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MICROANNULUS AND CEMENT BOND EVALUATION USING MULTI-MODE MEASUREMENTS

Abstract

Aspects of the subject technology relate to systems, methods, and computer-readable media for determining a quality of cementation and detecting a presence of microannulus formations within the cement bonded to the casing. An example method may include transmitting a first type of energy at a first angle to a surface of a casing of a wellbore. In some instances, the casing may be bonded to cement layer that is between the casing and a formation of the wellbore. Additionally, the example method may include receiving a first signal from the casing. Moreover, the example method may include determining a first attenuation of the first type of energy based on the first signal. Further, the example method may include determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.

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Background/Summary

BACKGROUND
1. Technical Field
[0001] The present disclosure generally relates to microannulus detection and cement bond evaluation.
2. Introduction
[0002] In some examples, a drill site may include one or more wells. Additionally, a wellbore of each of the one or more wells may be cased. For example, casing or tubing may line the surface of the wellbore. Additionally, an adhesive material, such as cement, may be utilized to affix the casing or tubing to the surface of the wellbore. In such examples, a microannulus may form between the casing and the adhesive material, such as cement, that affixes the casing to the wellbore surface.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0003] The various advantages and features of the present technology will become apparent by reference to specific implementations illustrated in the appended drawings. A person of ordinary skill in the art will understand that these drawings only show some examples of the present technology and would not limit the scope of the present technology to these examples. Furthermore, the skilled artisan will appreciate the principles of the present technology as described and explained with additional specificity and detail through the use of the accompanying drawings in which:
[0004] FIG. **1** illustrates an example computing environment, according to some examples of the present disclosure;
[0005] FIG. **2** illustrates an example S0 measurement device within an example wellbore according to some examples of the present disclosure;
[0006] FIG. **3** illustrates an example graph illustrating symmetric lamb wave energy after it passes through mediums with various types of annulus materials, according to some examples of the present disclosure;
[0007] FIG. **4** illustrates an example graph illustrating peak amplitudes of symmetric lamb wave energy as it passes through mediums with various microannulus thicknesses, according to some examples of the present disclosure;
[0008] FIG. **5**, illustrates an example graph illustrating peak amplitude ratios of energy detected by multiple receivers of a S0 measurement detection device as it passes through mediums with various microannulus thicknesses, according to some examples of the present disclosure;
[0009] FIG. **6** illustrates an example graph illustrating peak amplitudes of energy detected by a receiver of an A0 measurement detection device as it passes through mediums with various microannulus thicknesses, according to some examples of the present disclosure;
[0010] FIG. **7** illustrates a flow chart of an exemplary process for determining the presence of a microannulus formation, according to some examples of the present disclosure;
[0011] FIG. **8** illustrates a flow chart of an exemplary process for determining cement property

information and microannulus thickness information, according to some examples of the present disclosure;

[0012] FIG. **9** illustrates an example graph illustrating the generation of different wave modes as the energy is projected at various angles, according to some examples of the present disclosure;

[0013] FIG. **10** illustrates an example pad-based S0 measurement device within an example wellbore according to some examples of the present disclosure;

[0014] FIG. **11** illustrates an example pad-based S0 measurement device within an example wellbore according to some examples of the present disclosure;

[0015] FIGS. **12**A, **12**B, and **12**C illustrates additional configurations of the pad-based SO measurement device;

[0016] FIG. **13** illustrates an example graph illustrating the sensitivity of lamb waves to a medium behind a casing;

[0017] FIG. **14** illustrates another example graph illustrating the sensitivity of lamb waves to a medium behind a casing; and

[0018] FIG. **15** illustrates an example processor-based system with which some aspects of the subject technology can be implemented.

DETAILED DESCRIPTION

[0019] The detailed description set forth below is intended as a description of various configurations of the subject technology and is not intended to represent the only configurations in which the subject technology can be practiced. The appended drawings are incorporated herein and constitute a part of the detailed description. The detailed description includes specific details for the purpose of providing a more thorough understanding of the subject technology.

[0020] However, it will be clear and apparent that the subject technology is not limited to the specific details set forth herein and may be practiced without these details. In some instances, structures and components are shown in block diagram form to avoid obscuring the concepts of the subject technology.

[0021] Cementing a space between a casing and the surface of the wellbore is a key operation during drilling and completion to provide an effective hydraulic isolation. Additionally, cementing may restrict fluid flow between formations around the well bore by providing an effective cement bond between a casing, such as a steel casing, and the formations. However, the quality of cementation could be affected by microannulus formations (e.g., a fine gap) that may develop between cement and the casing, called microannulus. In some examples, cementing evaluation processes may be implemented to determine the quality of the cementation. Examples of cement evaluation processes may include the Pulse Echo technique, the Cement Bond Log (CBL) technique and the flexural Mode technique. In such examples, measurements of the techniques for cement evaluation may be interpreted independently or jointly to determine the quality of the cementing of a wellbore. For example, the joint interpretation of measurements of the Pulse Echo technique and measurements of the CBL technique may indicate the cementing quality of a wellbore. As described herein, the measurements of the CBL technique may be sensitive to the loss of shear coupling between casing and cement, while the measurements of the Pulse-Echo technique may provide apparent annulus impedance which may have been tampered by the presence of microannulus. A combined use of the measurements of the CBL technique and the measurements of the Pulse-Echo technique may provide information about the cementing work quality. However, the CBL technique may have some limitations. For instance, the CBL technique includes utilizing a sonic tool to transmit/output a frequency around 20 kHz to a casing of a wellbore. As such, measurements by the sonic tool may not have a high spatial resolution, axially or azimuthally (e.g., may only indicate the quality of the bond between the cement and the casing and not whether the quality of the bond is due to a microannulus formation).

[0022] In another example, Pulse Echo and Flexural mode attenuation measurements may be used jointly to determine the quality of the cementation. In such an example, the Pulse Echo and flexural mode attenuation measurements are each affected differently by the presence of microannulus formations. However, despite various creative schemes, cement bond evaluation in the presence of possible microannulus is still challenging. For instance, the Pulse Echo technique may be performed twice, with and without additional borehole pressure to close the gap, to obtain enough measurements to determine the quality of the cementation. Such techniques are costly. Further, the impedance from Pulse Echo measurement is not mapped from the readings directly, but derived from inversion schemes, making use of the amplitude ratio, reverberation decay, and/or group delay in frequency domain, and often followed by calibration. Similar to all inversion schemes, there is uncertainty in the output value. The uncertainty of Pulse Echo impedance is in the range of +/−0.5Mrayl. Such uncertainty can affect interpretation in some situations. In another instance, the flexural mode attenuation measurements utilize flexural wave or asymmetric lamb waves (e.g., A0). As described herein, the asymmetric lamb waves may indicate the type of material behind the casing of the medium, such as gas, liquid or solid, but may not be sensitive to the presence of microannulus formations.

[0023] Aspects of the disclosed technology provide solutions for reducing the uncertainties and drawbacks associated with the above describe techniques for determining a quality of cementation and detecting a presence of microannulus formations within the cement bonded to the casing. Additionally, the solutions may include generating a first type of ultrasonic waves, such as symmetric lamb waves, that are more sensitive to the presence of microannulus formations within the cement, and utilizing measurements associated with the first type of ultrasonic waves to determine the quality of the cementation, detecting a presence of microannulus formations within the cement, and in some instances, calculating an impedance of the cement and estimating the microannulus thickness.

[0024] In some examples, a method comprises transmitting a first type of energy at a first angle to a surface of a casing of a wellbore. In some instances, the casing may be bonded to cement layer that is between the casing and a formation of the wellbore. Additionally, the method may further comprise receiving a first signal from the casing. Moreover, the method may further comprise determining a first attenuation of the first type of energy based on the first signal. Further, the method may further comprise determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.

[0025] In other examples, a computing system may comprise a communications interface, a memory storing instructions, and at least one processor coupled to the communications interface and the memory. In such examples, the at least one processor may be configured to execute the instructions to transmit a first type of energy at a first angle and to a surface of a casing of a wellbore. In some instances, the casing being bonded to cement layer that is between the casing and a formation of the wellbore. Additionally, the at least one processor may be further configured to receive a first signal from the casing. Moreover, the at least one processor may be further configured to determine a first attenuation of the first type of energy based on the first signal. Further, the at least one processor may be further configured to determine whether a microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.

[0026] In various examples, a non-transitory computer-readable storage medium storing instructions that, when executed by at least one processor, cause the at least one processor to perform operations comprising transmitting a first type of energy at a first angle to a surface of a casing of a wellbore. In some instances, the casing being bonded to cement layer that is between the casing and a formation of the wellbore. Additionally, the operations further comprise receiving a first signal from the casing. Moreover, the operations further comprise determining a first attenuation of the first type of energy based on the first signal. Further, the operations further comprise determining a microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.

[0027] Referring to FIG. **1**, example computing environment **100** may include a computing system, such as cementing evaluation computing system **110** (herein described as “CE” computing system **110**) and one or more computing devices, such as S0 measurement device **120**, pulse echo device **130**, cement bond long device **140** and A0 measurement device **150**. Additionally, CE computing system **110** may represent a computing system that includes one or more servers and tangible, non-transitory memory devices storing executable code and application modules. The one or more servers may each include one or more processors or processor-based computing devices, which may be configured to execute portions of the stored code or application modules to perform operations consistent with the disclosed embodiments. Moreover, CE computing system **110** may include a communications unit or interface coupled to the one or more processors for accommodating wired or wireless communication across one or more communications networks. Further, each of the computing system and the one or more computing devices may be interconnected through any appropriate combination of communications networks, such as communications network **160**.

[0028] Examples of communications network **160** include, but are not limited to, a wireless local area network (LAN), e.g., a “Wi-Fi” network, a network utilizing radio-frequency (RF) communication protocols, a Near Field Communication (NFC) network, a wireless Metropolitan Area Network (MAN) connecting multiple wireless LANs, and a wide area network (WAN), e.g., the Internet. In some instances, the devices and systems operating within computing environment **100** may perform operations that establish and maintain one or more secure channels of communication across communications network **160**, such as, but not limited to, a transport layer security (TSL) channel, a secure socket layer (SSL) channel, or any other suitable secure communication channel.

[0029] As described herein, the computing system, such as the CE computing system **110** may obtain information about a state of cement that seals an annulus between a casing and a surface of a wellbore the casing is in, such as sound waves/signals propagating through and/or reflected off a medium. In some instances, the medium may include a casing and cement bonded to the casing. Although the description discusses cement, the disclosure provided herein may apply to any material being utilized to seal an annulus between the casing and the surface of the wellbore the casing is in. Additionally, the computing system may determine one or more measurements and characteristics associated with the state of the cement, such as the amplitude of a sound wave. Moreover, the computing system may utilize the one or more measurements to determine whether a microannulus formation is present in the cement.

[0030] In some examples, CE computing system **110** may obtain the information about the state of the cement from S0 measurement device **120**. In such examples, S0 measurement device **120** may include one or more transducers, and one or more receivers. In some instances, the one or more transducers may be configured to project, output or transmit sound **214** at ultrasonic frequencies, such as between 200 kHz to 300 kHz, towards a casing and cement that is bonded to the casing. Additionally, the one or more transducers may transmit the sound at angle **216**, such as between 0 degrees with respect to a horizontal plane or axis and 35 degrees above the horizontal plane or axis. In some instances, the one or more transducers may each be attached to an electrical and/or mechanical component that may adjust angle **216** that the transducers transmit or project sound **214**. Further, the one or more receivers may be configured to detect sound signal **218** of the projected sound that may be propagating and attenuating through the casing and the cement. By way of example, FIG. **2** illustrates environment **200** that includes S0 measurement device **120** within casing **204** of wellbore **202**. In some instances, wellbore **202** may be filled with fluid that may carry energy to and from casing **204**. Additionally, environment **200** may include cement layer **206** that is between the surface **208** of wellbore **202** and casing **204**. Moreover, S0 measurement device **120** may include transducer **212** and receiver **210**. As described herein, transducer **212** may transmit or project sound **214** at an ultrasonic frequency towards casing **204**, and in some instances, through the fluid in wellbore **202**. Additionally, transducer **212** may project the sound at angle **216** above a horizontal plane or axis (e.g., x-axis). The projected sound **214** may propagate through casing **204** and cement layer **206** and may attenuate as it propagates through casing **204** and cement layer **206**. Moreover, receiver **210** may detect a sound signal **218** of projected sound **214** propagating through casing **204**, cement layer **206**, and in some instances, through the fluid. A processor and communications interface (not illustrated in FIG. **2**) may transmit the detected sound signal **218** to CE computing system **110**.

[0031] As described herein, sound projected to the casing and the cement may be in ultrasonic frequencies and may be projected at an angle towards the casing and the cement bonded to the casing. Additionally, the sound signal of the projected sound that is propagating and attenuating through the casing and the cement may include symmetric (e.g., S0) lamb waves. The symmetric lamb waves may be sensitive to the presence of microannulus formations in the material. For example, and referring to FIG. **3**, example graph **300** illustrates the attenuation of energy including symmetric lamb wave dominant ultrasonic sound waves, such as ultrasonic sound wave **302**, ultrasonic sound wave **304** and ultrasonic sound wave **306**, as it passes through mediums with various types of annulus materials. As illustrated in FIG. **3**, the mediums may include a 0.5 inch steel casing fully bonded to a 5 Mrayl cement with no microannulus formations, a 0.5 inch steel casing bonded to a 5 Mrayl cement with a 0.025 mm microannulus formation or channel, and a 0.5 inch steel casing adjacent to a 2 Mrayl mud. Additionally, the detected sound signals may each have originated from an ultrasonic sound projected at the same frequency, such as 200 kHz, to the corresponding medium. Moreover, each of the detected sound signals may be projected to corresponding mediums at the same angle, such as a 10 degree angle above a horizontal plane or axis. As indicated by graph **300**, the amplitude of ultrasonic sound wave **302** may be smaller than the amplitude of ultrasonic sound wave **306** because the ultrasonic sound may be better absorbed by a casing fully bonded to a cement layer with no gaps or microannulus formations than a casing that is bonded to a cement layer that includes microannulus formations. As such, an ultrasonic sound wave may indicate the presence of a microannulus formation when the amplitude is larger. For reference and comparison with ultrasonic sound wave **302** and ultrasonic sound wave **304**, ultrasonic sound wave **306** may characterize an ultrasonic sound propagating and attenuating through the casing in mud (e.g., a mud layer between the casing and the surface of the wellbore). The attenuation of ultrasonic sound wave **306** may be even less than the attenuation of ultrasonic sound wave **304** because mud may absorb the corresponding ultrasonic sound less than the casing that is bonded to a cement layer that includes microannulus formations.

[0032] Additionally, the symmetric lamb waves may be sensitive to the thickness of the microannulus formations in the material. For example, and referring to FIG. **4**, example graph **400** illustrates the peak amplitudes of symmetric lamb wave dominant ultrasonic sound waves or signals propagating and attenuating through mediums with various types of annulus materials. Additionally, a receiver of an S0 measurement device, such as receiver **210** of FIG. **2** may detect the sound waves or signals. The sound waves or signals may include symmetric lamb waves. As illustrated in FIG. **4**, graph **400** may include peak amplitudes of a detected symmetric dominant ultrasonic sound wave **402**, symmetric dominant ultrasonic sound wave **404**, symmetric dominant ultrasonic sound wave **406**, symmetric dominant ultrasonic sound wave **408** and symmetric dominant ultrasonic sound waves **410**. Additionally, symmetric dominant ultrasonic sound wave **402**, symmetric dominant ultrasonic sound wave **404**, symmetric dominant ultrasonic sound wave **406**, symmetric dominant ultrasonic sound wave **408** and symmetric dominant ultrasonic sound waves **410** may have propagated and attenuated through a 5 Mrayl cement, a 4.3 Mrayl cement, a 3.5 Mrayl cement, a 2.8 Mrayl cement, and a 2 Mrayl cement, respectively. Moreover, the detected sound signals may each have originated from an ultrasonic sound projected at the same frequency, such as 200 kHz, to the corresponding medium. Further, each of the detected sound signals may be projected to corresponding mediums at the same angle, such as a 10 degree angle above a horizontal plane or axis. As indicated by graph **400**, the peak amplitude of each detected symmetric lamb wave dominant ultrasonic sound wave drops drastically the smaller the microannulus thickness. For instance, the peak amplitude of symmetric lamb wave dominant ultrasonic sound wave **406** propagating and attenuating through 2.8 Mrayl cement is much lower when the 2.8 Mrayl cement is fully bonded (FB) to cement compared to when the microannulus thickness is 1.6 millimeters (mm). The peak amplitudes of detected symmetric lamb wave dominant ultrasonic sound waves included in graph **400** are drastically lower when the corresponding material or cement is fully bonded to the casing as opposed to when there is any level of microannulus thickness or if it is a free pipe (FP).

[0033] FIG. **5** illustrates another example indicating the sensitivity of symmetric lamb waves with respect to the thickness of a microannulus formation. For example, example graph **500** illustrates peak amplitude ratios of symmetric lamb wave dominant ultrasonic sound waves or signals propagating and attenuating through mediums with various types of annulus materials. The peak amplitude ratios may be between two receivers of a S0 measurement device, such as S0 measurement device **120**. For instance, a first receiver of S0 measurement device **120** may be 8 inches away from a transmitter of S0 measurement device **120**, while a second receiver of SO measurement device **120** may be 15 inches away from a transmitter of S0 measurement device **120**. Additionally, graph **500** may include peak amplitude ratios of symmetric lamb wave dominant ultrasonic sound wave **502**, symmetric lamb wave dominant ultrasonic sound wave **504**, and symmetric lamb wave dominant ultrasonic sound wave **506**. Moreover, symmetric lamb wave dominant ultrasonic sound wave **502**, symmetric lamb wave dominant ultrasonic sound wave **504**, and symmetric lamb wave dominant ultrasonic sound wave **506** may have propagated and attenuated through 5 Mrayl cement, a 3.5 Mrayl cement, and a 2 Mrayl cement, respectively. Further, the detected sound signals may each have originated from an ultrasonic sound projected at the same frequency, such as 200 kHz, to the corresponding medium. Additionally, each of the detected sound signals may be projected to corresponding mediums at the same angle, such as a 10 degree angle above a horizontal plane or axis. Similar to graph **400**, graph **500** indicates the peak amplitude ratios of each detected ultrasonic sound wave drops drastically the smaller the microannulus thickness. For instance, the peak amplitude ratio of symmetric lamb wave dominant ultrasonic sound wave **502** propagating and attenuating through 5 Mrayl cement is much lower when the 5 Mrayl cement is fully bonded (FB) to a casing as compared to when the microannulus thickness is 0.025 mm. The peak amplitude ratios of the detected symmetric lamb wave dominant ultrasonic sound waves included in graph **500** are drastically lower when the corresponding material or cement is fully bonded to the casing as opposed to when there is any level of microannulus thickness or if it is a free pipe (FP).

[0034] Referring back to FIG. **1**, S0 measurement device **120** may transmit, over one or more communications networks, such as communications network **160**, the detected sound signals to CE computing system **110**. In some examples, S0 measurement device **120** may include one or more processors and at least one communications interface or unit. In such examples, the one or more processors may transmit, over the one or more communications networks and to CE computing system **110**, the sound signals via the communications interface or unit. Additionally, CE computing system **110** may receive the detected sound signal generated by S0 measurement device **120** and determine one or more measurements based on the detected sound signal. As described herein, the sound signal may include symmetric lamb waves. In some examples, SO measurement device **120** may transmit, along with the detected sound signal, original sound data identifying and characterizing the frequency of the originally projected sound that corresponds to the detected sound signal and the angle at which the originally projected sound was projected at by one or more transducers of S0 measurement device **120**.

[0035] In some examples, at least one processor of CE computing system **110** may execute evaluation engine **116**. Executed evaluation engine **116** may obtain the detected sound signal from

S0 measurement device **120** and determine the one or more measurements based on the detected sound signal. For instance, executed evaluation engine **116** may determine a waveform of the detected sound signal generated by S0 measurement device **120**, such as ultrasonic sound wave **302** of FIG. **3**. Additionally, executed evaluation engine **116** may determine one or more characteristics or measurements for the determined waveform, such as the amplitude. Further, executed evaluation engine **116** may generate measurement data that identifies and characterizes the one or more measurements of the determined waveform. In some instances, measurement data may include one or more portions of the original sound data. In such instances, measurement data may identify and characterize the frequency of the corresponding originally projected sound and/or the angle at which the originally projected sound was projected at. In other instances, executed evaluation engine **116** may perform operations that store, within the one or more tangible non-transitory memories of CE computing system **110**, such as SO measurement database **117** of data repository **112**, the measurement data and the sound signal generated and received from S0 measurement device **120**.

[0036] Additionally, CE computing system **110** may determine whether a microannulus formation is present in a medium based on measurement data. For example, executed evaluation engine **116** may determine whether a microannulus formation is present in a medium (e.g., a casing and cement bonded to the casing) the measurement data is associated with. In some instances, executed evaluation engine **116** may determine whether a microannulus formation is present in the medium associated with the measurement data based on the measurement data and reference data. As described herein, reference data may be stored in S0 measurement database **117** and may include a record of determined measurements of waveforms for different mediums. For instance, the record of reference data may identify one or more mediums. Additionally, the record may identify and characterize, for each of the one or more mediums, the dimensions of the casing and the material the casing is bonded to, such as cement, one or more measurements of a waveform determined for the medium, the waveform, a frequency of an originally projected sound the waveform corresponds to, and an angle the originally projected sound is projected from.

[0037] Further, executed evaluation engine **116** may determine the presence of the microannulus formation in the medium by comparing the measurement data with the reference data. By way of example, executed evaluation engine **116** may parse measurement data to determine the frequency of the corresponding originally projected sound and/or the angle at which the originally projected sound was projected at. Additionally, executed evaluation engine **116** may identify portions of reference data that identifies similar or matching frequency and/or angle. The identified portions may include one or more measurements or characteristics of wave forms of various casing and cementing compositions. For instance, and referring to FIG. **3**, executed evaluation engine **116** may determine the frequency of the corresponding originally projected sound is 200 kHz and that the angle at which the originally projected sound is 10 degrees above a horizontal plane or axis. Additionally, based on the determined frequency and angle, executed evaluation engine **116** may identify one or more portions of reference data that identifies and characterizes waveforms and corresponding measurements as similarly illustrated and described with ultrasonic sound wave **302**, ultrasonic sound wave **304** and ultrasonic sound wave **306**. As illustrated in FIG. **3**, ultrasonic sound wave **302** is associated with a casing and cementing composition where the casing and cement are fully bonded (e.g., 5 Myral cement fully bonded) with no microannulus formations, ultrasonic sound wave **304** is associated with a casing and cementing composition where the casing and cement are bonded (e.g., 5 Myral cement) with a 0.025 mm microannulus formation/channel, and ultrasonic sound wave **306** is associated with a casing and cementing composition where the casing is in mud (e.g., 2 Myral mud).

[0038] Moreover, executed evaluation engine **116** may compare the one or more measurements identified and characterized by the measurement data with one or more measurements identified and characterized by the identified portions of reference data. For instance, and referring back to

FIG. **3**, executed evaluation engine **116** may compare the one or more measurements of the measurement data, such as one or more amplitudes, to the amplitudes of at least ultrasonic sound wave **302** and ultrasonic sound wave **304**. Based on the comparison, executed evaluation engine **116** may determine which of the one or more measurements or characteristics of wave forms of various casing and cementing compositions identified and characterized in the identified portions of reference data matches or is similar to the one or more measurements identified and characterized in the measurement data. Such a determination may indicate whether the measurement data indicates the presence of a microannulus formation in the medium. For instance, and referring back to FIG. **3**, executed evaluation engine **116** may determine the one or more measurements identified and characterized in the measurement data, such as one or more amplitudes of a waveform included in measurement data, is similar to or matches one or more amplitudes of ultrasonic sound wave **302**. In such an instance, executed evaluation engine **116** may determine the measurement data indicates no presence of a microannulus formation. In another instance, and referring back to FIG. **3**, executed evaluation engine **116** may determine the one or more measurements identified and characterized in the measurement data, such as one or more amplitudes of a waveform included in measurement data, is similar to or matches one or more amplitudes of ultrasonic sound wave **304**. In such an instance, executed evaluation engine **116** may determine the measurement data indicates a presence of a microannulus formation.

[0039] In some examples, CE computing system **110** may adjust the angle at which a transducer of S0 measurement device **120** projects or transmits sound. Additionally, or alternatively, CE computing system **110** may adjust the frequency of the sound projected or transmitted by the transducer of by S0 measurement device **120**. In some instances, CE computing system **110** may transmit instructions to SO measurement device **120** over one or more communications networks, such as communications network **160**, and via a communications interface or unit of S0 measurement device **120**. The instructions may indicate the angle that one or more transducers of SO measurement device **120** is to project or transmit a sound towards the casing. Additionally, the communications interface may route the instructions to one or more processors of SO measurement device **120**. The one or more processors may cause an electrical or mechanical component of one or more transducers of S0 measurement device **120** to adjust the angle of the corresponding transducer in accordance with the angle indicated in the instructions. Additionally, or alternatively, the instructions may indicate the frequency of the projected sound.

[0040] Further, the one or more processors may cause the one or more transducers to project the sound at the frequency indicated in the instructions. In some instances, the instructions may be based on a user provided input.

[0041] In other examples, CE computing system **110** may adjust the angle at which a receiver of S0 measurement device **120** may detect a sound signal propagating through the casing and the material. In such examples, CE computing system **110** may transmit instructions to S0 measurement device **120** over one or more communications networks, such as communications network **160**, and via a communications interface or unit of S0 measurement device **120**. The instructions may indicate the angle that one or more receivers of S0 measurement device **120** is to detect the sound signal propagating through the medium. Additionally, the communications interface may route the instructions to one or more processors of S0 measurement device **120**. The one or more processors may cause an electrical or mechanical component of one or more receivers of S0 measurement device **120** to adjust the angle of the corresponding receiver in accordance with the angle indicated in the instructions. In some instances, the instructions may be based on a user provided input.

[0042] In various examples, CE computing system **110**, such as executed evaluation engine **116**, may perform any of the example processes described herein to determine the quality of the cementation, detecting a presence of microannulus formations within the medium (e.g., cement), and in some instances, calculating an impedance of the medium and estimating the microannulus thickness. In such examples, CE computing system **110** may utilize measurements associated with sound signals obtained from S0 measurement device **120**, such as measurements associated with symmetric lamb wave dominant ultrasonic sound waves or signals, along with other measurements to make such determinations. Additionally, the other measurements may be based on information, such as sound signals, obtained from other computing devices, such as pulse echo device **130**, cement bond log device **140** and A0 measurement device **150**.

[0043] For example, CE computing system **110** may receive predicted cement property information (e.g., a value corresponding to the cement property) and predicted microannulus thickness information for a particular medium bonded to a casing (e.g., a value corresponding to the miraculous thickness between cement layer **206** and casing **204** of FIG. **2**), such as 5 Mrayl cement. Additionally, CE computing system **110** may determine predicted pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements based on the predicted cement property information and predicted microannulus thickness information. In some instances, CE computing system **110** may apply forward modeling techniques (numerically or using a proxy) to the predicted cement property information and predicted microannulus thickness information. Based on the application of the forward modeling techniques to the predicted cement property information and predicted microannulus thickness information, CE computing system **110** may determine predicted pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements based on the predicted cement property information. Moreover, CE computing system **110** may obtain the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements from pulse echo device **130**, A0 measurement device **150**, S0 measurement device **120**, and/or cement bond log device **140**, respectively. Further, CE computing system **110** may compare the predicted to the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements. Based on the comparison, CE computing system **110** may determine the difference between the predicted to the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements and determine whether the difference is smaller than a threshold value. As described herein, the threshold value may indicate an acceptable error threshold between the predicted to the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements.

[0044] In instances where CE computing system **110** determines the difference is smaller than the threshold value, CE computing system **110** may determine the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements match. Additionally, CE computing system **110** may determine the predicted cement property information and the predicted microannulus thickness information is accurate based on determining the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements match. Further, CE computing system **110** may output data indicating the property of the medium (e.g., the cement) based on the predicted cement property information and the predicted microannulus thickness information.

[0045] In instances where CE computing system **110** determines the difference is greater than or equal to the threshold value, CE computing system **110** may determine the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements do not match. Additionally, based on determining the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements do not match, CE computing system **110** may adjust the predicted cement property information and the predicted microannulus thickness information. Further, CE computing system **110** may repeat the example processes as described herein to determine whether the adjusted predicted cement property information and the adjusted predicted microannulus thickness information is accurate.

[0046] In some instances, executed evaluation engine **116** may obtain, from cement bond log device **140**, sound signals detected by a receiver of cement bond log device **140** that were propagating and attenuating through a medium. The medium may be the same medium of the measurement data. Additionally, the sound signals may originate from a sound projected by a transducer of the cement bond log device **140**, and the projected sound may be of a lower frequency than the frequency indicated in the measurement data (e.g., 20-30 kHz). Moreover, executed evaluation engine **116** may determine a waveform corresponding to the sound signals detected by cement bond log device **140** and determine one or more cement bond log measurements or characteristics associated with the waveform, such as the amplitude of the waveform. Further, executed evaluation engine **116** may determine one or more additional cement bond log measurements, such as the bond quality of the medium (e.g., the bond quality between a casing and cement), based on the one or more cement bond log measurements. For instance, executed evaluation engine **116** may determine for waveforms of sound signals obtained from mediums that have lower amplitudes, the bond quality of the casing and cement may be stronger compared to waveforms of sound signals obtained from mediums that have higher amplitudes. In some instances, executed evaluation engine **116** may perform operations that store, within the one or more tangible non-transitory memories of CE computing system **110**, such as cement bond log database **113** of data repository **112**, the sound signal generated and received from cement bond log device **140** and corresponding cement bond log measurements.

[0047] In other instances, executed evaluation engine **116** may obtain, from pulse echo device **130**, sound signals detected by a receiver of pulse echo device **130** may be propagating and attenuating through a medium. The medium may be the same medium of the measurement data. Additionally, the sound signals may originate from a sound projected by a transducer of pulse echo device **130**, and the projected sound may be an ultrasonic frequency (e.g., 200-300 kHz). Moreover, executed evaluation engine **116** may determine a waveform corresponding to the sound signals detected by pulse echo device **130** and determine one or more pulse echo measurements or characteristics associated with the waveform, such as the amplitude of the waveform. Further, executed evaluation engine **116** may determine additional pulse echo measurements, such as the depth or impedance of the medium (e.g., the depth or impedance between a casing and cement), based on the one or more pulse echo measurements. In some instances, executed evaluation engine **116** may perform operations that store, within the one or more tangible non-transitory memories of CE computing system **110**, such as pulse echo database **114** of data repository **112**, the sound signal generated and received from pulse echo device **130** and corresponding pulse echo measurements.

[0048] In various instances, executed evaluation engine **116** may obtain, from A0 measurement device **150**, sound signals detected by a receiver of A0 measurement device **150** may be propagating and attenuating through a medium. The medium may be the same medium of the measurement data. Additionally, the sound signals may originate from a sound projected by a transducer of A0 measurement device **150**, and the projected sound may be an ultrasonic frequency (e.g., 200-300 kHz). Moreover, the projected sound may be projected at an angle, such as an angle between 0 degrees with respect to a horizontal plane or axis and 35 degrees above the horizontal plane or axis. The sound signals that are propagating and attenuating through the medium may include an A0 measurement wave or asymmetric (e.g., A0) lamb waves. As described herein, the asymmetric lamb waves may indicate the type of material behind the casing of the medium, such as gas, liquid or solid. Additionally, executed evaluation engine **116** may determine a waveform corresponding to the sound signals detected by A0 measurement device **150** and determine one or more asymmetric lamb wave measurements or characteristics associated with the waveform, such as the amplitude of the waveform. Further, executed evaluation engine **116** may determine one or more additional asymmetric lamb wave measurements, such as the type of material behind the casing of the medium (e.g., cement) based on the one or more asymmetric lamb wave measurements. For instance, executed evaluation engine **116** may determine a vibrational energy of the sound signals based on the sound signals. Additionally, executed evaluation engine **116** may determine the type of material based on how large the vibrational energy is. In some instances, each type of material may be associated with a predetermined range of vibrational energy. As such, executed evaluation engine **116** may determine the material is gas if the vibrational energy is within a first range of vibrational energy, the material is liquid if the vibrational energy is within a second range of vibrational energy, and the material is solid if the vibrational energy is within a third range of vibrational energy. In such instances, the first range of vibrational energy may be higher than the second range of vibrational energy and the third range of vibrational energy and the second range of vibrational energy is higher than the third range of vibrational energy. In other instances, executed evaluation engine **116** may perform operations that store, within the one or more tangible non-transitory memories of CE computing system **110**, such as A0 measurement database **115** of data repository **112**, the sound signal generated and received from A0 measurement device **150** and corresponding asymmetric lamb wave measurements.

[0049] In some instances, the asymmetric lamb waves may be sensitive to a change of a thickness of a microannulus formation. In such instances, the response may be more prominent than that of a symmetric lamb wave. For example, and referring to FIG. **6**, example graph **600** illustrates the peak amplitudes of asymmetric lamb wave dominant ultrasonic sound waves or signals propagating and attenuating through mediums with various types of annulus materials. Additionally, the sound waves or signals may be detected by a receiver of an A0 measurement device, such as A) measurement device **150**, and may include asymmetric lamb waves. As illustrated in FIG. **6**, graph **600** may include peak amplitudes of a detected asymmetric dominant ultrasonic sound wave **602**, asymmetric dominant ultrasonic sound wave **604**, asymmetric dominant ultrasonic sound wave **606**, asymmetric dominant ultrasonic sound wave **608** and asymmetric dominant ultrasonic sound waves **610**. Additionally, asymmetric dominant ultrasonic sound wave **602**, asymmetric dominant ultrasonic sound wave **604**, asymmetric dominant ultrasonic sound wave **606**, asymmetric dominant ultrasonic sound wave **608** and asymmetric dominant ultrasonic sound waves **610** may have propagated and attenuated through a 5 Mrayl cement, a 4.3 Mrayl cement, a 3.5 Mrayl cement, a 2.8 Mrayl cement, and a 2 Mrayl cement, respectively. Moreover, the detected sound signals may each have originated from an ultrasonic sound projected at the same frequency, such as 200 kHz, to the corresponding medium. Further, each of the detected sound signals may be projected to corresponding mediums at the same angle, such as a 30 degree angle above a horizontal plane or axis. As indicated by graph **600**, a change in the peak amplitude of each detected asymmetric lamb wave dominant ultrasonic sound wave is relatively small and behaves differently for lighter and heavier cement. Additionally, there is an increase am peak amplitude between 3.2 mm to 1.6 mm microannulus thicknesses and a steep drop between 0.2 mm and 1.6 mm microannulus thicknesses.

[0050] FIG. **7** is a flow chart of example process **700** for determining whether a microannulus formation is present in a medium (e.g., a casing and cement bonded to the casing). In some instances, one or more components of computing environment **100** may perform all or a portion of the steps of example process **700**, which include but are not limited to transmitting a first type of energy at a first angle to a surface of a casing of a wellbore, receiving a first signal from the casing, determining a first attenuation of the first type of energy based on the first signal, and determining whether a microannulus formation is present between the casing and the cement layer.

[0051] Referring to FIG. **7**, CE computing system **110** may cause S0 measurement device **120** to transmit a first type of energy at a first angle to a surface of a casing of a wellbore (e.g., step **710**). In some examples, executed evaluation engine **116** may transmit instructions to S0 measurement device **120** over one or more communications networks, such as communications network **160**, and via a communications interface or unit of S0 measurement device **120**. Additionally, the instructions may indicate a frequency the one or more transducers, such as transducer **212**, of S0 measurement device **120** may project sound at. As described herein, the frequency may be within an ultrasonic frequency range (e.g., 200 kHz to 300 kHz). Moreover, the instructions may indicate an angle the one or more transducers of S0 measurement device **120** is to project or transmit the sound towards a medium (e.g., casing **204** and cement layer **206** of FIG. **2**). In some instances, the angle may be between 0 degrees with respect to a horizontal plane or axis and 35 degrees above the horizontal plane or axis. Further, one or more processors of S0 measurement device **120** may cause the one or more transducers to project the sound at the frequency and angle indicated in the instructions.

[0052] As described herein, the sound projected onto the medium may propagate and attenuate through the medium. Additionally, the angle and frequency, such as an angle between 0 degrees with respect to a horizontal plane or axis and 35 degrees above the horizontal plane or axis and a frequency within an ultrasonic frequency range (e.g., 200 kHz to 300 kHz) may cause the sound propagating and attenuating through the medium to include symmetric lamb waves. The symmetric lamb waves, as described herein, may be sensitive to the presence of microannulus formations within the medium (e.g., cement layer **206** bonded to casing **204** of FIG. **2**).

[0053] Additionally, CE computing system **110** may receive a first sound signal from the casing (e.g., step **720**). In some examples, one or more receivers of S0 measurement device **120**, such as receiver **210**, may detect the sound signal of the projected sound propagating and attenuating through the medium (e.g., casing **204** and cement layer **206**). As described herein, the sound signal propagating and attenuation through the medium may include symmetric lamb waves. Additionally, the one or more processors may transmit the detected sound signal to executed evaluation engine **116**. In some examples, S0 measurement device **120** may transmit original sound data identifying and characterizing the frequency of the originally projected sound that corresponds to the sound signal and the angle at which the originally projected sound was projected at by one or more transducers of S0 measurement device **120**.

[0054] In some examples, CE computing system **110** may adjust the angle at which a receiver of S0 measurement device **120** may detect the sound signal propagating through the medium. In such examples, CE computing system **110** may transmit instructions to SO measurement device **120** over one or more communications networks, such as communications network **160**, and via a communications interface or unit of S0 measurement device **120**. The instructions may indicate the angle that one or more receivers of S0 measurement device **120** is to detect the sound signal from the medium. Additionally, the communications interface may route the instructions to one or more processors of S0 measurement device **120**. The one or more processors may cause an electrical or mechanical component of one or more receivers of S0 measurement device **120** to adjust the angle of the corresponding receiver in accordance with the angle indicated in the instructions. In some instances, the instructions may be based on a user provided input. In other instances, the angle can also be set manually before the logging and fixed during the logging.

[0055] Referring to FIG. **7**, CE computing system **110** may determine a first attenuation of the first type of energy based on the first signal (e.g., step **730**). In some examples, executed evaluation engine **116** may receive the sound signal from SO measurement device **120**. Additionally, executed evaluation engine **116** may determine a waveform of the sound signal generated by S0 measurement device **120**. Moreover, executed evaluation engine **116** may determine one or more measurements or characteristics of the waveform, such as one or more amplitudes. The waveform may represent the attenuation of the sound signal detected by S0 measurement device **120**. Further, executed evaluation engine **116** may generate measurement data that identifies and characterizes the one or more measurements of the determined waveform. In some instances, measurement data may include one or more portions of the original sound data. In such instances, measurement data may identify and characterize the frequency of the corresponding originally projected sound and/or the angle at which the originally projected sound was projected at.

[0056] Additionally, CE computing system **110** may determine whether a microannulus formation is present between the casing and the cement layer (e.g., step **740**). In some examples, executed evaluation engine **116** may determine whether a microannulus formation is present in a medium (e.g., a casing and cement bonded to the casing) the measurement data is associated with. In some examples, executed evaluation engine **116** may determine whether a microannulus formation is present in the medium associated with the measurement data based on the measurement data and reference data. As described herein, reference data may be stored in SO measurement database **117** and may include a record of determined measurements of waveforms for different mediums. For example, the record of reference data may identify one or more mediums. Additionally, the record may identify and characterize, for each of the one or more mediums, the dimensions of the casing and the material the casing is bonded to, such as cement, one or more measurements of a waveform determined for the medium, the waveform, a frequency of an originally projected sound the waveform corresponds to, and an angle the originally projected sound is projected from. In some instances, may compare the measurement data with the reference data. Additionally, executed evaluation engine **116** may determine whether a microannulus formation is present in the in a medium (e.g., a casing and cement bonded to the casing) the measurement data is associated with, based on the comparison between the measurement data and the reference data.

[0057] FIG. **8** is a flow chart of example process **800** for determining the quality of the cementation, detecting a presence of microannulus formations within the medium, and in some instances, calculating an impedance of the medium and estimating the microannulus thickness. In some instances, one or more components of computing environment **100** may perform all or a portion of the steps of example process **800**, which include but are not limited to receiving predicted cement property information and predicted microannulus thickness information, predicting pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements, obtaining actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements, determining a difference between the predicted and actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging, determining whether the difference is smaller than a threshold value, and based on determining whether the difference is smaller than the threshold value, outputting the predicted cement property information and the predicted microannulus thickness information or adjusting the predicted cement properties information and predicted microannulus thickness information.

[0058] Referring to FIG. **8**, CE computing system **110** may receive predicted cement property information and predicted microannulus thickness information (e.g., step **810**). Additionally, CE computing system **110** may predict pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements (e.g., step **820**). In some examples, CE computing system **110** may apply forward modeling techniques (numerically or using a proxy) to the predicted cement property information and predicted microannulus thickness information. Based on the application of the forward modeling techniques to the predicted cement property information and predicted microannulus thickness information, CE computing system **110** may determine predicted pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements based on the predicted cement property information.

[0059] Moreover, CE computing system **110** may obtain actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements (e.g., step **830**). As described herein, CE computing system **110** may obtain the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements from pulse echo device **130**, A0 measurement device **150**, S0 measurement device **120**, and/or cement bond log device **140**, respectively.

[0060] Further, CE computing system **110** may determine a difference between the predicted and actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging (e.g., step **840**). Additionally, CE computing system **110** may determine whether the difference is smaller than a threshold value (e.g., step **850**). In instances where CE computing system **110** determines the difference is smaller than the threshold value, CE computing system **110** may output the predicted cement property information and the predicted microannulus thickness information (e.g., step **870**). In some instances, CE computing system **110** may determine the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements match. Additionally, CE computing system **110** may determine the predicted cement property information and the predicted microannulus thickness information is accurate based on determining the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements match. Further, CE computing system **110** may output data indicating the property of the medium (e.g., the cement) based on the predicted cement property information and the predicted microannulus thickness information.

[0061] In instances where CE computing system **110** determines the difference is greater than or equal to the threshold value, CE computing system **110** may adjust the predicted cement properties information and predicted microannulus thickness information (e.g., step **870**). In some instances, CE computing system **110** may determine the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements do not match. Additionally, based on determining the predicted and the actual pulse echo measurements, asymmetric lamb wave measurements, symmetric lamb wave measurements and/or cement bond logging measurements do not match, CE computing system **110** may adjust the predicted cement property information and the predicted microannulus thickness information. Further, CE computing system **110** may repeat example process **800** as described herein to determine whether the adjusted predicted cement property information and the adjusted predicted microannulus thickness information is accurate.

A. Multi-Modal S0 Measurement Device with Centered Sensors.

[0062] In some examples, S0 measurement device **120** may be configured to cause symmetric lamb waves and asymmetric lamb waves. Additionally, executed evaluation engine **116** may determine the material behind the casing of the medium and whether a microannulus formation is present in the medium based on sound signals from S0 measurement device **120**. In such examples, S0 measurement device **120** may operate in multiple modes. Additionally, each mode may be associated with one or more transducers of S0 measurement device **120** being configured in a particular angle. As described herein, the one or more transducers may project sound at the medium (e.g., the casing and the cement) at an ultrasonic frequency (e.g., 200 kHz to 300 kHz), and the angle at which the one or more transducers may project sound may cause the generation of symmetric lamb waves and/or asymmetric lamb waves within the medium. Further, executed evaluation engine **116** may cause S0 measurement device **120** to operating in a particular mode while S0 measurement device **120** is traveling in a particular direction within a wellbore.

[0063] By way of example, and referring to FIG. **2**, S0 measurement device **120** may travel in a first direction (e.g., down wellbore **202**). Additionally, executed evaluation engine **116** may transmit an instruction to S0 measurement device **120**. The instruction may cause S0 measurement device **120** to adjust the angle of transducer **212** to a first angle, such as 10 degrees above the horizontal plane or axis (e.g., x-axis). Additionally, the instruction may indicate and cause S0 measurement device **120** to project an ultrasonic sound (e.g., 200 kHz) to casing **204** and cement layer **206**. As described herein, the propagating and attenuating sound signals passing through casing **204** and cement layer **206** may include symmetric lamb waves. Moreover, S0 measurement device **120** may project the ultrasonic sound to casing **204** and cement layer **206** while S0 measurement device **120** travels in the first direction. Further, receiver **210** may detect the sound signals propagating and attenuating through casing **204** and cement layer **206** while S0 measurement device **120** travels in the first direction. The detected sound signal may be transmitted to executed evaluation engine **116**.

[0064] Additionally, S0 measurement device **120** may travel in a second direction (e.g., up wellbore **202**). Moreover, executed evaluation engine **116** may transmit an instruction to S0 measurement device **120**. The instruction may cause S0 measurement device **120** to adjust the angle of transducer **212** to a first angle, such as 35 degrees above the horizontal plane or axis (e.g., x-axis). Additionally, the instruction may indicate and cause S0 measurement device **120** to project an ultrasonic sound (e.g., 200 kHz) to casing **204** and cement layer **206**. As described herein, the propagating and attenuating sound signals passing through casing **204** and cement layer **206** may include A0 measurement waves. Moreover, S0 measurement device **120** may project the ultrasonic sound to casing **204** and cement layer **206** while S0 measurement device **120** travels in the second direction. Further, receiver **210** may detect the sound signals propagating and attenuating through casing **204** and cement layer **206** while S0 measurement device **120** travels in the second direction. The detected sound signal may be transmitted to executed evaluation engine **116**.

[0065] Referring to FIG. **9**, the angle at which the sound is projected from S0 measurement device **120** may cause the generation of symmetric lamb waves and/or A0 measurement waves in the medium (e.g., the casing and the cement). For example, as illustrated in graph **900** of FIG. **9**, one or more transducers of S0 measurement device **120** may project or transmit a sound at an ultrasonic frequency towards a medium. The detected sound signal may include symmetric lamb wave **904** between angles 0 degrees to 25 degrees above a horizontal plane or axis and asymmetric lamb wave **902** between angles 10 to 35 degrees above the horizontal plane or axis. In examples where the sound signal includes both symmetric lamb wave **904** and asymmetric lamb wave **902**, executed evaluation engine **116** may determine and identify symmetric lamb wave **904** and asymmetric lamb wave **902** based on the respective time frames.

B. Pad-Based S0 Measurement Device for Cement Bonding and Integrity Evaluation.

[0066] In some examples, examining cement bonding and integrity could be challenging and complicated because of the existence of eccentric casing (e.g., a thick casing), cement azimuthal heterogeneity and the presence of microannulus. In such examples, current cement bonding techniques, such as CBL techniques, cannot provide accurate quantitative evaluation in an azimuthal perspective or resolution. A pad-based S0 measurement device may be configured to provide accurate quantitative evaluation in an azimuthal perspective or resolution.

[0067] In some instances, the pad-based S0 measurement device may include one or more transducers and one or more receivers, and the pad-based S0 measurement device may be placed against the surface of a casing of a wellbore. In such instances, the pad-based S0 measurement device may be configured (e.g., cut) in a way that prevents waves propagating along the pad and to minimize the influence of pad on the casing wave propagation. Additionally, the pad-based SO measurement device may be placed onto the surface of the casing using one or more mechanical arms. Further, the pad-based S0 measurement device may be mechanically coupled to the surface of the casing using pads during logging operations. That way, sound signals detected by the receiver of the pad-based S0 measurement device may bypass any wellbore fluids, such as mud, and eliminating fluid attenuation effects to ensure a more accurate cement bond and integrity evaluation.

[0068] For instance, and referring to FIG. **10**, environment **200** may include pad-based SO measurement device **1002** within wellbore **202**. In some instances, wellbore **202** may be filled with fluid that may carry energy to and from casing **204**. Additionally, environment **200** may include cement layer **206** that is between the surface **208** of wellbore **202** and casing **204**. Moreover, pad-based S0 measurement device **1002** may include one or more transducers **1010** and receivers **1008**. Further, pad-based S0 measurement device **1002** may be coupled to or attached to the surface of casing **204**. Additionally, transducer **1010** and receiver **1008** maybe adjusted to different angles, for measuring different modes, for example the symmetric lamb waves or the asymmetric lamb waves.

[0069] In other instances, the transducers and the receivers may each be in separate pads, such as, a receiver pad may include the receiver while a transducer pad may include the transducer. Additionally, the transducer pad including a transducer and the receiver pad including the receiver may be placed onto the surface of the casing using one or more mechanical arms. Further, the transducer pad including a transducer and the receiver pad including the receiver may be mechanically coupled to the surface of the casing during logging operations. That way, sound signals detected by the receiver may bypass any wellbore fluids, such as mud, and eliminating fluid attenuation effects to ensure a more accurate cement bond and integrity evaluation.

[0070] For instance, and referring to FIG. **11**, a top down view of environment **200** may include transducer pad **1100** and receiver pad **1102** within wellbore **202**. Additionally, environment **200** may include cement layer **206** that is between the surface **208** of wellbore **202** and casing **204**. Moreover, transducer pad **1100** may include transducer **1104** and receiver pad **1102** may include receiver **1106**. Further, transducer pad **1100** and receiver pad **1102** may be coupled to or attached to the surface of casing **204**.

[0071] As described herein, and similar to transducer **212**, the transducer of the pad-based SO measurement device, such as transducer **1010** and transducer **1104**, may transmit or project sound towards a casing (e.g., casing **204** of FIG. **10**), such as sound **1108**. Additionally, and similar to receiver **210**, the receivers of the pad-based S0 measurement device, such as receiver **1008** and receiver **1106**, may detect a sound signal of the projected sound propagating and attenuating through the casing and medium (e.g., casing **204** and cement layer **206** of FIG. **10**), such as sound signal **1110**. In some instances, the transducer of the pad-based S0 measurement device may transmit or project sound in ultrasonic frequencies, such as 200 kHz to 300 kHz. For instance, transducer **1104** may transmit or project sound **1108** in ultrasonic frequencies. Additionally, the transducer of the pad-based S0 measurement device may transmit or project sound at an angle above a plane or axis. For instance, transducer **1104** may transmit or project sound **1108** at an angle above a plane or axis (e.g., an angle between 0 degrees above a plane or axis and 35 degrees above the plane or axis). Moreover, the sound signal (e.g., sound signal **1110** of FIG. **11**) propagating and attenuating through casing **204** and cement layer **206** may include lamb waves, as described herein, such as symmetric and/or asymmetric lamb waves. As described herein, the asymmetric lamb waves may be sensitive to the material behind the casing, such as cement layer **206**. Additionally, the symmetric lamb waves may be sensitive to the presence and thickness of microannulus formations that may be present between the casing and the medium (e.g., casing **204** and cement layer **206**).

[0072] Referring to FIGS. **12**A, **12**B and **12**C, environment **1200**, environment **1210** and environment **1020** illustrate various configurations of a transducer pads and receiver pads. For example, as illustrated in FIG. **12**A, environment **1200** may include casing **1202**, transducer pad **1204**, receiver pad **1206** and receiver pad **1208** in an axial configuration. Although FIG. **12**A illustrates two receiver pads, any number of receiver pads may be utilized. Additionally, transducer pad **1204** may include a transducer, similar to transducer **212**, transducer **1010**, and transducer **1104**, while the receiver pads, such as receiver pad **1206** and receiver pad **1208**, may include a receiver, similar to receiver **210**, receiver **1008** and transducer **1104**.

[0073] In another example, and as illustrated in FIG. **12**B, environment **1210** may include casing **1212**, transducer pad **1214**, receiver pad **1216** and receiver pad **1218** in an azimuthal configuration. Although FIG. **12**B illustrates two receiver pads, any number of receiver pads may be utilized. Additionally, transducer pad **1214** may include a transducer, similar to transducer **212**, transducer **1010**, and transducer **1104**, while the receiver pads, such as receiver pad **1216** and receiver pad

1218, may include a receiver, similar to receiver **210**, receiver **1008** and transducer **1104**.

[0074] In yet another example, and as illustrated in FIG. **12**C, environment **1220** may include casing **1222**, transducer pad **1224**, receiver pad **1226** and receiver pad **1228** in a diagonal configuration. Although FIG. **12**C illustrates two receiver pads, any number of receiver pads may be utilized. Additionally, transducer pad **1224** may include a transducer, similar to transducer **212**, transducer **1010**, and transducer **1104**, while the receiver pads, such as receiver pad **1226** and receiver pad **1228**, may include a receiver, similar to receiver **210**, receiver **1008** and transducer **1104**.

[0075] Additionally, CE computing system **110**, such as executed evaluation engine **116**, may obtain from the receiver, either from receiver pad or pad-based S0 measurement device, a sound signal, such as sound signal **606** or sound signal **1110**, propagating and attenuating through casing **204** and cement layer **206**. As described herein, sound signal **606** and/or sound signal **1110** may include symmetric lamb waves and/or asymmetric lamb waves. Moreover, CE computing system **110** may determine a waveform of the detected sound signal. In some instances, the sound signal may include multiple waves over a duration of time and each wave may correspond to a reflection of a corresponding lamb wave onto casing **204**. Moreover, CE computing system **110** may determine one or more measurements or characteristics of each of the waves of the waveform, such as a one or more amplitudes. The waveform may represent the attenuation of the sound signal, such as an attenuation of a symmetric lamb wave and/or an attenuation of asymmetric lamb wave. In some instances, CE computing system **110** may generate measurement data that identifies and characterizes the one or more measurements of each of the waves of the determined waveform.

[0076] Moreover, CE computing system **110**, such as executed evaluation engine **116**, may determine the bond and integrity of the cement based on the measurement data, such as whether the cement and the casing have any microannulus formations and/or the type and/or make up of the medium or material behind the casing (e.g., cement layer **206** of FIG. **10**). In some instances, the one or more measurements of one or more waves of the waveform may be utilized to determine a bonding condition and integrity of the cement. Additionally, the phase or travel time difference between waves, such as the first wave in time and the second wave in time, may provide information on the cement thickness while the amplitude change, peak frequency change, the reflected coefficient ad the minimum of the reflection spectrum reveal the bonding condition and integrity of the cement.

[0077] In other instances, CE computing system **110**, such as executed evaluation engine **116**, may perform any of the example operations to determine whether microannulus formations are present between the casing and the medium (e.g., casing **294** and cement layer **206**). As described herein, the measurement data may be associated with a sound (e.g., **1110**) that includes lamb waves, such as symmetric lamb waves, or is lamb wave dominant (e.g., the sound is symmetric lamb wave dominant). In such instances, CE computing system **110** may utilize the measurement data to make such determinations. Additionally, executed evaluation engine **116** may determine the presence of the microannulus formation in the medium by comparing the measurement data with the reference data, as described herein. For instance, executed evaluation engine **116** may parse measurement data to determine a frequency of the corresponding originally projected sound (e.g., sounds **1108** of FIG. **11**) and/or the angle at which the originally projected sound was projected at. Additionally, executed evaluation engine **116** may identify portions of reference data that identifies similar or matching frequency and/or angle. The identified portions may include one or more measurements or characteristics of wave forms of various casing and cementing compositions. Moreover, CE computing system **110** may compare the one or more measurements identified and characterized by the measurement data with one or more measurements identified and characterized by the identified portions of reference data. Based on the comparison, CE computing system **110** may determine which of the one or more measurements or characteristics of wave forms of various casing and cementing compositions identified and characterized in the identified portions of reference data matches or is similar to the one or more measurements identified and characterized in the measurement data. Such a determination may indicate whether the measurement data indicates the presence of a microannulus formation in the medium.

[0078] In various instances, CE computing system **110**, such as executed evaluation engine **116**, may perform any of the example operations, similar to process **800** of FIG. **8**, to determine cement property information and microannulus thickness information. In such instances, cementing computing system **110** may obtain the symmetric lamb wave measurements and symmetric lamb wave measurements from a pad-based S0 measurement device, such as pad-based S0 measurement device **1002** of FIG. **10**. Additionally, or alternatively, CE computing system **110** may determine the type of material or medium behind the casing. As described herein, the amplitude or attenuation of the lamb waves may be sensitive to the material behind the casing. Additionally, the measurement data may include one or more measurements of symmetric lamb waves and/or asymmetric lamb waves. Moreover, CE computing system **110** may determine the type of material or medium behind the casing (e.g., whether the material or medium is water, mud, fast cement or slow cement). In some instances, the cement property information may further indicate the type of material (e.g., fast cement or slow cement) behind the casing.

[0079] Referring to FIG. **13**, example graph **1300** illustrates the sensitivity of the lamb waves, such as the symmetric and/or asymmetric lamb waves, to the material behind the casing. Additionally, example graph **1300** illustrates an example cross plot of asymmetric lamb waves and symmetric lamb waves detected by a pad-based S0 measurement device. As illustrated in FIG. **13**, example graph **1300** includes grouping **1302**, grouping **1304** and grouping **1306**. Each of the grouping **1302**, grouping **1304** and grouping **1306** may represent the amplitude of symmetric lamb waves and symmetric lamb waves for various types of material or mediums. For instance, grouping **1302** may be associated with slow cement, grouping **1304** may be associated with fast cement and grouping **1306** may be associated with fluid, such as mud.

[0080] Referring to FIG. **14**, example graph **1400** further illustrates the sensitivity of the lamb waves, such as the symmetric and/or asymmetric lamb waves, to the material behind the casing. Additionally, example graph **1400** illustrates an example cross plot of asymmetric lamb waves and symmetric lamb waves detected by a pad-based S0 measurement device. As illustrated in FIG. **14**, example graph **1400** includes grouping **1402** and grouping **1404**. Each of the grouping **1402** and grouping **1404** may represent the amplitude of symmetric lamb waves and symmetric lamb waves for various types of material or mediums. For instance, grouping **1402** may be associated with cement, and grouping **1404** may be associated with fluid, such as mud.

C. Example Hardware and Software Implementations

[0081] FIG. **15** illustrates an example computing device architecture **1500** which can be employed to perform various steps, methods, and techniques disclosed herein. Specifically, the computing device architecture can be integrated with the electromagnetic imager tools described herein. Further, the computing device can be configured to implement the techniques of controlling borehole image blending through machine learning described herein.

[0082] As noted above, FIG. **15** illustrates an example computing device architecture **1500** of a computing device, such as CE computing system **110**, which can implement the various technologies and techniques described herein. The components of the computing device architecture **1500** are shown in electrical communication with each other using a connection **1505**, such as a bus. The example computing device architecture **1500** includes a processing unit (CPU or processor) **1510** and a computing device connection **1505** that couples various computing device components including the computing device memory **1515**, such as read only memory (ROM) **1520** and random access memory (RAM) **1525**, to the processor **1510**.

[0083] The computing device architecture **1500** can include a cache of high-speed memory connected directly with, in close proximity to, or integrated as part of the processor **1510**. The computing device architecture **1500** can copy data from the memory **1515** and/or the storage device

1530 to the cache **1512** for quick access by the processor **1510**. In this way, the cache can provide a performance boost that avoids processor **1510** delays while waiting for data. These and other modules can control or be configured to control the processor **1510** to perform various actions. Other computing device memory **1515** may be available for use as well. The memory **1515** can include multiple different types of memory with different performance characteristics. The processor **1510** can include any general purpose processor and a hardware or software service, such as service **1 1532**, service **2 1534**, and service **3 1536** stored in storage device **1530**, configured to control the processor **1510** as well as a special-purpose processor where software instructions are incorporated into the processor design. The processor **1510** may be a self-contained system, containing multiple cores or processors, a bus, memory controller, cache, etc. A multi-core processor may be symmetric or asymmetric.

[0084] To enable user interaction with the computing device architecture **1500**, an input device **1545** can represent any number of input mechanisms, such as a microphone for speech, a touch-sensitive screen for gesture or graphical input, keyboard, mouse, motion input, speech and so forth. An output device **1535** can also be one or more of a number of output mechanisms known to those of skill in the art, such as a display, projector, television, speaker device, etc. In some instances, multimodal computing devices can enable a user to provide multiple types of input to communicate with the computing device architecture **1500**. The communications interface **1540** can generally govern and manage the user input and computing device output. There is no restriction on operating on any particular hardware arrangement and therefore the basic features here may easily be substituted for improved hardware or firmware arrangements as they are developed.

[0085] Storage device **1530** is a non-volatile memory and can be a hard disk or other types of computer readable media which can store data that are accessible by a computer, such as magnetic cassettes, flash memory cards, solid state memory devices, digital versatile disks, cartridges, random access memories (RAMs) **1525**, read only memory (ROM) **1520**, and hybrids thereof. The storage device **1530** can include services **1532**, **1534**, **1536** for controlling the processor **1510**. Other hardware or software modules are contemplated. The storage device **1530** can be connected to the computing device connection **1505**. In one aspect, a hardware module that performs a particular function can include the software component stored in a computer-readable medium in connection with the necessary hardware components, such as the processor **1510**, connection **1505**, output device **1535**, and so forth, to carry out the function.

[0086] For clarity of explanation, in some instances the present technology may be presented as including individual functional blocks including functional blocks comprising devices, device components, steps or routines in a method embodied in software, or combinations of hardware and software.

[0087] In some embodiments the computer-readable storage devices, mediums, and memories can include a cable or wireless signal containing a bit stream and the like. However, when mentioned, non-transitory computer-readable storage media expressly exclude media such as energy, carrier signals, electromagnetic waves, and signals per se.

[0088] Methods according to the above-described examples can be implemented using computer-executable instructions that are stored or otherwise available from computer readable media. Such instructions can include, for example, instructions and data which cause or otherwise configure a general purpose computer, special purpose computer, or a processing device to perform a certain function or group of functions. Portions of computer resources used can be accessible over a network. The computer executable instructions may be, for example, binaries, intermediate format instructions such as assembly language, firmware, source code, etc. Examples of computer-readable media that may be used to store instructions, information used, and/or information created during methods according to described examples include magnetic or optical disks, flash memory, USB devices provided with non-volatile memory, networked storage devices, and so on.

[0089] Devices implementing methods according to these disclosures can include hardware, firmware and/or software, and can take any of a variety of form factors. Typical examples of such form factors include laptops, smart phones, small form factor personal computers, personal digital assistants, rackmount devices, standalone devices, and so on. Functionality described herein also can be embodied in peripherals or add-in cards. Such functionality can also be implemented on a circuit board among different chips or different processes executing in a single device, by way of further example.

[0090] The instructions, media for conveying such instructions, computing resources for executing them, and other structures for supporting such computing resources are example means for providing the functions described in the disclosure.

[0091] In the foregoing description, aspects of the application are described with reference to specific embodiments thereof, but those skilled in the art will recognize that the application is not limited thereto. Thus, while illustrative embodiments of the application have been described in detail herein, it is to be understood that the disclosed concepts may be otherwise variously embodied and employed, and that the appended claims are intended to be construed to include such variations, except as limited by the prior art. Various features and aspects of the above-described subject matter may be used individually or jointly. Further, embodiments can be utilized in any number of environments and applications beyond those described herein without departing from the broader spirit and scope of the specification. The specification and drawings are, accordingly, to be regarded as illustrative rather than restrictive. For the purposes of illustration, methods were described in a particular order. It should be appreciated that in alternate embodiments, the methods may be performed in a different order than that described.

[0092] Where components are described as being “configured to” perform certain operations, such configuration can be accomplished, for example, by designing electronic circuits or other hardware to perform the operation, by programming programmable electronic circuits (e.g., microprocessors, or other suitable electronic circuits) to perform the operation, or any combination thereof.

[0093] The various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the examples disclosed herein may be implemented as electronic hardware, computer software, firmware, or combinations thereof. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present application.

[0094] The techniques described herein may also be implemented in electronic hardware, computer software, firmware, or any combination thereof. Such techniques may be implemented in any of a variety of devices such as general purposes computers, wireless communication device handsets, or integrated circuit devices having multiple uses including application in wireless communication device handsets and other devices. Any features described as modules or components may be implemented together in an integrated logic device or separately as discrete but interoperable logic devices. If implemented in software, the techniques may be realized at least in part by a computer-readable data storage medium comprising program code including instructions that, when executed, performs one or more of the method, algorithms, and/or operations described above. The computer-readable data storage medium may form part of a computer program product, which may include packaging materials.

[0095] The computer-readable medium may include memory or data storage media, such as random access memory (RAM) such as synchronous dynamic random access memory (SDRAM), read-only memory (ROM), non-volatile random access memory (NVRAM), electrically erasable programmable read-only memory (EEPROM), FLASH memory, magnetic or optical data storage media, and the like. The techniques additionally, or alternatively, may be realized at least in part by a computer-readable communication medium that carries or communicates program code in the form of instructions or data structures and that can be accessed, read, and/or executed by a computer, such as propagated signals or waves.

[0096] Other embodiments of the disclosure may be practiced in network computing environments with many types of computer system configurations, including personal computers, hand-held devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, and the like. Embodiments may also be practiced in distributed computing environments where tasks are performed by local and remote processing devices that are linked (either by hardwired links, wireless links, or by a combination thereof) through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

[0097] In the above description, terms such as “upper,” “upward,” “lower,” “downward,” “above,” “below,” “downhole,” “uphole,” “longitudinal,” “lateral,” and the like, as used herein, shall mean in relation to the bottom or furthest extent of the surrounding wellbore even though the wellbore or portions of it may be deviated or horizontal. Correspondingly, the transverse, axial, lateral, longitudinal, radial, etc., orientations shall mean orientations relative to the orientation of the wellbore or tool. Additionally, the illustrate embodiments are illustrated such that the orientation is such that the right-hand side is downhole compared to the left-hand side.

[0098] The term “coupled” is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The connection can be such that the objects are permanently connected or releasably connected. The term “outside” refers to a region that is beyond the outermost confines of a physical object. The term “inside” indicates that at least a portion of a region is partially contained within a boundary formed by the object. The term “substantially” is defined to be essentially conforming to the particular dimension, shape or another word that substantially modifies, such that the component need not be exact. For example, substantially cylindrical means that the object resembles a cylinder, but can have one or more deviations from a true cylinder.

[0099] The term “radially” means substantially in a direction along a radius of the object, or having a directional component in a direction along a radius of the object, even if the object is not exactly circular or cylindrical. The term “axially” means substantially along a direction of the axis of the object. If not specified, the term axially is such that it refers to the longer axis of the object. Although a variety of information was used to explain aspects within the scope of the appended claims, no limitation of the claims should be implied based on particular features or arrangements, as one of ordinary skill would be able to derive a wide variety of implementations. Further and although some subject matter may have been described in language specific to structural features and/or method steps, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to these described features or acts. Such functionality can be distributed differently or performed in components other than those identified herein. The described features and steps are disclosed as possible components of systems and methods within the scope of the appended claims.

[0100] Moreover, claim language reciting “at least one of” a set indicates that one member of the set or multiple members of the set satisfy the claim. For example, claim language reciting “at least one of A and B” means A, B, or A and B.

[0101] Statements of the disclosure include: [0102] Statement 1. A computer-implemented method comprising: transmitting a first type of energy at a first angle to a surface of a casing of a wellbore, the casing being bonded to cement layer that is between the casing and a formation of the wellbore; receiving a first signal from the casing; determining a first attenuation of the first type of energy based on the first signal; and determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation. [0103] Statement 2. The computer-implemented method of Statement 1, further comprising: transmitting a second type of energy at a second angle to the surface of the casing; receiving, a second signal from the casing; determining a second attenuation of the second type of energy based on the first signal; and determining a state of the cement layer and the microannulus formation based on one or more characteristics of the second attenuation. [0104] Statement 3. The computer-implemented method of Statement 2, further comprising: determining a state of the bond between the casing and the cement layer based on the determination of whether the microannulus formation is present between the casing and the cement layer and the determination of the state of the cement layer and the formation. [0105] Statement 4. The computer-implemented method of Statement 2, wherein the first type of energy is transmitted by a device, and the device transmits the first type of energy while the device is traveling in the wellbore in a first direction. [0106] Statement 5. The computer-implemented method of Statement 2, wherein the second type of energy is transmitted by a device, the device transmits the second type of energy while the device is traveling in the wellbore in a second direction. [0107] Statement 6. The computer-implemented method of Statement 2, wherein the second angle is between 10 and 35 degrees. [0108] Statement 7. The computer-implemented method of Statement 2, wherein the second attenuation of the second type of energy includes A0 measurement waves. [0109] Statement 8. The computer-implemented method of Statement 2, wherein the second type of energy is ultrasonic energy. [0110] Statement 9. The computer-implemented method of Statement 1, further comprising: receiving a second signal from the casing; determining a first attenuation of the first type of energy based on the first signal; determining a second attenuation of the first type of energy based on the second signal; and determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation and one or more characteristics of the second attenuation. [0111] Statement 10. The computer-implemented method of Statement 1, wherein the first angle is between 0 and 25 degrees. [0112] Statement 11. The computer-implemented method of Statement 1, wherein the first attenuation of the first type of energy includes lamb waves. [0113] Statement 12. The computer-implemented method of Statement 1, wherein the first type of energy is ultrasonic energy. [0114] Statement 13. A computing system comprising: a communications interface; a memory storing instruction; and at least one processor coupled to the communications interface and the memory, the at least one processor being configured to: transmit a first type of energy at a first angle to a surface of a casing of a wellbore, the casing being bonded to cement layer that is between the casing and a formation of the wellbore; receive a first signal from the casing; determine a first attenuation of the first type of energy based on the first signal; and determine whether a microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation. [0115] Statement 14. The computing system of Statement 13, wherein the at least one processor is further configured to: transmit a second type of energy at a second angle to the surface of the casing; receive, a second signal from the casing; determine a second attenuation of the second type of energy based on the first signal; and determine a state of the cement layer and the microannulus formation based on one or more characteristics of the second attenuation. [0116] Statement 15. The computing system of Statement 14, wherein the at least one processor is further configured to: determine a state of the bond between the casing and the cement layer based on the determination of whether the microannulus formation is present between the casing and the cement layer and the determination of the state of the cement layer and the formation. [0117] Statement 16. The computing system of Statement 14, wherein to transmit the first type of energy, the at least one processor is further configured to: cause a transmission device to transmit the first type of energy. [0118] Statement 17. The computing system of Statement 16, wherein the transmission device transmits the first type of energy while the transmission device is traveling in the wellbore in a first direction. [0119] Statement 18. The computing system of Statement 14, wherein to transmit the second type of energy, the at least one processor is further configured to: cause a transmission device to transmit the second type of energy. [0120] Statement 19. The computing system of Statement 14, wherein the transmission device transmits the second type of energy while the transmission device is traveling in the wellbore in a second direction. [0121] Statement 20. The computing system of Statement 14, wherein the second angle is between 10 and 35 degrees. [0122] Statement 21. The computing system of Statement 14, wherein the second attenuation of the second type of energy includes A0 measurement waves. [0123] Statement 22. The computing system of Statement 14, wherein the second type of energy is ultrasonic energy. [0124] Statement 23. The computing system of Statement 13, wherein the at least one processor is further configured to: receive a second signal from the casing; determine a first attenuation of the first type of energy based on the first signal; determine a second attenuation of the first type of energy based on the second signal; and determine whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation and one or more characteristics of the second attenuation [0125] Statement 24. The computing system of Statement 13, wherein the first angle is between 0 and 25 degrees. [0126] Statement 24. The computing system of Statement 13, wherein the first attenuation of the first type of energy includes lamb waves. [0127] Statement 25. The computing system of Statement 13, wherein the first type of energy is ultrasonic energy. [0128] Statement 26. A tangible, non-transitory computer readable medium storing instructions that, when executed by at least one processor, cause the at least one processor to perform operations comprising: transmitting a first type of energy at a first angle to a surface of a casing of a wellbore, the casing being bonded to cement layer that is between the casing and a formation of the wellbore; receiving a first signal from the casing; determining a first attenuation of the first type of energy based on the first signal; and determining a microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation. [0129] Statement 27. The tangible, non-transitory computer readable medium of Statement 26, wherein the at least one processor performs operations further comprising: transmitting a second type of energy at a second angle to the surface of the casing; receiving, a second signal from the casing; determining a second attenuation of the second type of energy based on the first signal; and determining a state of the cement layer and the microannulus formation based on one or more characteristics of the second attenuation. [0130] Statement 28. The tangible, non-transitory computer readable medium of Statement 27, wherein the at least one processor performs operations further comprising: determining a state of the bond between the casing and the cement layer based on the determination of whether the microannulus formation is present between the casing and the cement layer and the determination of the state of the cement layer and the formation. [0131] Statement 29. The tangible, non-transitory computer readable medium of Statement 27, wherein the first type of energy is transmitted by a device, and the device transmits the first type of energy while the device is traveling in the wellbore in a first direction. [0132] Statement 30. The tangible, non-transitory computer readable medium of Statement 27, wherein the second type of energy is transmitted by a device, the device transmits the second type of energy while the device is traveling in the wellbore in a second direction. [0133] Statement 31. The tangible, non-transitory computer readable medium of Statement 27, wherein the second angle is between 10 and 35 degrees. [0134] Statement 32. The tangible, non-transitory computer readable medium of Statement 27, wherein the second attenuation of the second type of energy includes A0 measurement waves. [0135] Statement 33. The tangible, non-transitory computer readable medium of Statement 27, wherein the second type of energy is ultrasonic energy. [0136] Statement 34. The tangible, non-transitory computer readable medium of Statement 26, wherein the at least one processor performs operations further comprising: receiving a second signal from the casing; determining a first attenuation of the first type of energy based on the first signal; determining a second attenuation of the first type of energy based on the second signal; and determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation and one or more characteristics of the second attenuation. [0137] Statement 35. The tangible, non-transitory computer readable medium of Statement 26, wherein the first angle is between 0 and 25 degrees.

[0138] Statement 36. The tangible, non-transitory computer readable medium of Statement 27, wherein the first attenuation of the first type of energy includes lamb waves. [0139] Statement 37. The tangible, non-transitory computer readable medium of Statement 27, wherein the first type of energy is ultrasonic energy.

Claims

1. A computer-implemented method comprising: transmitting a first type of energy at a first angle to a surface of a casing of a wellbore, the casing being bonded to cement layer that is between the casing and a formation of the wellbore; receiving a first signal from the casing; determining a first attenuation of the first type of energy based on the first signal; and determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.
2. The computer-implemented method of claim 1, further comprising: transmitting a second type of energy at a second angle to the surface of the casing; receiving, a second signal from the casing; determining a second attenuation of the second type of energy based on the first signal; and determining a state of the cement layer and the microannulus formation based on one or more characteristics of the second attenuation.
3. The computer-implemented method of claim 2, further comprising: determining a state of the bond between the casing and the cement layer based on the determination of whether the microannulus formation is present between the casing and the cement layer and the determination of the state of the cement layer and the formation.
4. The computer-implemented method of claim 2, wherein the first type of energy is transmitted by a device, and the device transmits the first type of energy while the device is traveling in the wellbore in a first direction.
5. The computer-implemented method of claim 2, wherein the second type of energy is transmitted by a device, the device transmits the second type of energy while the device is traveling in the wellbore in a second direction.
6. The computer-implemented method of claim 2, wherein the second angle is between 10 and 35 degrees.
7. The computer-implemented method of claim 2, wherein the second attenuation of the second type of energy includes A0 measurement waves.
8. The computer-implemented method of claim 2, wherein the second type of energy is ultrasonic energy.
9. The computer-implemented method of claim 1, further comprising: receiving a second signal from the casing; determining a first attenuation of the first type of energy based on the first signal; determining a second attenuation of the first type of energy based on the second signal; and determining whether microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation and one or more characteristics of the second attenuation.
10. The computer-implemented method of claim 1, wherein the first angle is between 0 and 25 degrees.
11. The computer-implemented method of claim 1, wherein the first attenuation of the first type of energy includes lamb waves.
12. The computer-implemented method of claim 1, wherein the first type of energy is ultrasonic energy.
13. A computing system comprising: a communications interface; a memory storing instructions; and at least one processor coupled to the communications interface and to the memory, the at least one processor being configured to execute the instructions to perform operations including: transmit a first type of energy at a first angle to a surface of a casing of a wellbore, the casing being

bonded to cement layer that is between the casing and a formation of the wellbore; receive a first signal from the casing; determine a first attenuation of the first type of energy based on the first signal; and determine whether a microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.

14. The computing system of claim 13, wherein the at least one processor is further configured to: transmit a second type of energy at a second angle to the surface of the casing; receive, a second signal from the casing; determine a second attenuation of the second type of energy based on the first signal; and determine a state of the cement layer and the formation based on one or more characteristics of the second attenuation.

15. The computing system of claim 14, wherein the at least one processor is further configured to: determine a state of the bond between the casing and the cement layer based on the determination of whether the microannulus formation is present between the casing and the cement layer and the determination of the state of the cement layer and the formation.

16. The computing system of claim 14, wherein to transmit the first type of energy, the at least one processor is further configured to: cause a transmission device to transmit the first type of energy.

17. The computing system of claim 16, wherein the transmission device transmits the first type of energy while the transmission device is traveling in the wellbore in a first direction.

18. The computing system of claim 14, wherein to transmit the second type of energy, the at least one processor is further configured to: cause a transmission device to transmit the second type of energy.

19. The computing system of claim 18, wherein the transmission device transmits the second type of energy while the transmission device is traveling in the wellbore in a second direction.

20. A tangible, non-transitory computer readable medium storing instructions that, when executed by at least one processor, cause the at least one processor to perform operations comprising: transmitting a first type of energy at a first angle to a surface of a casing of a wellbore, the casing being bonded to cement layer that is between the casing and a formation of the wellbore; receiving a first signal from the casing; determining a first attenuation of the first type of energy based on the first signal; and determining a microannulus formation is present between the casing and the cement layer based on one or more characteristics of the first attenuation.