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Datasheet for the decision of 8 October 2021

Case Number: T 0371/18 - 3.2.03

Application Number: 12188975.2

Publication Number: 2549055

IPC: E21B44/00, G05D19/02

Language of the proceedings: EN

Title of invention:
Method and apparatus for reducing stick-slip

Patent Proprietor:
National Oilwell Varco, L.P.

Opponent:
ENGIE Electroproject B.V.

Headword:

Relevant legal provisions:
RPBA Art. 12(4)
EPC Art. 83, 54, 56

Keyword:
Late-filed evidence - admitted (yes)
Late-filed evidence - submitted with the statement of grounds of appeal - admitted (no)
Late-filed request - request could have been filed in first instance proceedings (yes)
Sufficiency of disclosure - (yes)
Novelty - main request (no) - auxiliary request (yes) - enabling disclosure
Inventive step - non-obvious modification

Decisions cited:
T 2344/15, G 0009/91, G 0010/91

Catchword:

Boards of Appeal of the
European Patent Office
Richard-Reitzner-Allee 8
85540 Haar
GERMANY
Tel. +49 (0)89 2399-0
Fax +49 (0)89 2399-4465

Case Number: T 0371/18 - 3.2.03

D E C I S I O N
of Technical Board of Appeal 3.2.03
of 8 October 2021

Appellant: (Patent Proprietor)	National Oilwell Varco, L.P. 7909 Parkwood Circle Drive Houston, TX 77036 (US)
Representative:	Docherty, Andrew John Marks & Clerk LLP Aurora 120 Bothwell Street Glasgow G2 7JS (GB)
Appellant: (Opponent)	ENGIE Electroproject B.V. Computerweg 21 1033 RH Amsterdam (NL)
Representative:	Algemeen Octrooi- en Merkenbureau B.V. P.O. Box 645 5600 AP Eindhoven (NL)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 5 December 2017 concerning maintenance of the European Patent No. 2549055 in amended form.**

Composition of the Board:

Chairman	G. Patton
Members:	B. Miller
	N. Obrovski

Summary of Facts and Submissions

I. European patent No. 2 549 055 ("the patent") relates to a method of damping stick-slip oscillations in a drill string.

The patent as a whole was opposed on the grounds that its subject-matter was insufficiently disclosed (Article 100(b) EPC) and lacked novelty and inventive step (Article 100(a) EPC).

II. In the interlocutory decision, the opposition division found that:

- claim 1 as granted lacked novelty
- the patent as amended on the basis of auxiliary request 1 filed in the oral proceedings before it met the requirements of the EPC

The interlocutory decision was appealed by both parties. As the patent proprietor and the opponent are both appellants and respondents in the appeal proceedings, for the sake of simplicity, the Board will continue to refer to the parties as the patent proprietor and the opponent in the present decision.

III. The patent proprietor requested that the appealed decision be set aside and that the patent be maintained as granted or, alternatively, as amended on the basis of one of the following auxiliary requests:

- auxiliary requests 1 to 3 filed with its statement setting out the grounds of appeal (submission dated 16 April 2018)
- auxiliary request 4, filed as auxiliary request 1 in the oral proceedings on 28 June 2017 and found

allowable by the opposition division in its interlocutory decision

The opponent requested that the appealed decision be set aside and that the patent be revoked. In addition, the opponent requested that auxiliary requests 1 to 3 not be admitted into the appeal proceedings.

IV. Independent method claim 1 as granted reads as follows (using the feature numbering introduced by the opponent and used by both parties):

(1) A method of damping stick-slip oscillations in a drill string (12),
(2) wherein the stick-slip oscillations comprise torsional waves propagating along said drill string (12), which method comprises the steps of:
(3) (a) damping said stick-slip oscillations using a drilling mechanism (30) at the top of said drill string; and
(4) (b) controlling the speed of rotation of said drilling mechanism (30) using a PI controller (42);

characterised by the steps of
(5) (c) tuning said PI controller (42) so that said drilling mechanism (30) absorbs most torsional energy from said drill string (12) at a frequency that is at or near a fundamental frequency of said stick-slip oscillations by adjusting an I-term of said PI controller (42) to be dependent on an approximate period of said fundamental frequency of said stick-slip oscillations and on an effective inertia of said drilling mechanism (30), whereby said drilling mechanism has a frequency dependent reflection coefficient of said torsional waves, which reflection

coefficient is substantially at a minimum at or near said fundamental frequency of stick-slip oscillations; and

(6) (d) reducing the effective inertia of said drilling mechanism (30) by tuning said PI controller (42) with an additional torque term that is proportional to the angular acceleration of said drilling mechanism,

(7) and/or by changing into a higher gear of said drilling mechanism (30),

(8) whereby a damping effect of said drilling mechanism is increased for frequencies above said fundamental frequency.

Claim 1 of auxiliary request 4 differs from claim 1 of the main request in that feature (7) has been deleted and that the following additional features of claims 2 to 4 of the main request have been added:

(9) said additional torque term is generated by multiplying said angular acceleration by a compensation inertia (J_C), which compensation inertia (J_C) is adjustable so as to control the amount of the reduction of the effective inertia of said drilling mechanism (30),

(10) when reduced in step (d) using said additional torque term, said effective inertia comprises the total mechanical inertia of said drilling mechanism (30) at an output shaft thereof minus said compensation inertia (J_C),

(11) in step (c) said I-term of said PI controller (42) is adjusted according to $I = \omega_s^2 J$, where ω_s is the approximate or estimated angular frequency of said stick-slip oscillations and J is the reduced effective inertia value of said drilling mechanism (30).

The wording of auxiliary requests 1 to 3 is of no relevance for this decision since these requests were not admitted into the proceedings.

V. Cited evidence

(a) The following documents filed in the opposition proceedings are referred to in this decision:

A1: Tucker, R.W. and Wang, C., "Torsional Vibration Control and Cosserat Dynamics of a Drill-Rig Assembly", Meccanica, 38(1), 2003, pp. 143-159

A5: Van den Steen, L., "Suppressing Stick-Slip-Induced Drillstring Oscillations: A Hyperstability Approach", PhD thesis, University of Twente, 1997

A6: Hori, Y., "A Review of Torsional Vibration Control Methods and a Proposal of Disturbance Observer-Based New Techniques", IFAC Proceedings Volumes, 29(1), 1996, pp. 7-12

Annexes 1 and 2: Results of computer simulations based on the teaching of A1 submitted by the patent proprietor with the letter dated 14 March 2016

(b) With its statement of grounds of appeal, the opponent filed in addition:

A9: Schmidt, P.B. and Lorenz, R.D., "Design Principles and Implementation of Acceleration Feedback to Improve Performance of dc Drives", IEEE Trans. on Ind. Appl., 28(3), 1992

A10: Moatemri, M.H. et al., "Implementation of a DSP-Based, Acceleration Feedback Robot Controller: Practical Issues and Design Limits", Proc. of IEEE-IAS Conference 1991, vol. 2

A11: Younkin, G.W. et al., "Considerations for Low Inertia AC Drives in Machine Tool Axis Servo Applications", IEEE Trans. on Ind. Appl., 27 (2), 1991

(c) In its reply to the patent proprietor's grounds of appeal, the opponent further submitted the following document which had been filed in the opposition proceedings (submission dated 26 May 2017):

A12: Palm III, W.J, "Modeling, Analysis, and Control of Dynamic Systems", 2nd edition, 1999, pp. 272-304

VI. In a communication pursuant to Article 15(1) of the Rules of Procedure of the Boards of Appeal (RPBA 2020), the Board indicated its preliminary opinion to the parties.

VII. With the letter dated 12 March 2021, the patent proprietor further requested as auxiliary request 5 that the patent be maintained on the basis of the main or any of the first through fourth auxiliary requests, additionally amended to include any amendments found allowable in the related appeal proceedings against European patent No. 2 364 397 (Appeal T 1528/17).

VIII. Oral proceedings were held on 7 and 8 October 2021 by videoconference with the agreement of both parties.

IX. The patent proprietor's arguments, as far as they are relevant for this decision, can be summarised as follows.

(a) A9 to A12 - Admittance into the appeal proceedings

Documents A9, A10 and A11 related to motors for manufacturing and robotics (A9), robot motion control (A10) and machine tool axis servo applications (A11). Therefore, they were not obvious combinations that the skilled person working on a drill string would consider.

A12 referred to mechanical principles. However, it was irrelevant for the assessment of inventive step since it did not disclose features of claim 1 as granted and did not refer to methods for damping stick-slip oscillations.

These late-filed documents were irrelevant and should not be admitted into the appeal proceedings.

(b) Sufficiency of disclosure

The objection by the opponent was not substantiated since it did not set out the legal and factual reasons why the contested decision on this point should be set aside.

(c) Document A1 - Enabling disclosure

The information in A1 was insufficient to enable the skilled person to determine the proportional (κ_p) and integral (κ_i) gains of the PI controller to dampen stick-slip oscillations under real-life conditions. Equation (34) to determine κ_i on page 150 in A1 was clearly wrong since it provided values having the wrong unit. The skilled person was also not in the position to determine κ_p by using an FFT spectrum of torsional stick-slip frequencies, contrary to the statement in A1. Even when considering the specific values for κ_p and κ_i in Table 2 of A1, at best the skilled person could perform the method according to A1 for a specific drill having exactly the string length disclosed in Table 1 of A1. However, A1 did not provide enough information to enable the skilled person to achieve a damping for a drill string of any length.

In the absence of a clear teaching on how to determine κ_p and κ_i, the skilled person would not be able to put the teaching of A1 into practice.

(d) Main request - Interpretation of claim 1

The skilled person would recognise that claim 1 was directed to a method of damping stick-slip oscillations which could be used for drill strings of any length encountered in the field while drilling a wellbore.

The skilled person would understand from features (1) and (5) that the drill string referred to a transmission line in a real drilling mechanism and did not refer to a simple model such as a torsional pendulum. After all, a model could not provide a correct estimation of the real stick-slip period as required by these features.

The expression "tuning said PI controller" in feature (6) of claim 1 clearly told the skilled person to adapt the PI controller to be based on a P-term, I-term and the "additional torque term" according to equation (28) in paragraph [0126] of the patent. The wording of feature (6) excluded the option that the additional torque term was merely used to change the input for a PI controller.

(e) Main request - Novelty in light of A1

A1 failed to disclose a method of damping stick-slip oscillations in a drill string of any length occurring in the field. A1 did not disclose a method of tuning a PI controller as required by feature (5) since in this regard the disclosure in A1 was insufficient. Maintaining the form of the PI controller in equation (30) of A1 could not amount to a clear and unambiguous disclosure of a PI controller comprising an additional torque term according to claim 1.

A1 disclosed that the top contact torque signal was high-pass filtered and "used as a negative feedback with a coupling, h, to correct the target rotary speed settings in the standard rotary speed controller". By correcting the target rotary speed using a torque feedback with the coupling h, the magnitude of peak damping could be adjusted. But the output from the standard PI controller in A1 was still given by only two terms: the P-term and the I-term. Hence, A1 did not disclose to tune the PI controller itself by an additional torque term but to change only its input.

(f) Admittance of auxiliary requests 1 to 3

The patent proprietor had not been aware of the details of the opposition division's interpretation of claim 1 and A1 until receiving the written decision. Auxiliary requests 1 to 3 were filed at the first opportunity in response to the opposition division's decision.

(g) Auxiliary request 4 - Novelty in light of A5

A5 disclosed on pages 40 to 48 merely a concept for dimensioning a feedback circuit for a model of a drill string. In the last paragraph on page 45, A5 taught that the model described on pages 40 to 45 was not suitable for dampening stick-slip oscillations.

The results in Chapter 10 of A5 demonstrated that the model described on pages 40 to 48 was not directly used as such in the experimental work underlying A5.

A5 did not disclose a passive method of damping the stick-slip of a drill string comprising features (5) to (11) of claim 1.

(h) Auxiliary request 4 - Novelty in light of A1

Equation (34) of A1 did not correspond to the equation defined in feature (11) of claim 1. Like equation (34), equation (19) of A1 referred to the inertia J_{top} but not, as required by claim 1, to an effective inertia, which was the difference of the total inertia minus an adjustable inertia term. Although in A1 the rotary speed was corrected with a torque term $-h\tau_f(t)$, this correction was performed by changing the input of the PI controller but not by adjusting the I-term of the PI controller as required by the expression used of "tuning said PI controller".

Hence, the subject-matter of claim 1 was novel over A1.

(i) Auxiliary request 4 - Inventive step starting from A1

The patent was based on the finding that the reduction of the effective inertia by tuning the controller resulted in a more effective damping of any higher modes of stick-slip oscillations, without having to measure drill string torque directly (see paragraphs [0009], [0011], [0012] and [0120] of the patent). Moreover, the patent disclosed in paragraphs [0133] and [0135] with reference to Figure 11 that the claimed tuning of the I-term resulted in an increased absorption bandwidth on torsional vibrations, thus improving the damping effect of the drilling mechanism for frequencies above the fundamental frequency.

A1 neither disclosed features (10) and (11) nor provided any suggestion to adjust the I-term of the PI controller as defined by it to achieve these effects.

It was also not known from the common general knowledge to adjust the I-term of the PI controller in the way proposed by claim 1 to achieve a more effective damping of any higher modes of stick-slip oscillations.

Systems for damping stick-slip oscillations in drill strings as claimed and systems for damping torsional vibrations in steel rolling mills such as in A6 could not be considered to belong to neighbouring technical fields. Rather, they involved different technical problems. Hence, the skilled person starting from A1 would not look for suggestions in the field of steel rolling mills, irrespective of the formulation of the objective technical problem.

(j) Auxiliary request 4 - Inventive step starting from A5

A5 neither disclosed nor suggested reducing the effective inertia of the drilling mechanism by tuning the PI controller with an additional torque term. Furthermore, A5, similar to A1, neither disclosed nor taught to adjust the I-term of the PI controller as defined in features (10) and (11) of claim 1 to achieve a more effective damping of any higher modes of stick-slip oscillations.

X. The opponent's respective arguments can be summarised as follows.

(a) A9 to A12 - Admittance into the appeal proceedings

A9 to A11 demonstrated that it was known in the art to compensate commanded angular acceleration inertia by tuning the PI or speed controller and to generate an additional torque term by multiplying the angular acceleration by a compensation inertia.

A12 reflected the common general knowledge of the skilled person on gear systems.

Hence, the teaching of these documents was relevant and should be taken into account in the appeal proceedings.

(b) Main request - Sufficiency of disclosure

The invention was insufficiently disclosed as set out in the notice of opposition and the written submission in opposition proceedings dated 26 May 2017.

(c) Document A1 - Enabling disclosure

For the skilled person, it was clearly evident that in equation (34) of A1, a normalised angular frequency ($\hat{\omega}$, with dimension T) with a scaling factor $K = c^2/L^2$ having the dimension T^{-2} had been used ($\hat{\omega}=\omega/K$). Although the units provided by equation (34) and indicated for the values in Table 2 of A1 were not consistent, it was well within the ability of the skilled person to interpret equation (34) in a sensible manner. Hence, the skilled person was able to determine κ_p and κ_i based on their experience and general knowledge, in particular by considering the values in Table 2 of A1.

(d) Main request - Interpretation of claim 1

Claim 1 defined a method of damping stick-slip oscillations in a drill string. There was no reason for consulting the description and the drawings of the patent to give the wording of claim 1 a narrower meaning. Equation (28) of the patent was not in claim 1 and could not be used to distinguish the claimed subject-matter from the cited prior art.

The skilled person would recognise that, for estimating the stick-slip period, the drill string may be regarded as a simple torsional pendulum described by a lumped parameter model, and that a more accurate model would provide a more accurate result.

The expression "by tuning said PI controller with an additional torque term that is proportional to the angular acceleration of said drilling mechanism" in feature (6) could be interpreted to mean that a negative torque feedback is used to correct the control speed error of a standard PI controller.

(e) Main request - Novelty in light of A1

A1 disclosed the tuning step required by feature (5) for at least one drill string length of 3000 metres. Claim 1 was not limited to a method which had to be applicable to a drill string of any length.
A1 therefore disclosed a method of damping stick-slip oscillations in a drill string according to features (1) to (5). Feature (6) was anticipated by the teaching in paragraph 3.3 of A1. Hence, claim 1 lacked novelty over A1. Feature (8) was an inevitable consequence of feature (6).

(f) Admittance of auxiliary requests 1 to 3

Auxiliary requests 1 to 3 filed for the first time in appeal proceedings entailed a different direction of development and protection sought compared to the claims maintained in opposition proceedings. Given that the aim of opposition-appeal proceedings was for obtaining a judicial review of the opposition division's decision, claims deviating from the factual framework of the decision by the opposition proceedings should not be considered in appeal proceedings.

(g) Auxiliary request 4 - Novelty in light of A1

The equation defined in feature (11) of claim 1 corresponded to equation (34) of A1. In A1, the rotary speed was corrected with a torque term $\tau_f(t)$. Equation (19) of A1 confirmed that $\tau(t)$ was dependent on inertia.

Hence, the features added to claim 1 were also known from A1, and the subject-matter of claim 1 lacked novelty over A1.

(h) Auxiliary request 4 - Novelty in light of A5

Applying inertia compensation by acceleration control, i.e. torque control, as disclosed on page 48, lines 5 to 6 of A5, would lead the skilled person directly to reducing the effective inertia of the drilling mechanism according to feature (9) of claim 1.
Feature (10) merely described the result or effect of the inertia reduction by the compensation inertia.
A5 disclosed on page 45 with regard to the spring that $\kappa_f = \omega_f^2 J_3$, i.e. the I-term of the PI-controller, is equal to the square of the angular frequency and the effective inertia at the top of the drilling mechanism.
Hence, A5 also disclosed feature (11) of claim 1.
Chapter 10 of document A5 presented experimental results illustrating how the drive torque could be taken into account in a method of damping the stick-slip oscillations.
Hence, claim 1 lacked novelty over A5.

(i) Auxiliary request 4 - Inventive step

The subject-matter of claim 1 lacked an inventive step in view of A1 or A5 as the closest prior art.

The skilled person would consider A6, A9, A10 and A11 since they all belonged to neighbouring technical fields.

Starting from A1 or A5 and taking into account the teaching of any of A6 or A9 to A11, the subject-matter of claim 1 was obvious.

The subject-matter of claim 1 was obvious even when considering A1 on its own or in combination with the common general knowledge.

A1 alone disclosed that the control of the drive speed took into account an additional torque term. The skilled person knew that this term could alternatively be used to modify the input of the PI-controller or its P- or I-term.
To provide an alternative method for damping stick-slip oscillations, it was therefore obvious starting from A1 to tune the I-term of the PI-controller as defined in claim 1, in particular in view of A6.

Should the skilled person formulate the objective technical problem as to provide an improved method of damping oscillations, they would consider any document dealing with oscillations, including A6.

Reasons for the Decision

1. Applicable rules of procedure

The revised Rules of Procedure of the Boards of Appeal (RPBA 2020) entered into force on 1 January 2020. Subject to the transitional provisions (Article 25 RPBA 2020), the revised version also applies to appeals pending on the date of the entry into force. In the case at issue, the statements of grounds of appeal were filed before 1 January 2020, and the replies to them were filed in due time. Thus, Article 12(4) to (6) RPBA 2020 do not apply to these submissions; Article 12(4) RPBA 2007 does (Article 25(2) RPBA 2020).

2. Documents A9 to A12 - Admittance into the appeal proceedings

2.1 The opponent filed A9 to A11 for the first time with the statement setting out the grounds of appeal. It has relied on these documents to raise a new objection of lack of inventive step against the subject-matter of claim 1 as amended on the basis of auxiliary request 4. These new facts, objections and evidence constitute an amendment to the opponent's opposition case.

The opponent has not provided any valid reasons why these documents could not have been filed before the opposition division or whether and to what extent their filing can be regarded as an appropriate reaction to the appealed decision. The purpose of the opposition appeal proceedings is to give the losing party the possibility to challenge the decision of the opposition division on its merits and to obtain a judicial ruling on whether the decision is correct (G 9/91 and G 10/91, OJ EPO 1993, 408, 42, point 18 of the Reasons). Opposition appeal proceedings are not an alternative way of dealing with and deciding upon an opposition (see T 2344/15 of 12 September 2019, point 2.2 of the Reasons).

The opponent submits that, starting from either A1 or A5 as the closest prior art, the provision of feature (6) of claim 1 according to auxiliary request 4 is rendered obvious by the teaching of A9, A10 or A11.

Even though this request was filed for the first time in the oral proceedings on 28 June 2017, amended claim 1 essentially entails a combination of claims 1 to 4 as granted, with feature (6) having been part of granted claim 1.

Thus, the filing of A9 to A11 with the statement of grounds of appeal to support objections against auxiliary request 4 cannot be considered an appropriate reaction to the patent proprietor's filing of this request at the oral proceedings before the opposition division.

Furthermore, these documents do not even relate to methods for damping stick-slip oscillation in drill strings but instead to motors for manufacturing and robotics (A9, abstract), robot motion control (A10, abstract) and machine tool axis servo applications (A11, title). The content of documents A9 to A11 does not go beyond that of A6 previously filed in the opposition proceedings and does not seem to be highly relevant for the evaluation of inventive step.

By exercising its discretion under Article 12(4) RPBA 2007, the Board therefore decided not to admit documents A9, A10 and A11 into the appeal proceedings.

2.2 In its reply to the patent proprietor's statement of grounds of appeal, the opponent referred to the general textbook A12. This document supports the opponent's objection that feature (7) of claim 1 as granted is an obvious measure in light of common general knowledge. The filing of A12 can be considered an appropriate reaction to the patent proprietor's contention that the common general knowledge is unsubstantiated by documentary evidence.

Thus, the Board admitted A12 into the appeal proceedings (Article 12(4) RPBA 2007).

3. Main request - Sufficiency of disclosure

The opposition division ruled that the patent as granted disclosed the claimed invention in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (point II.2 of the contested decision). In its statement of grounds of appeal, the opponent made a general reference to its objection of insufficient disclosure presented in the notice of opposition and its written submission dated 26 May 2017 without commenting on the assessment of that objection in the decision under appeal. Thus, the opponent has not substantively challenged the opposition division's decision on this point.

The Board therefore has no reason to deviate from the finding by the opposition division that the ground of opposition pursuant to Article 100 (b) EPC does not prejudice the maintenance of the patent.

4. Main request - Novelty

4.1 Document A1 - Enabling disclosure

4.1.1 The patent proprietor challenges the decision of the opposition division that the information in A1 is sufficient to enable the skilled person to put its technical teaching into practice while taking into account also common general knowledge at the publication date of A1.

4.1.2 For determining the proportional (κ_p) and integral (κ_i) terms of the PI controller, A1 discloses uncontroversially on page 150 to use the following equations (33) and (34):

equation (33): $$\kappa_p = \frac{G\Gamma(1+\hat{r})}{c_\tau(1-\hat{r})}$$

equation (34): $$\kappa_i = \frac{c_\tau^4 \hat{\omega}^2 J_{top}}{L^4}$$

(a) The value of proportional term κ_p

The parties dispute whether κ_p can be determined according to equation (33) of A1 with the value of the minimum reflection coefficient ($\hat{r}$) previously derived from equation (35) $$\Delta\omega = \frac{G\Gamma L^2}{J_{top} c_\tau^3} \frac{2}{1-\hat{r}} \sqrt{\frac{3\hat{r}+1}{\hat{r}+3}}$$ by estimating $\Delta\omega$ by examining the FFT spectrum, i.e. the angular frequency spectrum of the top rotary speed curve obtained from an FFT analysis (see page 151, lines 28 and 29 and Figure 6 of A1).

This question can be left unanswered. In the Board's view, finding an appropriate value of κ_p is merely a matter of choice to set an appropriate value for the reflection coefficient $\hat{r}$ in equation (33) for the PI controller to achieve the desired damping effect.

In fact, $\hat{r}$ is a dimensionless quantity, and it is stated in A1 (page 155, line 10) that it is set at 0.2, 0.4 and 0.8 to obtain different values of κ_p by using equation (33). A1 even illustrates in Figure 7 the influence of the set $\hat{r}$ value on the bandwidth of the spectral absorption for torsional waves. There is no evidence that this way of determining an appropriate value for $\hat{r}$ and thus κ_p would require a lot of work, let alone constitute an undue burden.

Moreover, it is apparent that the skilled person could set κ_p to 700 $Nmsrad^{-1}$. This is recommended as the optimal scenario on page 158, lines 32 to 34 of A1.

(b) The value of integral gain κ_i

While the values of κ_i mentioned on pages 151, 154, 155 and 158 of A1 have the dimension $[ML^2T^{-2}]$ ($Nmrad^{-1}$), equation (34) for calculating κ_i results in a value having dimension $[ML^2T^{-6}]$. Hence, the disclosure on κ_i in A1 is contradictory.

In view of this contradiction, the parties disagree whether a skilled person would:

- realise that equation (34) is erroneous
- consider it correct but containing a scaling factor $K = c_\tau^2/L^2$ (where c_τ is the speed of torsional waves and L is the length of the drill string) for obtaining a normalised angular frequency "$\hat{\omega}$"
- be able to correct equation (34) or interpret it accordingly based on the common general knowledge to obtain appropriate κ_i values

Notwithstanding these questions, the Board is of the opinion that the skilled person could in any case select an appropriate value for κ_i based on the values in Table 2 of A1 and vary them in light of general knowledge in the field of the invention.

4.1.3 In fact, the simulation results in Annexes 1 and 2 presented by the patent proprietor further confirm that the skilled person could identify and correct the inaccuracies in the teaching of A1 to determine values for κ_p and κ_i which at least allow curing stick-slip in a vertical drill string with a length L of 3000 metres (Figure 3 in Annex 1) and a deviated drill string with a length L of 3152 metres (Figure 11 in Annex 2), i.e. for the examples described in Table 2 of A1.

The patent proprietor questioned whether an ordinary skilled person could provide simulations as presented in Annexes 1 and 2. The Board does not share this view. Any experienced person working in this field would be able to provide simulations similar to the ones presented by the patent proprietor by using their common general knowledge and the values in Tables 1 and 2 of A1. A certain amount of trial and error and adaptation of the teaching in a scientific paper is well within the ability of the skilled person.

4.1.4 Soft torque modification

Paragraph 3.3 on page 155 of A1 discloses how the standard PI controller previously described in paragraph 3.2 of A1 is modified by including a negative torque feedback ($-h\tau_f(t)$) in the control error (compare equation (38): $\dot{\xi}(t) = \Omega_0 - hT_f(t) - \dot{\phi}(0,t)$ with equation (31): $\dot{\xi}(t) = \Omega_0 - \dot{\phi}(0,t)$).

Even though it is further explained in paragraph 3.3 of A1 that $\tau_f(t)$ may be calculated using the drill string torque $-G\Gamma\varphi'(0,t)$, it is common ground that in practice it cannot be measured directly and fed back to the PI controller. However, the skilled person would use an indirect measurement of the drill string torque based on the angular acceleration and the actual drive torque based on equation (19): $J_{top}\ddot{\phi}(0,t) = G\Gamma\phi'(0,t) + T(t)$ of A1.

Since the angular acceleration is readily derived from the angular speed, the skilled person would have no practical difficulty in implementing the soft torque control described in A1.

4.1.5 In conclusion, the Board is of the opinion that A1 sufficiently discloses a method of tuning the PI controller to dampen stick-slip oscillations at least in two cases, meaning that this method is in the state of the art pursuant to Article 54(2) EPC.

4.2 Interpretation of claim 1

Feature (1) of claim 1 simply defines a method of damping stick-slip oscillations in a drill string. The language of this feature is clear, albeit broad. For instance, claim 1 covers embodiments in which the drill string is 3000 metres in length and perfectly vertical. Since claim 1 itself imparts a clear and technically sound teaching to the skilled person, there is no reason for consulting the description and the drawings of the patent to give the claim a narrower meaning.

Even though it is explained in paragraphs [0059] and [0060] of the patent that a transmission-line model is used to describe the torsional waves comprised in the stick-slip oscillations and to calculate a frequency-dependent reflection coefficient of the torsional waves at the drill string/top drive interface, there is no reason to read this limitation into the claim. The claim covers alternative embodiments in which the stick-slip frequency is estimated using other models, e.g. a lumped parameter model, to tune the I-term and thus provide the desired damping effect, with the inevitable result that the reflection coefficient of the torsional waves would be "substantially at a minimum at or near" this frequency (feature (5)), should it be calculated.

It is further clear from the term "approximate" used in feature (5) that the estimated or measured fundamental stick-slip period does not have to be completely accurate. The estimated or measured stick-slip period may be higher or lower than the actual fundamental period while still providing the desired damping effect. This understanding is confirmed by the teaching in the patent in paragraphs [0015], [0017], [0072] and [0076].

Feature (6) of claim 1 further requires that the PI controller be tuned "with an additional torque term that is proportional to the angular acceleration of said drilling mechanism", i.e. a torque term proportional to the derivative of the speed. Also, the expression "tuning the PI controller with an additional torque term" has a broad but not totally unambiguous meaning. Hence, there is no reason for the skilled person to take into account the teaching in the description of the patent, such as equation (28) in paragraph [0126], to define the scope of protection.

Since the patent also clearly refers in paragraphs [0059], [0060], [108] to [110] and [0113] to models used to describe the drill string and the stick-slip oscillations, it can be concluded that in the context of the patent, a model of damping stick-slip oscillations in a drill string is synonymous with the corresponding method in a wellbore. Hence, documents describing a model of damping stick-slip oscillations in a drill string model inherently disclose a method as in claim 1.

4.3 Novelty over A1

4.3.1 A1 relates to a torsional vibration control of a drill-rig assembly (see the abstract). According to page 150, lines 4 to 15 of A1, the rotary motion of the drill string is driven by an electric motor at the top using various feedback control mechanisms, such as a PI-type rotary speed controller.

A1 therefore undisputedly discloses features (1) to (4) of claim 1.

4.3.2 A1 discloses (on page 150, lines 13 to 15) that the choice of the proportional gain parameter κ_p or P-term and the integral gain parameter κ_i or I-term of the PI controller significantly affects the torsional stability of the drill string, in particular when unwanted torsional relaxation oscillations occur.

Table 2 of A1 discloses preferred values for κ_p and κ_i for a drill string having a length of 3000 metres (see Table 1). Figure 6 demonstrates that stick-slip oscillations can be damped according to the method of A1.

Neither feature (5) nor the remaining features of claim 1 require that the claimed method must be suitable for a drill string of any length.

Hence, in view of the interpretation of feature (5) discussed under point 4.2 above, feature (5) of claim 1 cannot be distinguished in this regard from the disclosure in A1.

4.3.3 Feature (6) and the intended result to be achieved as defined in feature (8) of claim 1 are also disclosed in A1 by the description of the soft torque modification in paragraph 3.3. On page 155, it is disclosed how the standard PI controller previously described in paragraph 3.2 is modified by including a negative torque feedback ($-h\tau_f(t)$) in the control error (compare equation (38): $\dot{\xi}(t) = \Omega_0 - h\mathcal{T}_f(t) - \dot{\phi}(0,t)$ with equation (31): $\dot{\xi}(t) = \Omega_0 - \dot{\phi}(0,t)$).

The negative torque feedback ($-h\tau_f(t)$) can be obtained by equation (36): $\mathcal{T}_f(t) = -G\Gamma\phi'(0,t) - \mathcal{T}_c(t)$, which, thanks to equation (19): $J_{top}\ddot{\phi}(0,t) = G\Gamma\phi'(0,t) + \mathcal{T}(t)$, makes the negative torque feedback ($-h\tau_f(t)$) a direct function of the angular acceleration of the drilling mechanism $\ddot{\phi}$. Hence, the inclusion of the control error $\dot{\xi}(t)$ of equation (38) with the modified torque feedback in the rotary speed controller according to equation (30): $\mathcal{T}(t) = \kappa_p\dot{\xi}(t) + \kappa_i\xi(t)$ inevitably leads to the PI controller being tuned by an additional torque term proportional to the angular acceleration of the drilling mechanism according to feature (6) of claim 1.

As far as the expression "tuning said PI controller" is concerned, the Board considers that feature (6) does not provide a specific definition as to what is actually performed in the claimed step, in contrast to feature (5), where the tuning is clearly done by adjusting the I-term. Feature (6) is therefore to be interpreted in the broadest manner in this respect. Consequently, by including a negative torque feedback in the control error and, hence, in the rotary speed controller, A1 discloses that the PI controller is tuned.

The Board shares the opponent's view that feature (8) corresponds to an inevitable result of the steps according to feature (6). Hence, feature (8) is also considered to be known from A1.

Hence, the method of A1 tunes the PI controller in line with feature (6) of claim 1.

4.3.4 The Board therefore concludes that the subject-matter of claim 1 as granted lacks novelty over A1 and that the ground of opposition pursuant to Article 100 (a) EPC in combination with Article 54 EPC prejudices the maintenance of the patent as granted.

5. Auxiliary requests 1 to 3 - Admittance

The patent proprietor filed auxiliary requests 1 to 3 for the first time with the statement setting out the grounds of appeal.

In accordance with Article 12(4) RPBA 2007, it lies within the discretion of the Board to admit these requests into the appeal proceedings. In exercising its discretion, the Board must take into account whether the filing of the new requests could be considered an appropriate reaction to the events in the opposition proceedings.

The patent proprietor has not provided any valid reasons:

i) why these new requests were not submitted before the opposition division

ii) whether and to what extent the amendments of claim 1 of each request can be regarded as an appropriate reaction to the appealed decision

Claim 1 of auxiliary requests 1, 2 and 3 differs from claim 1 of the main request considered in the appealed decision in that it has been limited to the alternative of features (6) and (8) (feature (7) has been deleted) and that features have been added to further define the "additional torque term" of feature (6). More specifically, from claim 1 of auxiliary request 1 considered in the appealed decision ("auxiliary request 4"), features (9) to (11) have been deleted and features have been added to further define the "additional torque term" of feature (6).

In the initial stage of the opposition proceedings, it was already a matter of dispute between the parties whether the expression "additional torque term" in feature (6) could be construed broadly or whether it referred to an extra control term to be added to the P-term and the I-term of the PI controller, as shown in equation (28) in paragraph [0126] of the patent. The patent proprietor thus became aware of the need to file amendments to claim 1 and indeed did so in its response to the summons dated 26 May 2017. The patent proprietor therefore could not be surprised in this regard by the reasoning in the contested decision.

Moreover, after the opposition division had decided that claim 1 as granted lacked novelty in view of A1, the patent proprietor had the opportunity during the oral proceedings before the opposition proceedings to react, and indeed it did file a new auxiliary request 1 replacing auxiliary request 1 previously on file, which was eventually found to be allowable by the opposition division.

It thus appears that the new claim requests could and should, at the latest, have been submitted during the oral proceedings of the opposition proceedings.

The Board therefore decided not to admit auxiliary requests 1 to 3 into the appeal proceedings (Article 12(4) RPBA 2007).

6. Auxiliary request 4 - Novelty over A1

Compared to claim 1 as granted, claim 1 of auxiliary request 4 further defines in features (10) to (11) that the I-term of the PI controller is adjusted according to $I = \omega_s^2 J$, where
ω_s is an approximate or estimated angular frequency of the stick-slip oscillations and
J is the reduced effective inertia value of the drilling mechanism (total mechanical inertia of the drilling mechanism at an output shaft (J_d) minus an adjustable compensation inertia (J_c)).

A1 discloses in this regard the I-term on page 155 in equation (34)

$$\kappa_i = \frac{c_\tau^4 \hat{\omega}^2 J_{top}}{L^4}.$$

However, this equation does not correspond to the definition in feature (11) of claim 1 for various reasons.

The inertia J_{top} defined in equation (34) refers to the inertia of the top drive and therefore is not the reduced effective inertia defined in feature (10) based on the total mechanical inertia of the drilling mechanism at an output shaft minus an adjustable compensation inertia.

Furthermore, equation (34) requires considering the ratio c_τ^4/L^4.

This ratio can, under specific conditions, be close to 1, as argued by the opponent. Nevertheless, it is not negligible and cannot be ignored.

The subject-matter of claim 1 of auxiliary request 4 therefore differs from the direct and unambiguous disclosure of A1 by at least features (10) to (11).

7. Auxiliary request 4 - Novelty over A5

7.1 A5 discloses a method for suppressing stick-slip induced drill string oscillations based on a hyperstability approach (see the title).
The drill string is modelled, according to A5, as a torsional spring having a stiffness k_f and a parallel viscous damper c_f as disclosed on page 30 under the heading "The drillstring". The opening sentence of Chapter 1.4.1 of A5 indicates that the principle of damping torsional drill string vibrations involves providing the drive with a feedback circuit that changes the drive characteristics. Chapter 2 of A5 discloses the underlying modelling and basic concepts in more detail and discloses the schematic representation of the effect of the feedback circuit

and its mechanical representation in Figures 2.6 and 2.8.

7.2 The dimensioning and implementation of the feedback circuit is discussed in Chapters 2.3 and 2.4 of A5, i.e. on pages 40 to 48. In particular, Chapter 2.4.1 of A5 discloses the practical implementation of the damping principle by using a silicon-controlled rectifier drive comprising a PID controller in which the D-part can usually be ignored.

A5 further discloses on page 30 in relation to the drill string model comprised of a spring and parallel viscous damper that the drive torque T3 operating at the drill string at a rotary speed can be expressed by

$$T_3 = c_f\left(\Omega_{ref} - \Omega_3\right) + k_f \int\left(\Omega_{ref} - \Omega_3\right)dt.$$

Comparing this equation with equation (2) of the patent, it is apparent that c_f equals the P-term and k_f equals the I-term of a PI-controller.
Tuning the stiffness k_f as referred to by A5 is therefore equivalent to adjusting the I-term of a PI-controller as defined in claim 1.

As disclosed on page 45 of A5, the feedback circuit should be tuned to:

$$\omega_f = \sqrt{\frac{k_f}{J_3}} \text{ or } k_f = \omega_f^2 \cdot J_3$$

Hence, the stiffness k_f depends on the inertia of the rotary table J_3 and the resonant frequency ω_f of the feedback circuit.

On the one hand, A5 further discloses (page 45, first paragraph, second bullet point) that the resonant frequency ω_f of the feedback circuit should be tuned to that of the drill string ω_s. On the other hand, the drill string constitutes a torsional pendulum which has a preference to oscillate in its fundamental mode (see paragraphs 1 and 2 of the summary of A5).

It follows that tuning the resonant frequency of the feedback circuit ω_f to the resonant frequency of the drill string ω_s is equivalent to adjusting the feedback circuit at a frequency at or at least near ("approximate") a frequency of the stick-slip oscillations as required by claim 1.

Hence, the basic concept disclosed on pages 40 to 48 of A5 can be considered to disclose features (1) to (5) of claim 1.

7.3 A5 discloses further on page 108, last four lines, that a prime design criterion is to have the rotary table inertia J_3 as small as possible to achieve maximum system damping, i.e. a large bandwidth for the absorption of energy.

However, this teaching in the experimental section of A5 belongs to the specific model developed by the author of A5, i.e. a hyperstable damping system, on which the work described in A5 is based.

This reading of A5 is confirmed by the experimental results provided in Chapter 10 (starting on page 227). On page 229, A5 sets out a simulation "based on the theory developed in the preceding chapters".

Input data for the simulation is set out on page 229 (first bullet point), and the following input data for the simulation is defined:
J_3 = 812 kgm^2 and ω_s = 2.1 s^{-1}.

If κ_f is calculated according to the equation on page 45 in regard to the basic model, the simulation of A5 should result in a value for κ_f derived from $\kappa_f = \omega_f^2 J_3 = \omega_s^2 J_3 = 3580.92$ Nm.

However, A5 teaches to use a value of 5139 Nm (see page 230 under "Second phase, active damping system activated").

Hence, the specific values in A5 confirm that the further teaching with regard to an additional torque term to be used according to the experimental section of A5 does not refer to the basic concept described on pages 40 to 48.

Moreover, in regard to the basic concept according to pages 40 to 48, A5 consistently refers to the inertia of the rotary table (J_3). A5 does not disclose that the I-term of the PI controller is adjusted according to

$$I = \omega_s^2 J,$$

where J is the reduced effective inertia value of the drilling mechanism (total mechanical inertia of the drilling mechanism at an output shaft (J_d) minus an adjustable compensation inertia (J_c)).

Nor does the basic concept of A5 disclose to reduce the effective inertia of the drilling mechanism by tuning the PI controller with an additional torque term proportional to the angular acceleration of the drilling mechanism.

The subject-matter of claim 1 of auxiliary request 4 therefore differs from the direct and unambiguous disclosure of A5 by features (6) to (11).

8. Auxiliary request 4 - Inventive step

8.1 The parties agree that documents A1 and A5 both represent a suitable starting point for the assessment of inventive step. The Board sees no reason to deviate from this assessment since both documents deal with stick-slip oscillations and therefore focus on the same purpose as the patent.

8.2 Obviousness in view of A1 on its own

8.2.1 The subject-matter of claim 1 differs from the disclosure in A1 by features (10) to (11) (see point 6 above).

The patent describes (in paragraphs [0133] and [0135] with reference to Figure 11) that setting the I-term of the speed controller at $I = \omega_s^2 J$, where $J = J_d - J_c$, causes the drilling mechanism to have an increased absorption bandwidth on torsional vibrations.

8.2.2 The objective technical problem can therefore be regarded as to provide an improved method of damping stick-slip oscillations including frequencies higher than the fundamental frequency of the stick-slip oscillations.

8.2.3 A1 does not provide any motivation for the skilled person to modify the method it describes in the manner defined by claim 1.

A1 cites equation (30) $T(t) = \kappa_p \dot{\xi}(t) + \kappa_i \xi(t)$ in general on page 150 and further teaches on page 155 the possibility of modifying the standard PI controller by including a negative torque feedback ($-h\tau_f(t)$) in the control error. However, these statements in A1 cannot be regarded as a clear prompt to:

i) tune the I-term of the PI controller according to feature (11)

ii) thus consider an adapted, effective inertia

8.2.4 Arguments according to which the skilled person would also tune the I-term of the PI controller and inherently consider the effective inertia as defined in feature (11) in view of equation (34) $\kappa_i = \frac{c_\tau^4 \hat{\omega}^2 J_{top}}{L^4}$ on page 155 are based on hindsight for the following reasons.

(a) There is no suggestion in A1 that these modifications could lead to a more effective damping of frequencies higher than the fundamental frequency of the stick-slip oscillations.

(b) With regard to equation (34), A1 consistently refers to the inertia of the top but does not provide any teaching that in this formula an effective inertia of the total drilling mechanism should be considered.

(c) No teaching is provided that equation (34) can be simplified to read $I = \omega_S^2 J$, i.e. that the ratio c_τ^4/L^4 can simply be deleted from equation (34) of A1.

8.2.5 This finding applies not only in view of the above defined objective technical problem. It applies equally if the effects described in the patent are neglected and the objective technical problem is formulated as the provision of an alternative method.

8.2.6 Hence, considering the teaching of A1 on its own, the subject-matter of claim 1 is not obvious.

8.3 Obviousness in view of A1 in combination with common general knowledge

It has not been demonstrated that it is within the common general knowledge of the skilled person that frequencies higher than the fundamental frequency of the stick-slip oscillations could be damped more effectively when tuning the I-term of the PI controller as defined by claim 1.

Hence, the argument that the subject-matter of claim 1 is obvious when starting from A1 and taking into account the common general knowledge is a mere allegation and cannot be found convincing as such.

8.4 Obviousness in view of A1 in combination with A6

Systems for damping stick-slip vibrations in drill strings according to claim 1 and systems for damping torsional vibrations in steel rolling mills according to A6 cannot be considered to belong to neighbouring technical fields because they involve different equipment, different working forces, different dimensions and hence different technical problems.

Hence, starting from a document such as A1 on stick-slip oscillations in the field of drill strings, the skilled person would not look for suggestions in the field of steel rolling mills, to which A6 belongs.

This argument does not change when reformulating the objective technical problem as it inherently relates to a method of damping stick-slip oscillations.

Hence, starting from A1, the subject-matter of claim 1 is not rendered obvious in view of A6.

8.5 Obviousness starting from A5

As argued above, the subject-matter of claim 1 differs from the disclosure in A5, *inter alia,* also by features (10) to (11).

Concerning the basic concept described on pages 40 to 48, A5 does not provide any teaching or suggestion to modify the PI controller to arrive at a system as defined in claim 1.

Hence, the same arguments as with regard to A1 also apply when starting from A5, which even differs by the further features (6) to (9) and therefore is more remote from the claimed subject-matter than A1.

8.6 It follows that the subject-matter of claim 1 of auxiliary request 4 is not rendered obvious by the cited prior art.

9. In conclusion, after consideration of the arguments of the appealing patent proprietor and opponent, the Board sees no reason to deviate from the finding of the opposition division that the patent in amended form on the basis of auxiliary request 4 meets the requirements of the EPC.

Order

For these reasons it is decided that:

The appeals are dismissed.

The Registrar: The Chairman:

C. Spira G. Patton

Decision electronically authenticated