}(h) = c_{g_0}$ in this case, since the group velocity for the non-dispersive SH0 mode is constant for any thickness. Also, in this case, a time gate for $T_{I1}$ or $T_{R1}$ cannot be defined, therefore no time gate restriction was applied and the whole SH1 signal on the region is considered to calculate the $T_{I1}$ coefficient, whereas $T_{R1}$ is not calculated in this case.

Prior to calculating the experimental reflection and transmission coefficients, it is necessary to compensate for attenuation. The experimental attenuation of the guided wave modes was calculated by receiving the SH0 and SH1 signals in several positions in a non-machined sample and fitting the peak-to-peak of the signals versus the position with an exponential decay curve. The exponential coefficient was then used to compensate the values of the amplitudes, $A_i^{(1)+}$, $A_i^{(1)-}$, $A_j^{(2)+}$, $A_j^{(2)-}$ and

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**Fig. 1.** Plate dimension with a machined section. Marked positions denote the origin $O$, where transmitter is positioned, and receiver positions before the thinning region (1), in the middle of the region (2) and after the region (3).

**Fig. 2.** Machined plate at 45° edges and 4 mm depth.
Finally, the sixteen coefficients were calculated for each thinning depth and taper angle. In addition to experiments, finite-element analysis was also performed using a commercial, time-domain, Finite-Element Method (FEM) solver, PZFlex©, which allows simulation of SH waves in two-dimensional models. The numerical model was executed for thinning depth from 0.5 to 7.5 mm in 0.5 mm step with the following taper angles, 90°, 65°, 55°, 45°, 35°, 30°, 25° and 10°, therefore including all the experimental thinning geometries. Numerical simulation mimicked the PPM EMATs generation by applying forces in surface nodes along the transducer length according to the transducer spatial profile following the procedure used and validated previously [3,5], whereas reception

Fig. 3. Coefficients for SH0 generation, obtained experimentally (symbols) and numerically (lines) at 90° edge (a) and (b), 55° (c) and (d), 45° (e) and (f) and 10° (g) and (h).

Fig. 4. Coefficients for SH1 generation, obtained experimentally (symbols) and numerically (lines) at 90° edge (a) and (b), 55° (c) and (d), 45° (e) and (f) and 10° (g) and (h).
was done by numerically convolving the wave field on the surface of the model with the probe spatial profile. Then, likewise in the experiments, the dual excitation and reception procedure, filtering and time gating were applied. Therefore numerical and experimental data can be straightforwardly compared. The only procedure which was not included in the numerical data was attenuation compensation since damping was not included in the model.

Figs. 3 and 4 show the experimental and numerical coefficients for generation of the SH0 and SH1 mode, respectively. This data not only helps on understanding the interaction of the SH0 and SH1 modes with wall thinning sections but also allows one to address the capabilities and limitation on the use of ultrasonic SH guided wave to estimate and detect wall thinning when both modes are allowed to propagate (see Ref. [1]).

**Acknowledgements**

Authors would like to thank the Brazilian National Council for Scientific and Technological Development, CNPq, for financial support.

**Transparency document. Supporting information**

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2018.11.053.

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