The Design and Simulation Patterns in Ultrasonic Wedges for Non-Destructive Testing

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Received: 6 December 2013 Accepted: 4 January 2014 Published: 15 January 2014

Abstract

The design and simulation patterns in ultrasonic wedges for non-destructive testing are critical to the assessment and characterization of a material or structure. Its significance is the mitigation of failures in members. The approach is relevant mostly to non-destructive testing of very expensive and critical mechanical members requiring high level of reliability in operation. In this paper, the design and simulation of ultrasound through both straight and angle wedges are discussed. Also, the characterization of the material using pulse-echo and through-transmission ultrasonic methods is illustrated.

Index terms— design, simulation, ultrasonic wedges, nondestructive testing.

1 Introduction

he performance and effectiveness of ultrasonic wedges in non-destructive testing cannot be optimised except appropriate design simulation approach is adopted. Design and simulation of the ultrasound will fix problems of wedge configuration and the interface angle [1]. Ultimately, this approach will enable the simulation of the sound wave into the test sample.

In ultrasonic testing, both longitudinal and shear waves can be transmitted into the specimen. However, refracted shear wave is exploited in angle beam inspection because of its low attenuation [2]. Most importantly, when refracted shear waves are utilized only in the inspection, the refracted longitudinal waves align with the material interface, enabling easy and accurate interpretation of signals [3]. The angle of the incident beam at which the parallel alignment of the longitudinal waves with the specimen surface occurs, is called the first critical angle.

Apart from the benefit of having one wave mode in the sample, the critical angle allows the inspection of sample surfaces such as weldments. For this modeconverted system, the transfer of energy is optimised in steel. Also the defect sensitivity is enhanced in the presence of shear waves [3].

2 II.

3 Wedge Design

To optimally design an ultrasonic wedge, some basic specifications must be made. The following are the specifications that were used in the study. Hence, ?"¨ is beyond the first critical angle in steel (i.e. 27.5 0). However, it is below the second critical angle (i.e. 57 0). Therefore, only shear waves would be refracted into the unit under test.

Also, the refracted shear angle ? in the specimen can be estimated as follows:

4 Material Characterization

The sound velocity of the specimen was measured using pulse-echo and through-transmission ultrasound. With this approach, the sound velocity of the specimen of known thickness can be found. Conversely, the sample thickness can be tested for material of known sound velocity especially in stress corrosion control [4].

As will be shown subsequently, the pulse-echo method gives more accurate results than the through transmission. Another advantage with the pulse-echo technique is that it is more amenable to ultrasonic testing because it requires only one scanning surface of the specimen [5].

For a steel block of thickness 20.3mm, the longitudinal sound velocity, using the two ultrasonic techniques, is compared as follows: ??——————————-(The simulation patterns are illustrated below.

5 Discussion of Results

For the experiments on material characterization (see section 3), the ideal longitudinal sound velocity of steel is 5890m/s. This literature value could not be attained due to errors of instruments, operator and temperature variations. Also, the pulse-echo method gave more accurate measurement than the through transmission technique as seen from the small deviation when compared to the literature value.

From Fig. ??, the longitudinal directivity is less directional and less focussed than the shear directivity in In Fig. ??, the longitudinal directivity pattern for the 20 degree wedge is asymmetrical and has a pronounced main lobe while in Fig. ??; the pattern is more distorted with many side lobes.

By reducing the centre frequency of the finite transducer, the following observations are made: a) The longitudinal directivity patterns for the 0 and 20 interface wedges are more omnidirectional compared to the previous patterns in Figs. ?? and 8. b) In Fig. 12, the shear directivity pattern for the 20 degree wedge is larger with fewer side lobes compared to that in Fig. ??.

Finally, it can be seen that the asymmetrical and distorted form of the patterns for the 20 degree angle wedge is due to mode conversion at the material interface. The directivity patterns for the straight wedge are symmetrical and on axis due the absence of mode conversion. Mode conversion is effected when the incident angle is not perpendicular to the interface in the presence of impedance mismatch [7].

6 VI.

7 Conclusion

Appropriate wedge design and simulation will greatly facilitate the modeling of ultrasonic wedges. The approach will determine the critical incident angle which is one of the input parameters to numerical modeling.

Also, the analytical simulation done in this study can provide a reasonable picture of the numerical approach.

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Figure 1: Fig. 1 :

[1]

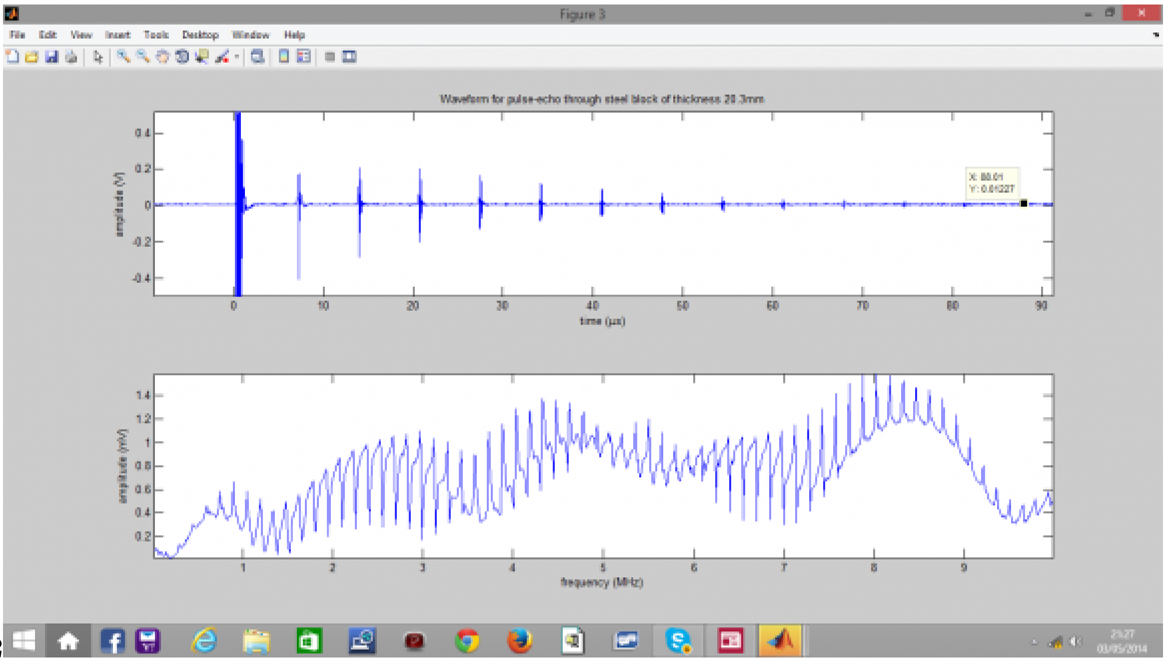
2 

Figure 2: Fig. 2 :

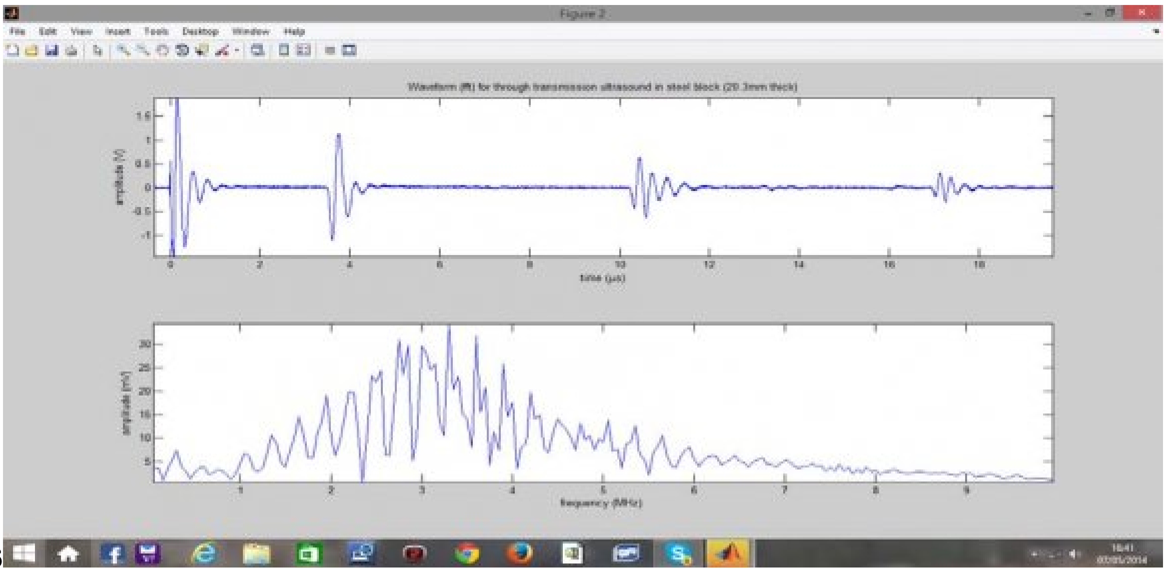
13456 

Figure 3: 1)Fig. 3 :Fig. 4 :Fig. 5 :Fig. 6 :

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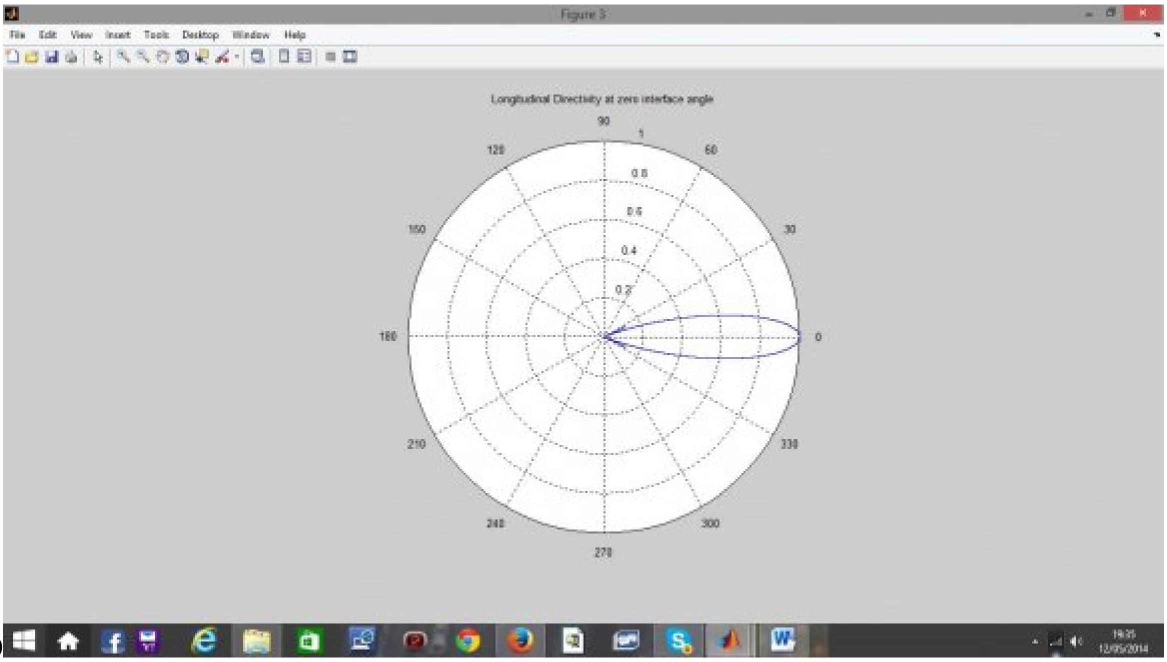

Figure 4: Fig. 8 :Fig. 9 :

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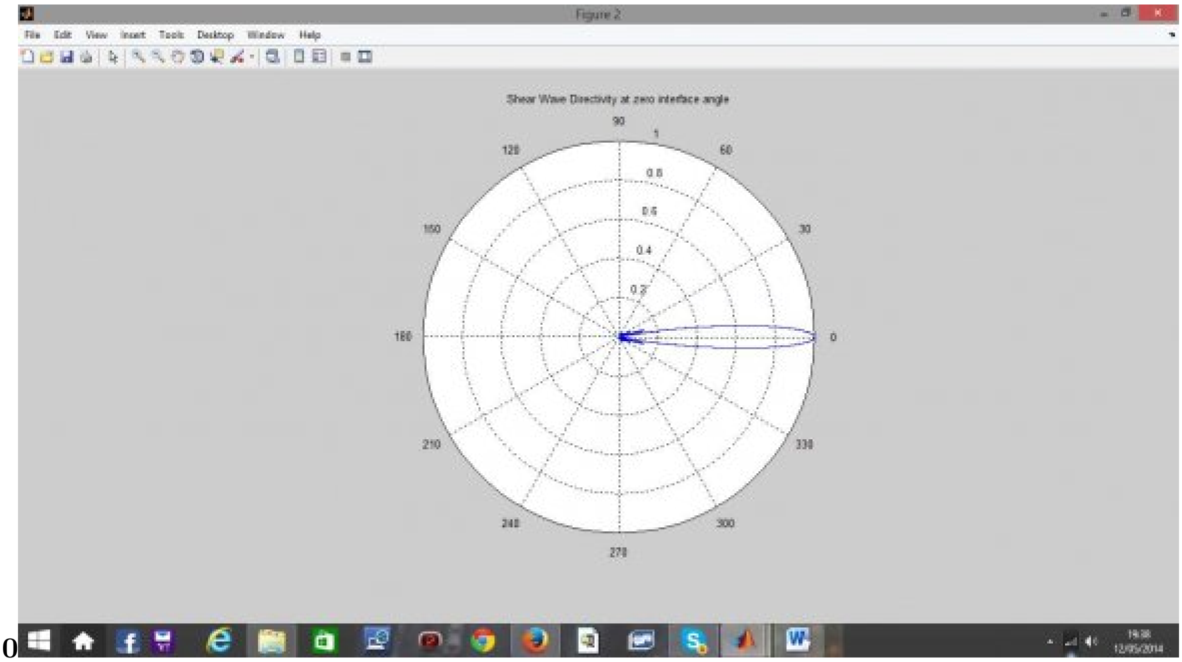

Figure 5: Fig. 10 :

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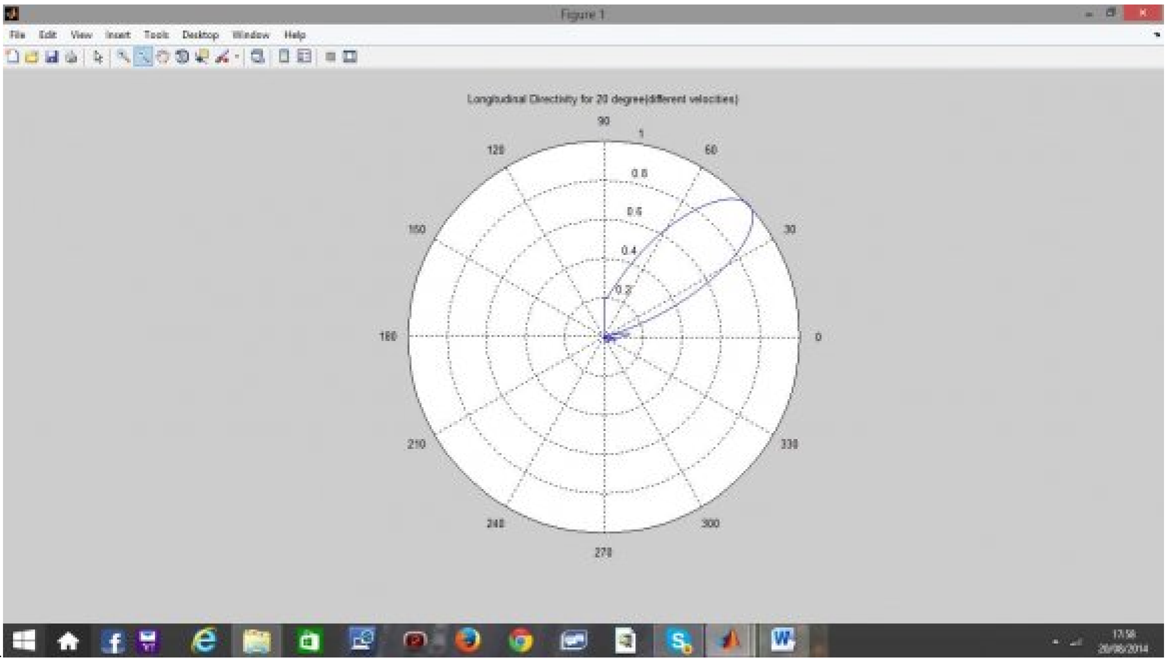

Figure 6: Fig. 11 :

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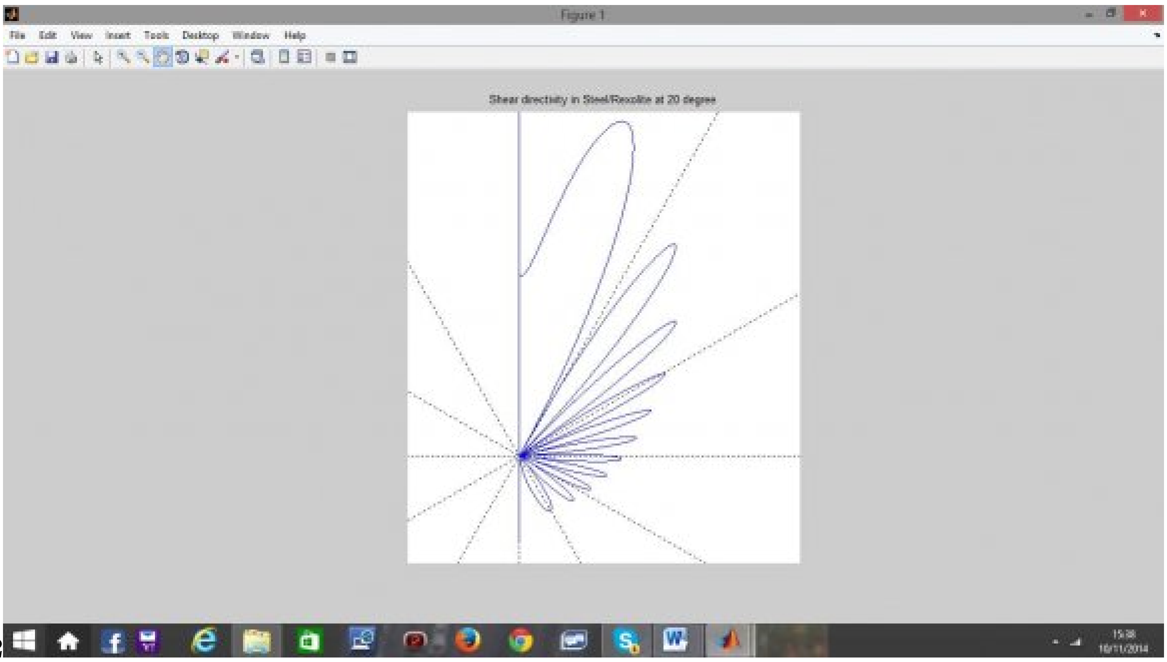

Figure 7: Fig. 12 :

6

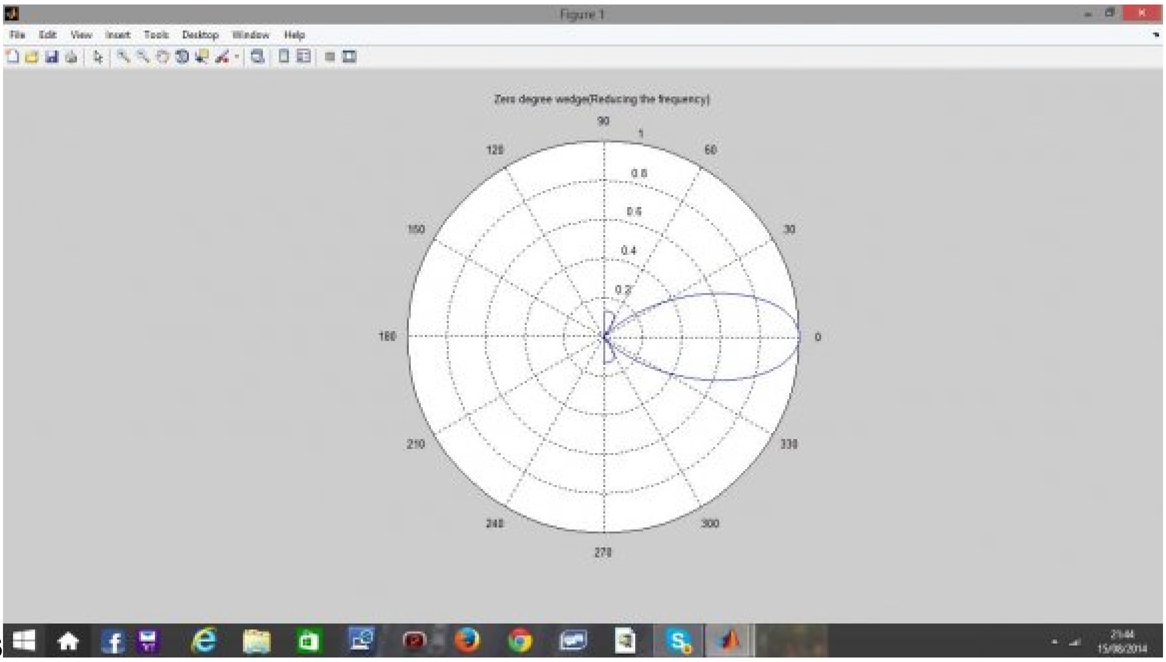

Figure 8: Fig. 6 .

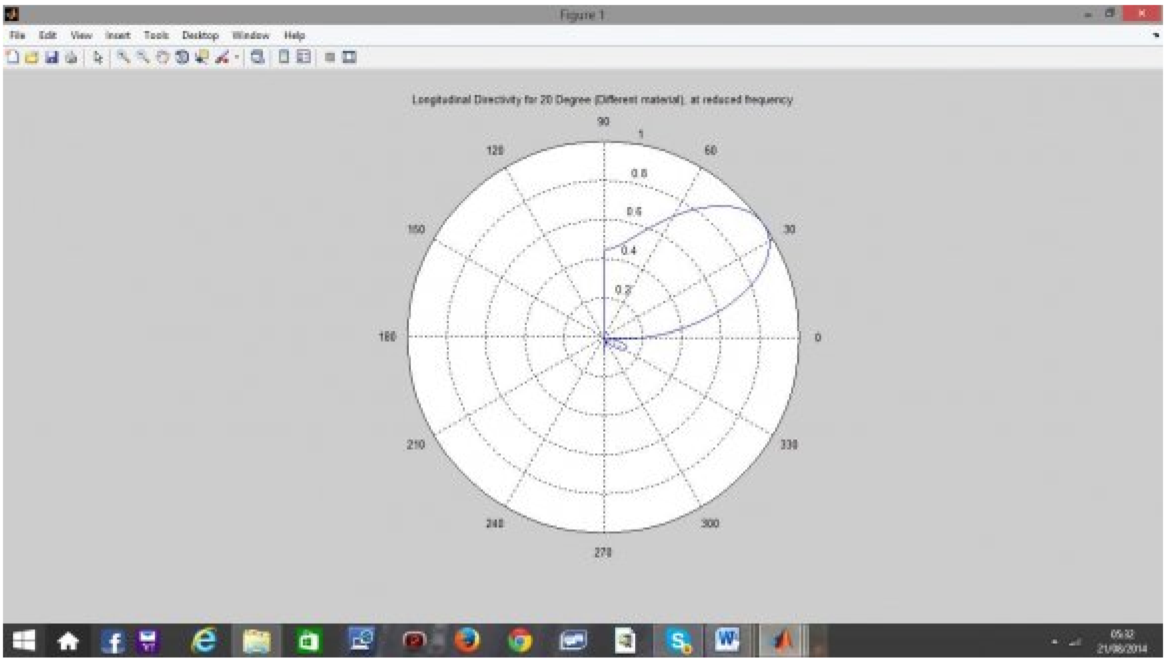

Figure 9:

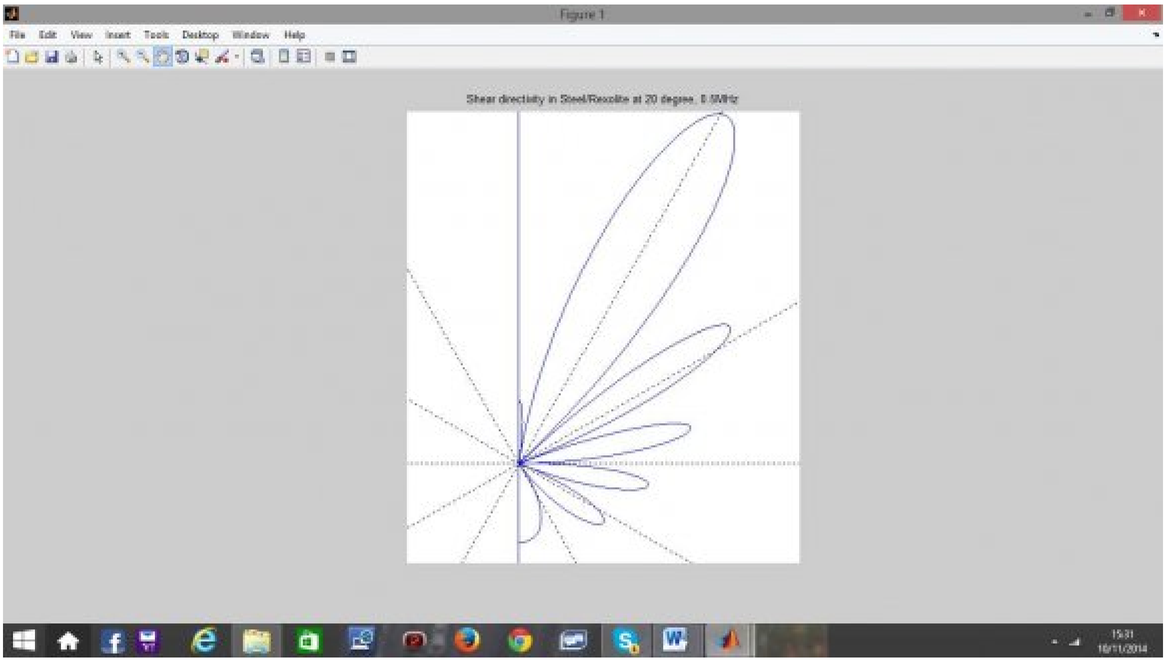
Figure 1
File Edit View Insert Tools Desktop Window Help
Shear directivity in Steel/Rexolite at 20 degree, 0.5MHz

Figure 10:

[Pawlak and Wrobel ()] 'A Comparison Study of Pulse-echo and Through-transmission Ultrasonics in Glass/Epoxy Composites'. S Pawlak , G Wrobel . *Journal of Achievements in Materials and Manufacturing Engineering* 2007.

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