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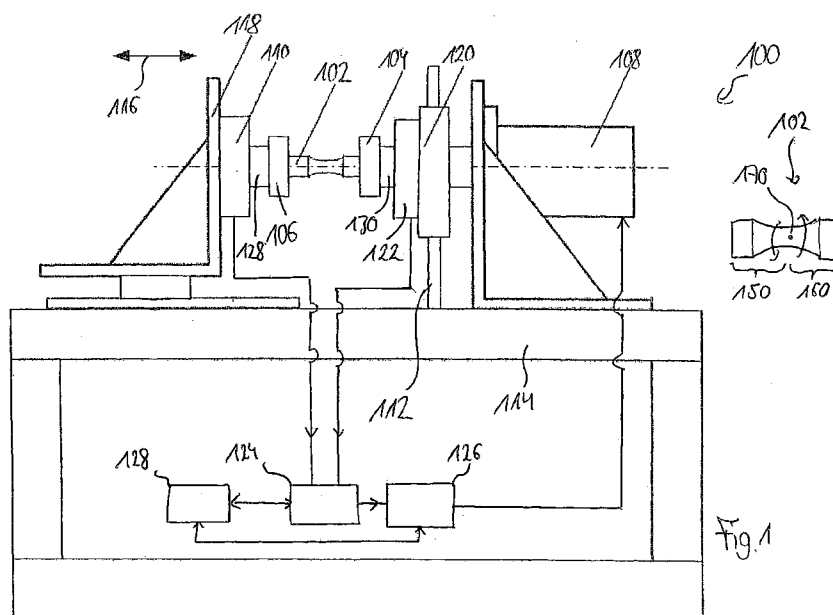
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(54) Title: SAMPLE ANALYSIS SYSTEM



(57) Abstract: An apparatus for analyzing a sample, the apparatus comprising a first clamping chuck adapted for receiving a first portion of the sample, a second clamping chuck adapted for receiving a second portion of the sample, a first measurement unit adapted for measuring an oscillation, particularly a self-oscillation, of the sample and being coupled to the first clamping chuck, and a second measurement unit adapted for measuring the oscillation of the sample and being coupled to the second clamping chuck, wherein the first measurement unit is coupled to the first clamping chuck and the second measurement unit is coupled to the second clamping chuck so that measurement signals captured by the first measurement unit and by the second measurement unit are indicative of the oscillation along the sample.

Sample Analysis System

This application claims the benefit of the filing date of European
5 Patent Application No. 08019114.1 filed October 31, 2008, the disclosure
of which is hereby incorporated herein by reference.

The invention relates to an apparatus for analyzing a sample.

The invention further relates to a method of analyzing a sample.

10

WO 2007/042275 discloses a method for checking a sample with
combined rotational bending and torsional loading, preferably at high
frequency, characterized by the combination of the following features:
setting the sample in rotation, subjecting the sample to a torsional load
15 by means of two torsional torques generated by electric motors applied
to two opposing ends of the sample and subjecting the sample to a
bending load either applied to the ends thereof or at a point between the
ends.

RU 2 321 848 C1 discloses a system for evaluation of stress-
20 deformed state of easily deformed fiber-containing compositions.

JP 2310443 discloses a torsional actuator having a servo valve
which is installed atop the stand installed via an air spring to a
foundation, such as ground surface. The installation of the torsional
actuator is so executed that the output shaft is positioned perpendicular.
25 A flange having a connecting fitting which supports the bar-shaped test
body perpendicularly at one end is connected via an accelerator detector
to the top end of the output shaft. An angle detector is mounted to the
torsional actuator and an acceleration detector to the free end of the test
body, respectively. The angle of the output shaft of the torsional actuator
30 is detected by the angle detector. The generation of the transverse
oscillation is obviated in this way even if the output shaft revolves
forward and backward. The exact measurement of the resonance point to

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be carried out by revolving the output shaft forward and backward and applying the torsional oscillation to the test body while changing the frequencies is thus assured.

Under undesired circumstances, measurement artefacts may
5 influence an analysis and may deteriorate accuracy of the result of the analysis.

It is an object of the invention to provide a sample analysis system which provides reproducible results.

10 In order to achieve the object defined above, a sample analysis system and a method of analyzing a sample according to the independent claims are provided.

According to an exemplary embodiment of the invention, an apparatus for analyzing a sample is provided, the apparatus comprising a
15 first clamping chuck adapted for receiving a first portion (which may be a first end portion) of the sample, a second clamping chuck adapted for receiving a second portion (which may be a second end portion) of the sample, a first measurement unit (for instance a first deformation sensor) adapted for measuring an oscillation (particularly a self-oscillation or an
20 independent-excited or a separate-excited oscillation, or any other kind of oscillation) of (at least a portion of) the sample (for instance a self-oscillation behaviour in a section of the sample adjacent to the first clamping chuck) and being coupled (for instance directly or indirectly, i.e. without or with an intermediate component) to the first clamping chuck,
25 and a second measurement unit (for instance a second deformation sensor) adapted for measuring the oscillation of (at least a portion of) the sample (for instance a self-oscillation behaviour in a section of the sample adjacent to the second clamping chuck) and being coupled (for instance directly or indirectly, i.e. via an intermediate component) to the
30 second clamping chuck, wherein the first measurement unit is coupled

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(for instance functionally or mechanically) to the first clamping chuck and the second measurement unit is coupled (for instance functionally or mechanically) to the second clamping chuck so that measurement signals captured by the first measurement unit and by the second measurement
5 unit are indicative (for instance are a fingerprint) of the oscillation along the sample.

According to another exemplary embodiment of the invention, a method of analyzing a sample is provided, the method comprising connecting a first portion of the sample to a first clamping chuck,
10 connecting a second portion of the sample to a second clamping chuck, measuring an oscillation, particularly a self-oscillation, of the sample by a first measurement unit being coupled to the first clamping chuck, measuring the oscillation of the sample by a second measurement unit being coupled to the second clamping chuck, and coupling the first
15 measurement unit to the first clamping chuck and the second measurement unit to the second clamping chuck so that measurement signals captured by the first measurement unit and by the second measurement unit are indicative of the oscillation along the sample.

According to still another exemplary embodiment of the invention,
20 a program element (for instance a software routine, in source code or in computer-executable code) is provided, which, when being executed by a processor, is adapted to control or carry out a method of analyzing a sample having the above mentioned features.

According to yet another exemplary embodiment of the invention,
25 a computer-readable medium (for instance a CD, a DVD, a USB stick, a floppy disk or a harddisk) is provided, in which a computer program is stored which, when being executed by a processor, is adapted to control or carry out a method of analyzing a sample having the above mentioned features.

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The test control scheme according to embodiments of the invention can be realized by a computer program, that is by software, or by using one or more special electronic optimization circuits, that is in hardware, or in hybrid form, that is by means of software components and
5 hardware components.

In the context of this application, the term "oscillation" may particularly denote an oscillation of a sample being a self-oscillation or being a separate-excited oscillation. A separate-excited oscillation may be an oscillation which is generated by an external oscillation source such
10 as a vibration in a lab or the like.

The term "self-oscillation" may particularly denote an oscillation of a sample in or close to or similar to a resonant state. Such a self-oscillation or natural oscillation or natural resonance may occur for instance when a sample undergoes a mechanical testing procedure,
15 which may involve the application of a time-dependent load, for instance employing a specific frequency. Exciting a sample close to an eigenfrequency may result in such a self-oscillation. Such an eigenfrequency may be considered as a frequency at which a sample oscillates after a single excitation.

20 The term "sample" may particularly denote any physical structure (particularly any technical apparatus, member, or a portion thereof) in the real world which may be under development or production or machining and shall therefore be investigated regarding its physical or economical properties such as mechanical stability, quality, usability, etc.
25 Examples of such a physical structure may be a member or tool such as a cast or forged or moulded component. "Samples" may be complete products or semifinished parts, members made of electrically conductive or electrically insulating material, carbon fiber members, steel parts, etc.

The term "measurement unit" may particularly denote any system
30 capable of performing a measurement on the sample, that is to say for

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determining or sensing a parameter characterizing the sample in a specific scenario or under certain conditions such as an applied mechanical stress or load. Such a measurement device may be a strain gauge or any other deformation sensor. Examples are the determination of the deformation characteristic by a temperature detection, an optical detection (for instance implementing a laser-based measurement), a capacitive detection (where a deformation modifies the geometric properties of a capacitor), a force detection, a magnetic or inductive detection, etc. Such a measurement unit may directly detect a torsional moment, may determine a torsional angle, etc. More generally, a measurement unit may measure a relative motion between two components or sections of an object. In an embodiment, the first and the second measurement units may both be arranged apart or outside or separate from one or more optional drive units.

15 The term "property of the sample" may particularly denote technical information, features or attributes characterizing the result of the analysis of the sample, for instance a mechanical characterization.

 According to an exemplary embodiment, two measurement units may be implemented in a sample analysis apparatus and may be functionally or mechanically coupled with clamping chucks for receiving end portions of a sample under test so that the undesired event of oscillations such as self-oscillations of the sample can be detected based on a difference between measurement signals captured by the two measurement units mechanically assigned to the respective end portions of the sample. The present inventors have surprisingly recognized that the occurrence of such oscillations are excitation frequency dependent and may significantly deteriorate the reliability and reproducibility of the measurement results so that the early detection of such oscillations allows for the recognition of such artefacts and their suppression or even elimination by modifying the operation conditions of the sample analysis

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procedure, for instance by changing parameters such as frequency, amplitude or phase positions.

Particularly in the context of servo hydraulic test equipment (for instance for measuring a torsion behaviour of a sample) measurement errors may occur depending on the measurement frequency. Such artefacts can be detected particularly when testing or analyzing spatially elongated samples. In such a scenario, the generation of an eigenfrequency or the detection of self-oscillation or natural oscillation of such a sample may be performed by two measurement units such as two torsional moment detectors. In order to ensure that the two measurement units provide detection signals which are indicative of self-oscillation of the sample, it is necessary that the coupling between the respective clamping chucks and the respective measurement units is sufficiently stiff or rigid so that the self-oscillation property of the sample is basically the same at the position of the clamping chuck and at the position of the respective measurement units. For this purpose, a constructionally stiff coupling between clamping chuck and the respective measurement unit should be realized. In one embodiment, this can be achieved by a direct neighbourhood between clamping chuck and measurement unit. In another embodiment, a passive material block may be placed between the respective clamping chuck and the respective measurement unit which does not significantly shift the self-oscillation properties in a spatial manner, for instance which does not spatially shift a torsion node within the sample. For this purpose, it may be advantageous that the clamping chuck is coupled to the respective measurement unit so that the detection of sample internal oscillation properties is enabled. In other words, an accurate detection of a self-oscillation of a sample requires that the assembly of the various components does not influence the self-oscillation properties of the sample which shall perform its motion without being disturbed by an

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environment. The mounting procedure should be performed in such a manner that there is no impact of the assembly conditions on the torsion or oscillation node in the sample. Such a torsion node can be denoted as a specific point or portion of the sample via which mutual deformation events occurs. Such a torsion node may also be denoted as a point or
5 portion at which no motion amplitude occurs.

The measurement signals detected by the measurement units may then be analyzed regarding differences or deviations or may be compared according to another algorithm or criteria which may allow to eliminate
10 artefacts of a first order, a second order and/or any higher order eigenfrequency by correspondingly regulating the sample analysis device. For instance, a test frequency may be modified so as to obtain both, a sufficiently high test frequency and consequently a high analysis speed and also the suppression of measurement artefacts which may
15 conventionally deteriorate the accuracy of a measurement.

Upon having detected differences between the two measurement signals, a regulation of the sample analysis apparatus may be performed in order to remove corresponding measurement artefacts. This may include the modification of the measurement frequency so that the
20 system is driven into an operation mode which is free of (or at least sufficiently far away from) a resonance of the sample. Such a regulation may be performed by altering an excitation signal (amplitude, frequency, etc.). For instance, such a modification may be performed in order to spatially shift a torsional node by an applied momentum. Particularly, the
25 system may be regulated in such a manner that the differences of the two measurement signals are reduced, particularly are reduced to zero.

In order to finish the tests in a short time, high operation frequencies of up to 60 Hz or even up to 120 Hz and more are desired. On the other hand, the frequencies should be not smaller than 1 Hz to 2
30 Hz. According to an exemplary embodiment, the frequency may be

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adjusted to be as large as possible and at the same time as small as possible to avoid self-oscillation based artefacts.

According to an exemplary embodiment, a regulation of a torsional moment signal particularly for vibration resistance experiments may be provided. In such a context, a measurement system may be provided which comprises two or more torsional momentum and/or rotation angle measurement units, at least one on each side of a sample under analysis. Such a measurement arrangement may allow for the detection of torsional eigenoscillations which can significantly reduce the quality of the measurement signals. By evaluating amplitude, average value and/or phase position of the two measured torsional moments or the detected rotational angles, oscillation nodes in the sample may be recognized and may be suppressed by a corresponding regulation, for instance by a variation of the excitation frequency. This may allow for the compensation or correction of self-oscillations or natural oscillations connected with such a torsion.

In an embodiment, a measurement arrangement for the detection of torsional eigenfrequencies in a torsion fatigue test bench is provided. The time variant torque and/or twist angle may be detected at both ends of the specimen and post-processed, if necessary. Due to this, eigenfrequencies can be detected. This may allow to increase the meaningfulness of the detection signals and the quality of the result. It may further save time and costs as compared to manual regulations. Moreover, a significant increase of the flexibility of the analysis devices may be obtained.

The inventors have experimentally verified that samples tend to generate torsional eigenoscillations depending on the exciting test frequency. Calculations show that by a modification of the excitation frequency, this problem may be suppressed or even eliminated. Conventionally, torsional moments or twist angles may be measured at

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one position of a torsional test equipment. In contrast to such a conventional approach, an exemplary embodiment of the invention comprises a measurement facility which measures torsional moments and/or twist angles on both sides (for instance ends) of a sample under
5 analysis. By a corresponding evaluation of the load-time-characteristics, an undesired torsional eigenfrequency may be detected. In the presence of differences regarding amplitude, middle or phase positions, such torsional eigenfrequencies may superposition the actual test signal. By a controlled modification of an operation of parameters such as the test
10 frequency, a reproducible and defined load condition may be adjusted. Such a signal adjustment in an automatic torsional test equipment significantly improves the reliability of the detection results.

In the following, further exemplary embodiments of the apparatus
15 will be explained. However, these embodiments also apply to the method.

The first measurement unit and/or the second measurement unit may be adapted for measuring at least one physical parameter indicative of a property of the sample received by the first clamping chuck and the
20 second clamping chuck in response to an application of a force of the first clamping chuck and/or to the second clamping chuck. Particularly, each of the two or more measurement units may be adapted for measuring the at least one physical parameter in a static manner, in a dynamic manner, or in a cyclic manner. Therefore, the performance of the
25 apparatus covers many applications in very different technical fields, so that an analysis of different mechanical members is possible with a large freedom for a user.

For instance, each of the two or more measurement units may be adapted for measuring torque, an angle of torsion and/or a deformation
30 behaviour. Particularly, the apparatus may measure one of such

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parameters at a time, for instance torque or an angle of torsion of a sample under analysis. However, it is alternatively possible that two or more of such physical parameters are measured simultaneously, for instance torque and an angle of torsion. This may allow to obtain a
5 powerful and very accurate system.

Anyone of the first clamping chuck and the second clamping chuck may comprise a mechanically actuatable clamping chuck or a hydraulically actuatable clamping chuck. A mechanically actuatable clamping chuck may be fixed at a sample by means of a mechanical or manual actuation of a
10 user, for instance by turning an adjustment screw. Alternatively, a hydraulically actuatable clamping chuck may use hydraulic forces to ensure reliable clamping of the sample, i.e. fastening of the sample at a groove of the chucks.

The apparatus may comprise an evaluation unit adapted for
15 evaluating the measurement signals captured by the first measurement unit and by the second measurement unit to detect the self-oscillation along the sample. In a very basic embodiment, such an evaluation unit may comprise a comparator which simply compares the two signals and, upon detection of differences, regulates the apparatus so as to eliminate
20 the differences and drive back the system into an operation mode in which the two signals are identical. However, the evaluation may involve more complex algorithms analyzing the signals in view of possible self-oscillation to get a deeper understanding of the procedures within the sample as a basis for a subsequent elimination of such artefacts.

25 The evaluation unit may be adapted for detecting the presence of the self-oscillation when the measurement signal captured by the first measurement unit significantly differs from the measurement signal captured by the second measurement unit. Such a difference in at least one property may be the fingerprint of undesired eigenoscillations of the
30 samples which can be averaged out by a corresponding regulation.

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The apparatus may comprise a modifying unit adapted for modifying operation of the apparatus, when the evaluation unit has detected the self-oscillation along the sample, so that the apparatus is driven back into an operation mode which is free of the self-oscillation along the sample. Such an automatic feedback-based regulation may eliminate the need of manually measuring deformation behaviours and manually regulating the system to suppress artefacts. Such an automatic method is significantly more reliable and is faster than a manual regulation.

10 The modifying unit may be adapted for modifying an operation frequency and/or an operation amplitude of the apparatus, when the evaluation has detected the self-oscillation along the sample, so that the apparatus is driven back into an operation mode which is free of the self-oscillation along the sample or between different portions of the sample.

15 In other words, the modifying unit may change the operation conditions so that a resonance free state of the sample may be obtained.

 The modifying unit may be adapted for modifying the operation frequency of the apparatus, when the evaluation unit has detected the self-oscillation along the sample, so that the apparatus is driven back into the operation mode which is free of the self-oscillation along the sample and in which the operation frequency is as large as possible. Considering two boundary conditions or operation criteria at the same time, namely a high test frequency for a fast test or a short test time, and an eigenoscillation-free operation mode necessary for reproducibility of measurement results may allow to optimize the apparatus regarding precision and efficiency.

 The first measurement unit may be positioned directly adjacent to the first clamping chuck and/or the second measurement unit may be positioned directly adjacent to the second clamping chuck. The term

30 “directly adjacent” may particularly denote that no physical element is

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between the respective measurement unit and the respective clamping chuck which may hence be in direct physical contact. This allows for a direct transfer of the force conditions and therefore of the self-oscillation properties of a sample portion to the respective measurement unit. In
5 such an embodiment, the respective measurement unit may be directly connected or may directly contact the respective clamping chuck.

In an alternative embodiment, the first measurement unit may be coupled to the first clamping chuck and/or the second measurement unit may be coupled to the second clamping chuck via an intermediate body
10 which transfers or conveys a self-oscillation characteristic from the sample to the respective measurement unit. Such an intermediate body may be mounted or sandwiched between the respective clamping chuck and the respective measurement unit in a manner that the character of the self-oscillation of the sample is not changed when being (virtually)
15 transferred from the clamping chuck via the intermediate body to the measurement unit. It may happen that such a stiffly coupled body changes individual parameters (for instance reduces a torsional frequency due to its own mass), however it should be mounted in a way that the self-oscillation properties are still derivable from the transferred signal.

20 The apparatus may be free of an automatic drive unit to enable a free oscillation of the sample. In such an embodiment, the sample may be freely mounted and may be excited for instance manually or by another trigger.

In an alternative embodiment, the apparatus may comprise a drive
25 unit adapted for applying a force to at least one of the first clamping chuck and the second clamping chuck. In one embodiment, the apparatus may comprise exactly one drive unit so that the sample is excited at one of the clamping chucks, whereas the other clamping chuck may be free of a drive unit.

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In still a further embodiment, the apparatus may comprise a further drive unit adapted for applying a force to the other one of the first clamping chuck and the second clamping chuck. In such an embodiment, two drive units may arranged symmetrically with respect to a sample,
5 each drive unit being assigned to one of the clamping chucks.

Anyone of the drive units may comprise a servo drive, a combustion engine, a hydraulic drive, a synchronous machine, or an asynchronous machine. Other drive units such as wind engines or the like can be implemented as well. Drive units such as servo drive may be
10 preferred which allow (due to their construction and/or drive characteristic) to rotate the sample with an unlimited rotation angle.

In an embodiment, in addition to the at least two measurement units coupled to the respective clamping chucks, it may be possible that at least one further measurement unit is included internally in one of the
15 drive units. However, the mechanical distance and the functionality between the drive units and the sample is usually so large that these measurement units incorporated in the drive units are not capable of providing signals which are a fingerprint of self-oscillation properties of the samples. Thus, such measurement units may be used for the purpose
20 of operating the drive unit properly, but can usually not serve to measure or average out torsional momentums in the sample.

In an embodiment, the first measurement unit and the first clamping chuck may be arranged, in relation to the sample, symmetrically with respect to the second measurement unit and the
25 second clamping chuck. For instance, the two measurement units may be identical in construction as well as the two clamping chucks may be identical in construction. Also two servo drives or other drive units may be identical in construction.

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In an alternative embodiment, the two measurement units may be different measurement units, for instance one twist angle detector and one torsional momentum detector.

Exemplary fields of applications of exemplary embodiments of the invention are a testing apparatus for testing a sample, a combustion engine, or a plant involving a sample analysis portion. Embodiments of the invention may be used in all fields in which sample testing is required and self-oscillation based artefacts should be suppressed.

The aspects defined above and further aspects of the invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to these examples of embodiment.

The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 to Fig. 6 illustrate apparatuses for analyzing a sample according to exemplary embodiments of the invention.

The illustration in the drawing is schematically. In different drawings, similar or identical elements are provided with the same reference signs.

In the following, referring to **Fig. 1**, an apparatus 100 for analyzing a sample 102 according to an exemplary embodiment of the invention will be explained.

The apparatus 100 comprises a first clamping chuck 104 adapted for receiving a first end of the sample 102. A second clamping chuck 106 is provided opposing the first clamping chuck 104 for receiving a second end of the sample 102. In the described embodiment, the first clamping chuck 104 and the second clamping chuck 106 are hydraulically actuable clamping chucks.

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A drive unit 108 is provided for applying a force at a first clamping chuck 104, and, in turn, to the sample 102. The drive unit 108 is a servo drive. The sample 102 may be fixedly clamped into the second clamping chuck 106.

5 A first measurement unit 110 is adapted for measuring a physical parameter such as a torsion moment and/or a angle of torsion of the sample 102 in response to the application of the force at the first clamping chuck 104.

10 A second measurement unit 122 is adapted for measuring a physical parameter such as a torsion moment and/or a angle of torsion of the sample 102 in a region close to the first clamping chuck 104.

It is noted that, in the described embodiment, the second clamping chuck 106 is free of a separate drive unit. In other words, the second clamping chuck 106 remains spatially fixed, apart from an impact of a load which may act on the second clamping chuck 106 in response to the application of the force to the first clamping chuck 104 by the drive unit 108. However, no separate drive unit is provided for the left hand portion of Fig. 1 so that a single drive unit 108 is sufficient to supply the entire apparatus 100 with mechanical forces.

20 A first mount 112 is provided which is fixed (for instance screwed) to a base plate 114 or support of the apparatus 100 in a fixed manner. Thus, the first mount 112 is spatially fixed, and, as can be taken from Fig. 1, the first clamping chuck 104 is mounted rigidly coupled to the first mount 112.

25 Beyond this, the apparatus 100 comprises a spatially moveable (see bidirectional arrow 116) second mount 118, so that a distance between the clamping chucks 104 and 106 in a horizontal direction in Fig. 1 can be adjusted by sliding the moveable mount 118 along the direction 116.

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The apparatus 100 further comprises a variable test module 120 which can be substituted.

Thus, Fig. 1 shows a variable test equipment concept for torsion analysis under static and cyclic, multiple stage torsion load or stress. The concept shown in Fig. 1 comprises the servo drive 108 which can be substituted by any other appropriate drive as well. The variable test module 120 can be substituted, for instance, by a gear for a proper transfer of a torsion moment in the context of static experiments. The clamping or chucking units 104, 106 which may also be denoted as sample fastening elements can also be configured in a mechanical mechanism, instead of a hydraulic configuration. The measurement units 110, 122 can be a torsion sensor and/or an angle of rotation pickup sensor. Reference numeral 118 may also be denoted as a torsion momentum support, which is slidable (by a sliding cartridge member) in a longitudinal direction 116 and/or can be adjustable regarding angular properties or orientation properties along other axes than the sliding axis 116.

In the following, the apparatus 100 will be described in more detail.

Via the servo drive 108, it is possible to apply a static or a cyclic torsion momentum to the sample 102 which is supported on the torsion momentum support 118. This torsion momentum support 118 may be slidable in a longitudinal direction 116 and/or may be angularly elastic, in order to balance, if desired, length modifications at the sample 102 by cyclic loss of cohesion effects and by imperfections in the sample geometry. The variably employable module 120 allows the mounting of a gear for a transfer of the torsion momentum for static twisting experiments as well as the provision of a resonance module to operate the apparatus in a resonance state. Via a modification of a fly wheel mass, a first torsion eigenfrequency of the system 100 can be adjusted in

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order to enter a region of a test frequency relevant for the analysis of the dynamic strength/vibration resistance. The clamping system 104, 106 can be adapted, for instance, in a mechanical or in a hydraulic manner. At the measurement units 110, 122, it is possible to detect the torsion
5 momentum as well as the twist angle at the sample 102.

In the following, advantages and differences of the apparatus 100 as compared to conventional approaches will be explained.

Conventional apparatuses for performing torsion experiments in a resonance region only allow for a limited angular examination of a sample
10 due to restrictions in the apparatus design. However, this limitation restricts the analyzable sample geometry.

Conventional hydraulic torsion momentum analysis devices also have a limited elongation range, and may suffer from restrictions to small analysis frequencies of around 20 Hz, depending on the stiffness of the
15 entire structure which is defined predominantly by the sample geometry.

Based on the above recognitions, exemplary embodiments of the invention have been developed by the present inventor. Using drives such as a servo drive, there limitations regarding possible rotation angles are relaxed. This allows to perform static twist experiments for analyzing
20 ductile materials which may require several rotations before breakage. Beyond this, vibration resistant experiments in the resonance region as well as without resonance are made possible. This may allow to investigate a possible influence of a frequency on the dynamic strength under torsion stress. Particularly, an operation of the apparatus at a first
25 torsion eigenfrequency may allow for an analysis of the vibration resistance with low power consumption.

According to exemplary embodiments of the invention, it is possible to measure the cyclic as well as the static deformation behaviour of the sample 102. Furthermore, by coupling energy supply systems of
30 two or more apparatuses 100 constructed in the same or in a similar

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way, it is possible to lower the total energy consumption of the both apparatuses.

The two measurement units 110 and 122 are adapted for measuring a possible self-oscillation of the sample 102 and are coupled
5 to the respective clamping chucks 104, 106.

A detailed view of the sample 102 in Fig. 1 shows schematically a scenario in which a drive frequency of the apparatus 100 has a value in which an undesired self-oscillation of the sample 102 takes place. A first
10 portion 150 of the sample 102 is twisted relative to a second portion 160 of the sample 102, wherein a central portion 170 forms a torsional node.

More precisely, the first measurement unit 110 is coupled to the clamping chuck 106, whereas the second measurement unit 122 is coupled to the clamping chuck 104. This coupling is in such a manner that measurement signals captured by the first measurement unit 110
15 and by the second measurement unit 122 are indicative of a possible self-oscillation along the sample 102. Such an undesired self-oscillation may result in differences between detection signals captured at the measurement units 110 and 122. An evaluation unit 124 is supplied with the measurement signals of the measurement units 110, 122 and
20 evaluates these measurement signals to detect a possible self-oscillation along the sample 102. For instance, such a self-oscillation may be assumed to be present when the detection signals 110 and 122 differ from one another by more than a predefined threshold value which is correlated with a still acceptable inaccuracy of the operation of the
25 apparatus 100.

A modification unit 126 is provided and is capable of modifying an operation mode of the apparatus 100. When the evaluation unit 124 has detected a self-oscillation along the sample 102, the apparatus 100 is driven back into an operation mode which is free of the self-oscillation
30 along the sample 102 by the modifying unit 126. For this purpose, the

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modifying unit 126 is coupled with the drive unit 108 so as to supply the drive unit 108 with control signals which define test frequency, test amplitude, phase positions, etc. After having performed an evaluation of the differences between the signals of the measurement units 110 and
5 122 by the evaluation unit 124, the modifying unit 126 modifies this operation mode of the drive unit 108 so that the sample 102 is driven out of a resonance condition and no self-oscillation or eigenoscillations of the sample 102 can still manipulate the measurement in an undesired manner.

10 Fig. 1 furthermore shows an input/output unit 128 which is bidirectionally coupled with the evaluation unit 124 and the modifying unit 126. The evaluation unit 124 and the modifying unit 126 may for instance be formed by a processor (such as a central processing unit, CPU, or a microprocessor). Via the input/output unit 128, a user may
15 input commands into the apparatus 100 or may be provided with results of a measurement of the apparatus 100. Hence, a user may input control commands to the apparatus 100 capable of influencing the operation of the apparatus 100. Furthermore, the detected self-oscillation as well as results of the analysis may also be presented to the user.

20 As can be taken from Fig. 1, a first intermediate element 128 such as a metal block is provided between the measurement unit 110 and the clamping chuck 106. In a simultaneous manner, an optional intermediate element 130 is arranged between the clamping chuck 104 and the measurement unit 122. These optional metal blocks 128, 130 provide for
25 an indirect coupling of the measurement units 110, 122 with the respective clamping chucks 106, 104 and are constructed in a stiff manner so as to prevent them from manipulating the self-oscillation properties which can thus be mechanically transferred from the clamped end portions of the sample 102 via the respective clamping chucks 104,
30 106 to the respective measurement units 110, 122. In an alternative

embodiment (see Fig. 5), the components 128, 130 may be omitted so that the clamping chucks 106, 104 are directly coupled to the respective measurement unit 110, 122.

Fig. 1 shows a completely symmetric configuration of the sample 102, the clamping chucks 104, 106, the intermediate elements 128, 130 and the measurement units 110, 122, wherein a center of gravity of the sample forms a symmetry axis.

In the following, some further embodiments will be described referring to Fig. 2 to Fig. 4 in which some of the components shown in Fig. 1 are omitted for the sake of simplicity.

In the following, referring to **Fig. 2**, an apparatus 200 for analyzing a sample 102 according to another exemplary embodiment of the invention will be explained.

Fig. 2 shows a dynamic module configuration without resonance operation of the apparatus 200.

In addition to the components shown in Fig. 1, the apparatus 200 shows a control cabinet 202 and has a protective housing 204. Linear guiding rails 206 are explicitly shown in detail as well. Reference numeral 112 may also be denoted as a drive bearing rack, and reference numeral 118 are also be denoted as a counter bearing rack.

Fig. 3 shows an apparatus 300 for analyzing a sample 102 according to a further exemplary embodiment of the invention.

The embodiment of Fig. 3 is a dynamic module operated with resonance. In addition to the components shown in Fig. 2, the apparatus 300 shown Fig. 3 further comprises a coupling 302 (or clutch) between the drive unit 108 and the first clamping chuck 104, which coupling 302 is stiff against torsion and is bending elastic. Moreover, an angular measurement system in a dynamic module configuration is shown and denoted with a reference numeral 304. Variable balance weights (inertia masses) are denoted with reference numeral 306. By adjusting the

position and the weight of the masses, the apparatus 300 can be operated at a specific frequency.

A bearing rack of the dynamic module is denoted with reference numeral 308. Moreover, a hollow shaft 310 is provided at the clamping
5 chuck 104.

In the following, referring to **Fig. 4**, an apparatus for analyzing a sample 102 according to another exemplary embodiment of the invention will be explained. The embodiment of Fig. 4 involves a static module.

In addition to the components shown in Fig. 2 and Fig. 3, the
10 apparatus 400 further comprises a harmonic drive gear 402, a bearing rack 404 of the static module, an angular measurement system 406 of the static module, and a static chuck 408 of the static module.

Fig. 5 shows an apparatus 500 according to a further exemplary embodiment of the invention.

15 As indicated with the dotted lines in Fig. 5, the servo drive 108 as well as the modifying unit 126 is optional in this embodiment. In the embodiment of Fig. 5, the apparatus 500 is free of an automatic drive unit and can be excited for instance with one short mechanical (for instance manual) pulse. However, also in the embodiment of Fig. 5, an
20 evaluation is performed based on the results of the measurement units 110, 122. Each of the measurement units 110, 122 may serve for measuring a torsional momentum and/or a rotational angle.

In the presence of a drive unit 108 (such as an electric engine), a cyclic torsional momentum may be applied to the sample 102. By the
25 torsional momentum or twist angle measurement units 110, 122, the time dependence of the torsional momentum and/or the torsional angle can be detected at both ends of the sample 102. When both load-time-characteristic curves are identical, there are no disturbing torsional self-oscillations of the sample 102, and the measurement signals are
30 undisturbed. However, in the presence of differences regarding

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amplitudes, middle positions and/or phase positions, torsional eigenoscillations are overlaid over the actual measurement signal, and a non-defined load state is present at the sample 102. By modifying the test frequency by a control signal supplied from the modifying unit 126 to
5 the drive unit 108, such an overlaid self-oscillation signal may be compensated.

This may allow to automate the test frequency selection and may result in time and cost savings. Manual deformation measurements at the sample may be omitted when a modification of the sample geometry or a
10 material of the sample takes place. Furthermore, the flexibility of the test opportunities is increased. Furthermore, the test quality may be improved.

Next, referring to **Fig. 6**, an apparatus 600 according to another exemplary embodiment of the invention will be explained. The apparatus
15 600 is adapted for checking a sample body 102 by a combined rotational bending and torsion loading.

In the embodiment of Fig. 6, the sample 102 is connected via a drive shaft 602 to two symmetrically arranged drive units 108, one assigned to each clamped end portion of the sample 102. The drive units
20 108 can be pivoted with their stators around a pivoting axis 604 with respect to a mount 606. Each drive unit 108 comprises an angle transmitter 608 and comprises a servo converter 610. Hence, a torsional momentum can be applied in a cyclic manner at each of the drive units 108 so that the sample 102 may be made subject of a cyclic torsional
25 momentum load and an additional torsional momentum.

The drive engines 108 may be electrically coupled so that, at a specific point of time, a decelerating drive unit 108 provides energy for the accelerating other drive unit 108.

To apply a bending load, a force generation unit 612 (such as a
30 lifting spindle) may be provided. By the force generating unit 612, a load

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may be applied to a support 614. Levers 616 are arranged in both end portions 618 of the support 614 via which the force is transferrable to the stators of the drive units 108. The force generating unit 612 is coupled with the support 614 via an elastic intermediate member 620 such as a spiral spring.

The detection signals received from the measurement units 110, 122 are supplied to the evaluation and modifying units 124, 126 bidirectionally coupled with an input/output unit 128. Hence, in response to a detected self-oscillation of the sample 102, the drive signals for driving the drive units 108 may be correspondingly modified to balance out such artefacts.

Breakage of the sample 102 may be detected by a switch 630.

It should be noted that the term "comprising" does not exclude other elements or features and the "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined.

It should also be noted that reference signs in the claims shall not be construed as limiting the scope of the claims.

Claims

1. An apparatus for analyzing a sample, the apparatus comprising
a first clamping chuck adapted for receiving a first portion of the
5 sample;
a second clamping chuck adapted for receiving a second portion of
the sample;
a first measurement unit adapted for measuring an oscillation,
particularly a self-oscillation, of the sample and being coupled to the first
10 clamping chuck;
a second measurement unit adapted for measuring the oscillation
of the sample and being coupled to the second clamping chuck;
wherein the first measurement unit is coupled to the first clamping
chuck and the second measurement unit is coupled to the second
15 clamping chuck so that measurement signals captured by the first
measurement unit and by the second measurement unit are indicative of
the oscillation along the sample.
2. The apparatus of claim 1, wherein the first measurement unit
20 and/or the second measurement unit is adapted for measuring at least
one physical parameter indicative of a property of the sample in response
to an application of a force to the first clamping chuck and/or to the
second clamping chuck.
- 25 3. The apparatus of any one of claims 1 to 2, wherein the first
measurement unit and/or the second measurement unit is adapted for
measuring the at least one physical parameter in a static manner, in a
dynamic manner, or in a cyclic manner.
- 30 4. The apparatus of any one of claims 1 to 3, wherein the first

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measurement unit and/or the second measurement unit is adapted for measuring at least one of the group consisting of torque, an angle of torsion, and a deformation behaviour.

5 5. The apparatus of any one of claims 1 to 4, comprising an evaluation unit adapted for evaluating the measurement signals captured by the first measurement unit and by the second measurement unit to detect oscillation characteristics, particularly a presence or an absence of an oscillation, along the sample.

10

6. The apparatus of claim 5, wherein the evaluation unit is adapted for detecting the presence of the oscillation when the measurement signal captured by the first measurement unit differs from the measurement signal captured by the second measurement unit,
15 particularly differs by more than a predefined threshold value of a measured parameter.

7. The apparatus of any one of claims 5 to 6, comprising a modifying unit adapted for modifying an operation mode of the
20 apparatus, when the evaluation unit has detected the oscillation along the sample, in a manner to drive the apparatus back into an operation mode which is free of the oscillation along the sample.

8. The apparatus of claim 7, wherein the modifying unit is adapted
25 for modifying an operation frequency and/or an operation amplitude of the apparatus, when the evaluation unit has detected the oscillation along the sample, in a manner to drive the apparatus back into an operation mode which is free of the oscillation along the sample.

30 9. The apparatus of claim 8, wherein the modifying unit is adapted

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for modifying the operation frequency of the apparatus, when the evaluation unit has detected the oscillation along the sample, in a manner to drive the apparatus back into the operation mode which is free of the oscillation along the sample and in which the operation frequency
5 is as large as possible.

10. The apparatus of any one of claims 1 to 9, wherein the first measurement unit is located directly adjacent to the first clamping chuck and/or the second measurement unit is located directly adjacent to the
10 second clamping chuck.

11. The apparatus of any one of claims 1 to 9, wherein the first measurement unit is indirectly coupled to the first clamping chuck and/or the second measurement unit is indirectly coupled to the second
15 clamping chuck via an intermediate body which is adapted to transfer an oscillation characteristic from the sample to the respective one of the first measurement unit and the second measurement unit.

12. The apparatus of any one of claims 1 to 11, being free of a
20 drive unit to enable a free oscillation of the sample.

13. The apparatus of any one of claims 1 to 11, comprising a drive unit, particularly exactly one drive unit, adapted for applying a force to one of the first clamping chuck and the second clamping chuck.
25

14. The apparatus of claim 13, comprising a further drive unit adapted for applying a force to the other one of the first clamping chuck and the second clamping chuck.

30 15. The apparatus of any one of claims 13 and 14, wherein the

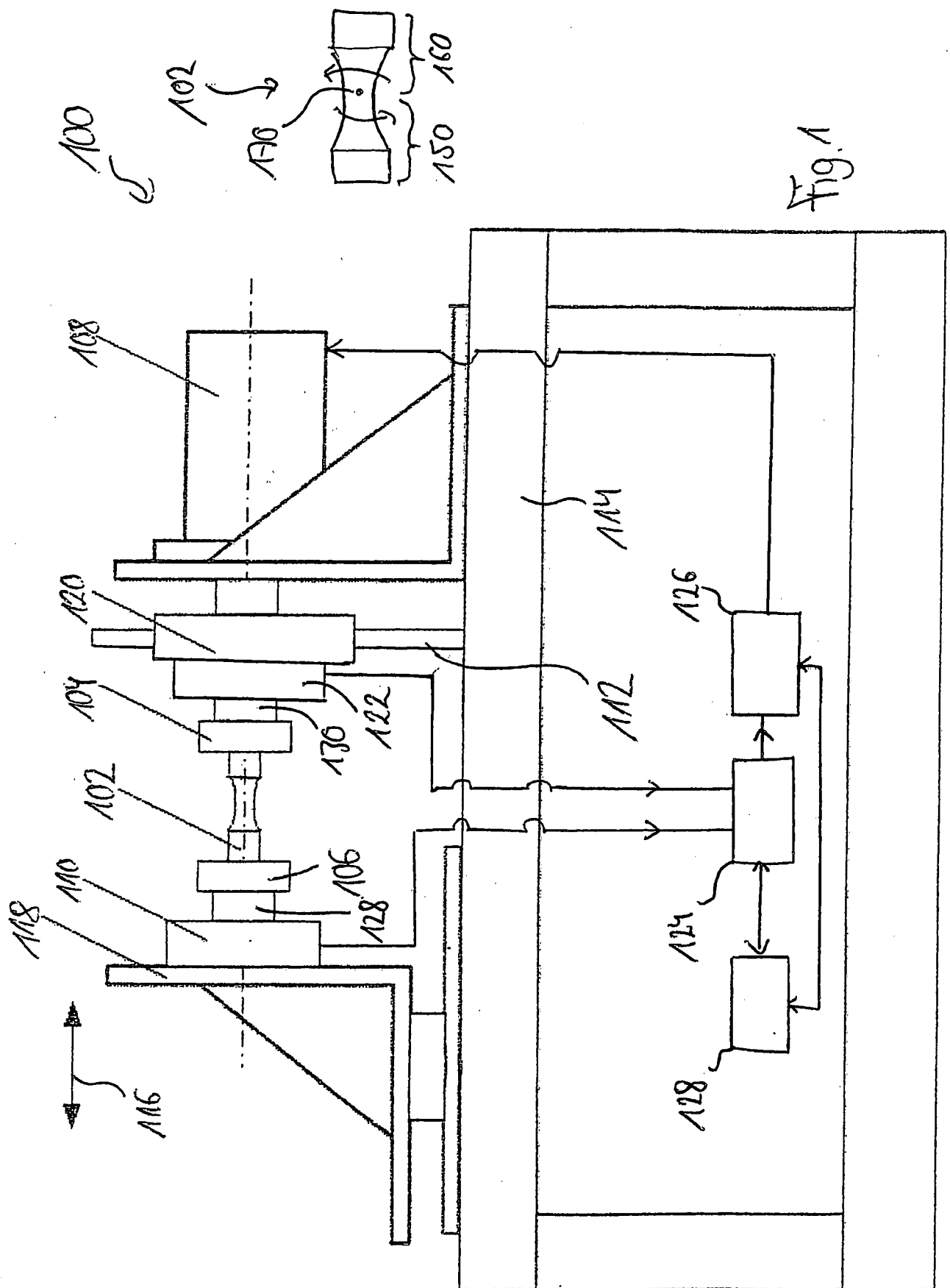
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drive unit comprises one of the group consisting of a servo drive, a combustion engine, a hydraulic drive, a synchronous machine, and an asynchronous machine.

5 16. The apparatus of any one of claims 1 to 15, wherein the first measurement unit and the first clamping chuck are arranged, in relation to the sample, spatially symmetrically with respect to the second measurement unit and the second clamping chuck.

10 17. The apparatus of any one of claims 1 to 16, adapted as at least one of the group consisting of a testing apparatus for testing the sample, a combustion engine, and a plant.

15 18. A method of analyzing a sample, the method comprising connecting a first portion of the sample to a first clamping chuck; connecting a second portion of the sample to a second clamping chuck; measuring an oscillation, particularly a self-oscillation, of the sample by a first measurement unit being coupled to the first clamping chuck; measuring the oscillation of the sample by a second measurement unit
20 being coupled to the second clamping chuck; coupling the first measurement unit to the first clamping chuck and the second measurement unit to the second clamping chuck so that measurement signals captured by the first measurement unit and by the
25 sample.



200

114

206

118

110

106

102

104

122

112

108

204

202

Fig.2

