Deliverable 3.2

Guided waves NDT demonstrator

1. Guided wave NDT equipment for demonstrator

To carry out experimental investigation using guided waves NDT technology, TELETEST Mk3 has been got ready. Technical details relevant to SWAK project of the equipment are given below.

Wave forms:	Sinusoidal
Frequency range:	20kHz to 200kHz
Amplitude (in volts):	300V
Type of modes:	Single frequency, multi frequency, frequency sweep.
Output channels:	32
Control:	Using proprietary GUI supplied by FOCUS^{+}
Mode of operation	Pitch-catch, Pulse-Echo

In the following sections, the details of guided wave NDT experimental setup, test results of the experiments conducted on lap joints are presented. Here, we refer to the samples with kissing bond defects as “defective-samples”, samples without kissing bond defects as “reference-samples”. All the samples under testing are referred to as “test-samples”.

2. Guided wave NDT

An illustration of the dimensions of the lap joints and position of transducers used for guided wave NDT inspection is presented in Fig. 1(a). Fig. 1(b) and Fig 1(c) shows the experimental setup and the actual lap joints with the piezo transducers attached. The transducers are installed on the lap joints so that it is possible to setup waves through the sample as well as bonded joints in both pitch-catch as well as pulse-echo mode. The guided wave NDT method is applied to six lap joints. Of the six lap joints, two are “defective-samples” and four are “reference-samples”.

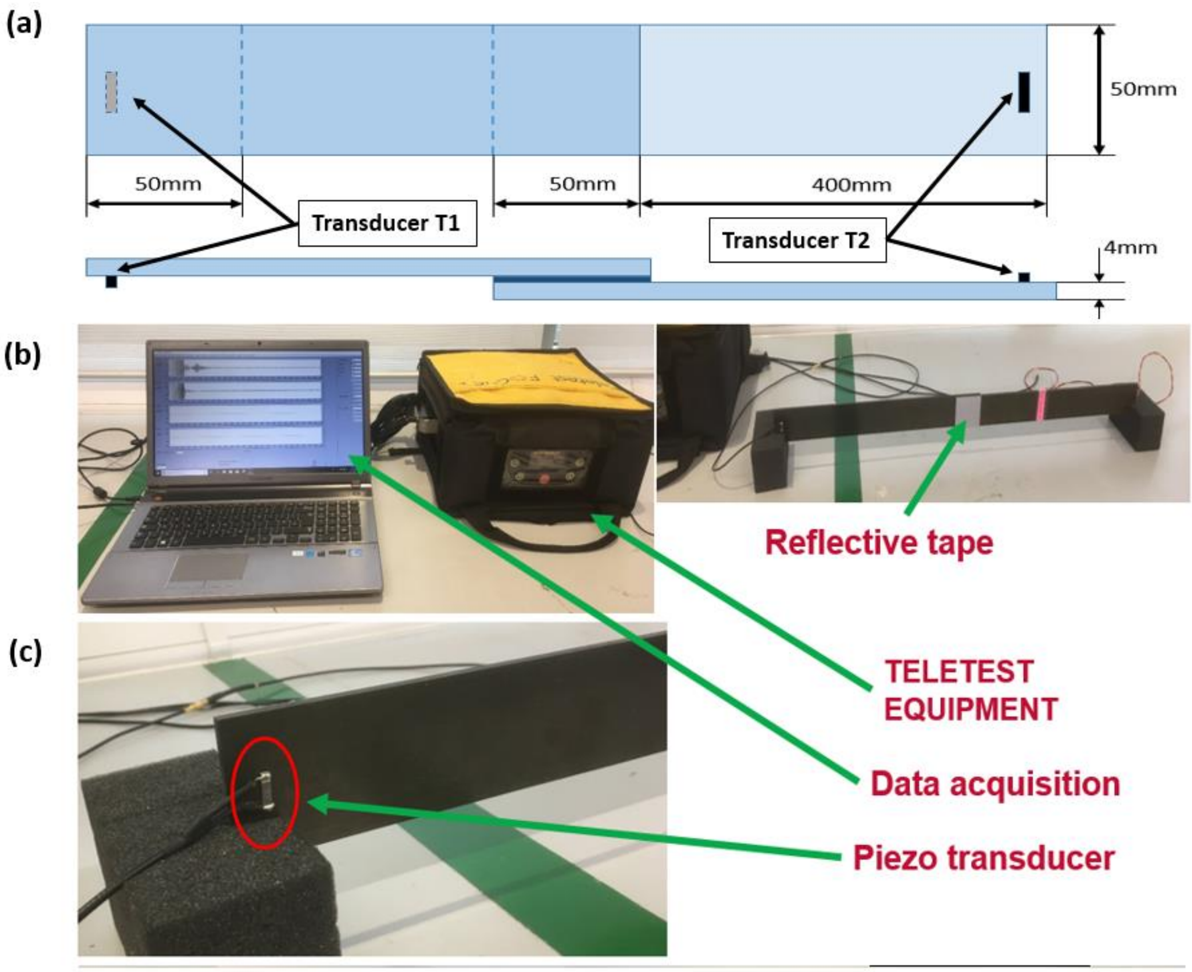

Figure 1: Test sample geometry for guided wave NDT

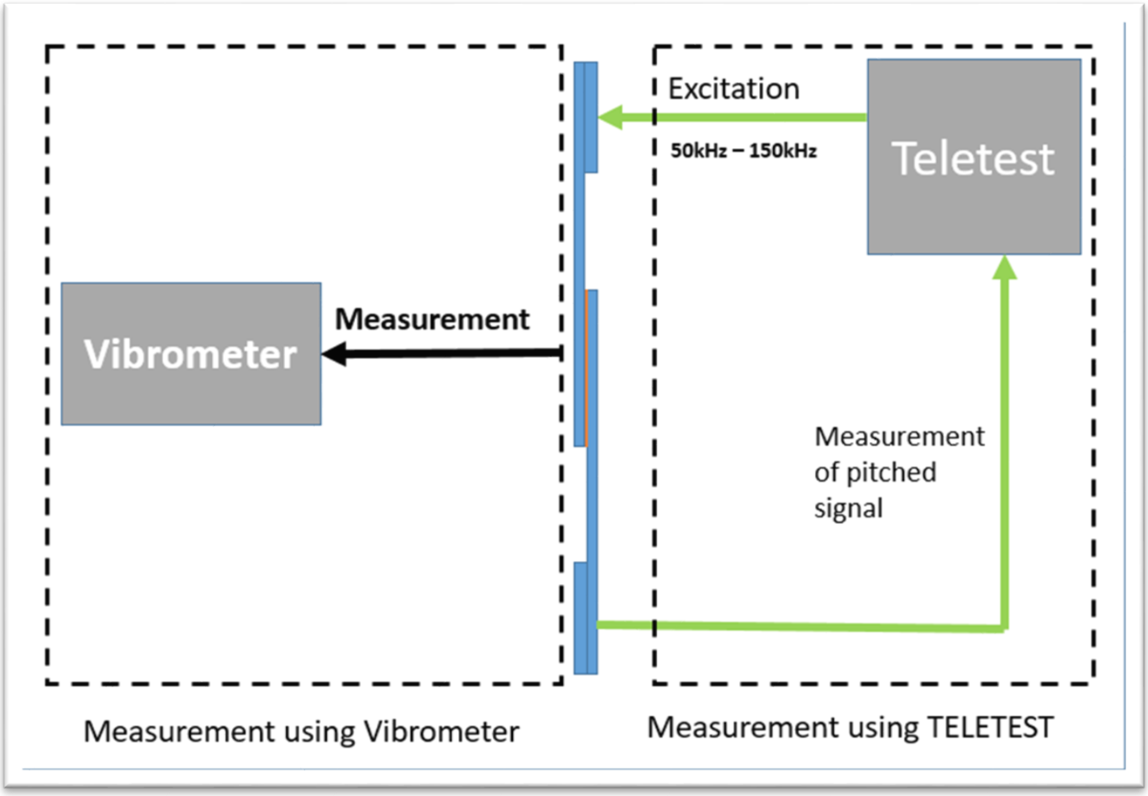

Figure 2: Guided wave NDT block diagram

Transducers from Eddyfy Technologies are attached to the test samples, which include a "ASS-3000-0070-B Fuzz Button Piezo Element & Bonded Face Plate" (see T1 and T2 in Fig 1(a), Fig 1(c)). Piezoelectric material is used to make the transducers, which are capable of vibrating at a variety of frequencies. TELETEST Mk3 equipment is used to excite the transducers at the required frequency. The equipment is capable of generating any frequencies between 20kHz to 200kHz of various modes. Within the range of lower and upper frequency limits, it can generate single, multiple, and sweeping mode of frequencies. In addition, it provides a range of modulation options. The sample surface velocity behaviour is measured with a laser-vibrometer from Polytech as guided waves are imposed on the sample by TELETEST Mk3. The vibrometer is capable of measuring frequencies up to a maximum of 24 MHz

In Figure 2, a block diagram of the experimental setup is shown. Data is collected in two different ways at a time while the guided waves are setup in lap joints. TELETEST is configured to pitch-catch mode to collect the data and at the same time, laser-vibrometer is used to read the test sample response. Figure 2 illustrates the two ways of data collection. In the following subsections, we discuss the technical details of both the data collections.

2.1 Measurement using TELETEST Mk3

Lap joint behaviour is recorded in pitch-catch measurements. To facilitate the testing, transducers are attached to the lap joints (see Fig. 1(c)). Transducer 1 (T1) is used for the excitation and Transducer 2(T2) is used to read the lap joint behaviour to the excitation. A sinusoidal signal ranging in frequency from 50kHz to 150kHz sampled at 1μs with a chirp duration of 500 μs of Tukey factor of 0.25 is given to T1. Guided waves are setup in the lap joint specimen to this excitation signal. As mentioned, the behaviour of the lap joint to the setup guided waves is read using T2 using TELETEST equipment. Each of the six lap joints are tested in the same procedure discussed here.

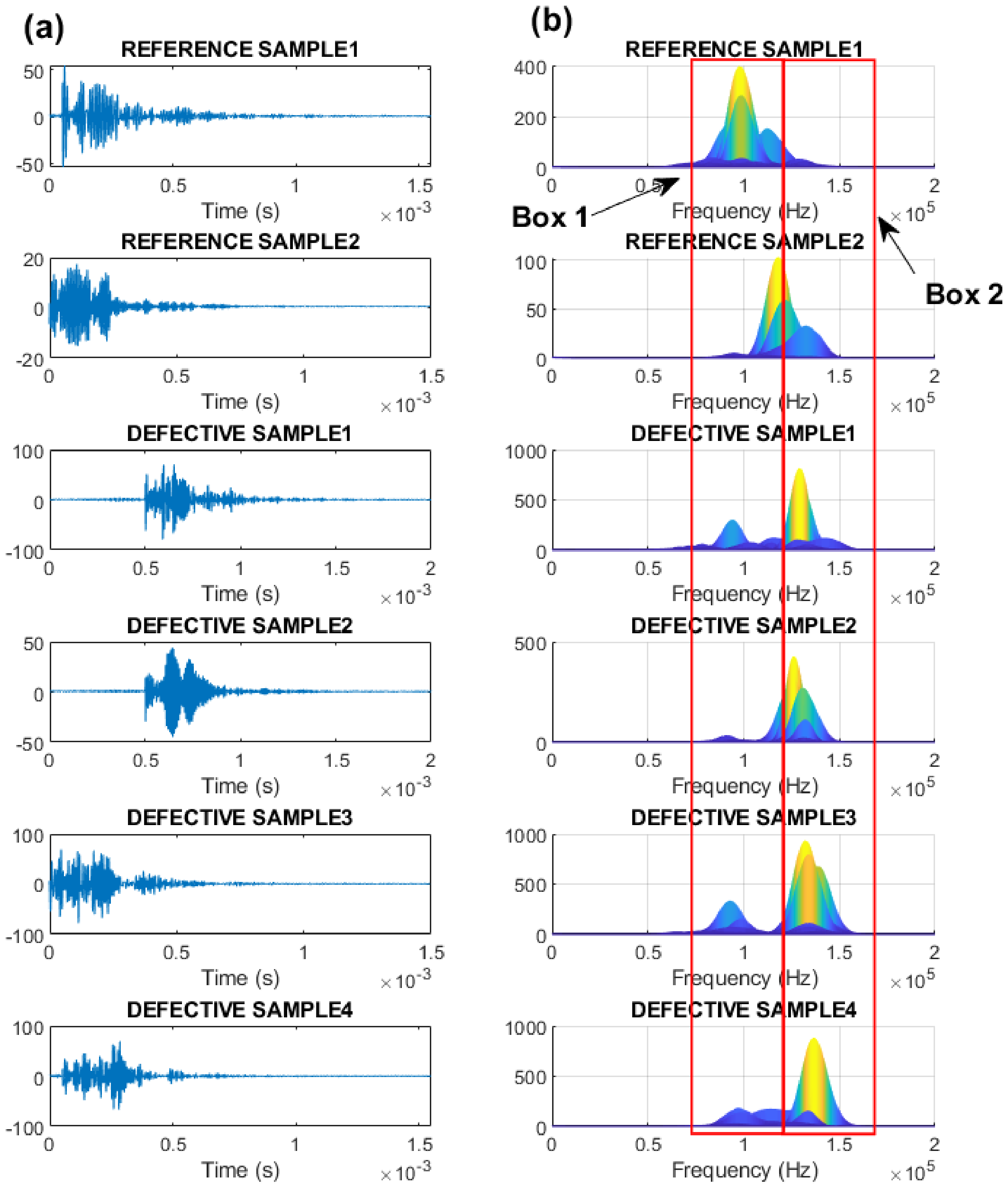

Figure 3: (a) Time response of the test samples (b) Power spectral plot of the time response in frequency domain

Fig. 3 shows the signals recorded during the experiment. All the test results as recorded by T2 are shown on amplitude-time plots in Fig 3(a). Power spectrum plot of the time signals shown in Figure 3(b). Plots of power spectra are shown in the amplitude-frequency domain. For the purpose of illustration of the results, red coloured boxes are placed in the plots with name “Box 1”, “Box 2”.

It is noteworthy that the frequencies with highest amplitudes of the "Reference-Samples" can be found, at frequencies less than 125 kHz. Majority of the peaks in the power spectrum plot of "Reference-Samples" are in "Box 1". The bonded joint therefore acts as a low pass filter in this case.

In the power spectrum plots of "Defective-Sample 1 - 4" it can be noted that the frequencies of highest amplitudes are found at a frequency above 125 kHz. The frequency bands with high amplitudes are all grouped in "Box 2" in the case of "Defective-Sample 1 - 4". Hence, the high pass filter effect is observed at a bonded joint “Defective-Samples”. Hence, there exist a clear difference in the behaviour of the lap joints with kissing bond defects and without kissing bond defects when the guided waves are setup.

4.3. Vibrometer measurement of guided waves

A laser vibrometer is used to measure the behaviour of bonded region of the “test-samples” while the guided waves are setup. Hence, vibrometer picks up the lap joint behaviour while T2 picks up the signal due to the set up guided waves. The results of T2 measurement are discussed in Section 4.2. The laser vibration is focused on a single point on the bonded joint of the “test-sample”, as shown in Figure 2.

In this experiment, T1 is excited by the same signal used in the TELETEST experiments. The laser vibrometer measurements are presented in Fig 4. Fig 4(b) show the time signal recorded by the laser vibrometer and Fig 4(a) is the power spectral plot of the time signal. Fig 4(a) has two boxes on the frequency domain plots for illustration purpose. For the “reference-samples”, the highest peak frequencies are within Box 1. The highest peak frequencies for the “defective-samples” are in Box 2.

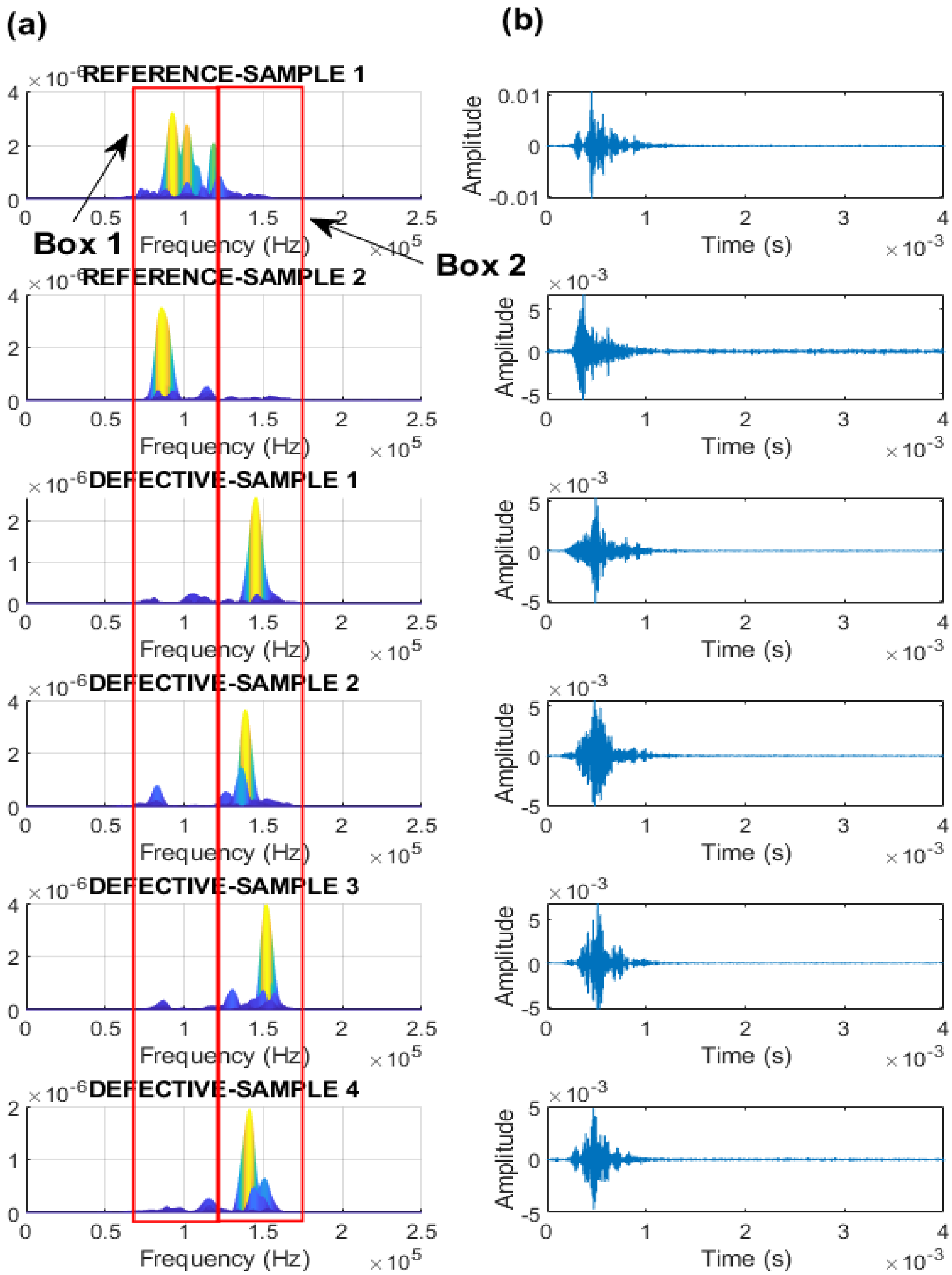

Figure 4: (a) Time signal measured at bonded joint (b) Spectrum plot of the time signal measured at bonded joint