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Datasheet for the decision of 22 December 2022

Case Number: T 0804/21 - 3.2.04

Application Number: 16886542.6

Publication Number: 3392493

IPC: F02D45/00, F02P5/152, F02P5/153, F02D35/02

Language of the proceedings: EN

Title of invention:
KNOCKING DETECTION METHOD, IGNITION PERIOD CONTROL METHOD, AND IGNITION PERIOD CONTROL SYSTEM

Applicant:
Mitsubishi Heavy Industries, Ltd.

Headword:

Relevant legal provisions:
EPC Art. 83

Keyword:
Sufficiency of disclosure - (yes)

Decisions cited:

Catchword:

Europäisches Patentamt
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Case Number: T 0804/21 - 3.2.04

D E C I S I O N
of Technical Board of Appeal 3.2.04
of 22 December 2022

Appellant: (Applicant)	Mitsubishi Heavy Industries, Ltd. 16-5, Konan 2-chome Minato-ku Tokyo 108-8215 (JP)
Representative:	Studio Torta S.p.A. Via Viotti, 9 10121 Torino (IT)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 21 December 2020 refusing European patent application No. 16886542.6 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	G. Martin Gonzalez
Members:	J. Wright
	T. Bokor

Summary of Facts and Submissions

I. The appeal was filed by the appellant applicant against the decision of the examining division to refuse the patent application.

The division held inter alia that the main request, filed on 27 December 2019, was not sufficiently disclosed, Art 83 EPC.

II. The appellant requests cancellation of the decision under appeal and grant of a patent according to the main request before the examining division, filed on 27 December 2019, or according to auxiliary requests 1-3, filed with the grounds of appeal on 15 April 2021.

They auxiliarily request oral proceedings.

III. The independent claims of the main request read as follows:

(a) Claim 1

"A knocking detection method of detecting occurrence of knocking in a combustion chamber (12) of an internal combustion engine (2), the method comprising:

a step of obtaining an oscillation waveform generated by combustion of air-fuel mixture in the combustion chamber (12);

a step of setting a first time window (TW1) preceding a maximum inner pressure time (T12) at which an inner pressure of the combustion chamber (12) is at maximum in a single combustion cycle and a second time window (TW2) immediately after the maximum inner pressure time (T12), and transforming each of a first

waveform portion (WV1) included in the first time window (TW1) and a second waveform portion (WV2) included in the second time window (TW2) into a frequency-domain expression, of the oscillation waveform; and

a step of setting a first frequency window (FW1) and a second frequency window (FW2), calculating a first representative value (P1) which is a representative value of the frequency domain expression of the first waveform portion (WV1) in the first frequency window (FW1) and a second representative value (P2) which is a representative value of the frequency domain expression of the second waveform portion (WV2) in the second frequency window (FW2), and determining whether knocking has occurred on the basis of a relationship between the second representative value (P2) and the first representative value (P1),

wherein the first representative value (P1) includes a first peak value at which an amplitude of the frequency domain expression of the first waveform portion (WV1) is at maximum in the first frequency window (FW1),

wherein the second representative value (P2) includes a second peak value at which an amplitude of the frequency domain expression of the second waveform portion (WV2) is at maximum in the second frequency window (FW2), and

wherein the step of determining whether knocking has occurred includes determining whether knocking has occurred on the basis of a relationship between the second peak value and the first peak value."

(b) Claim 2

Claim 2 is as claim 1 with different first and second representative values, defined as follows:

"... wherein the first representative value (P1) includes a first partial overall, POA, value which is a POA value calculated from the frequency domain expression of the first waveform portion (WV1) in the first frequency window (FW1),

wherein the second representative value (P2) includes a second POA value which is a POA value calculated from the frequency domain expression of the second waveform portion (WV2) in the second frequency window (FW2),

wherein the step of determining whether knocking has occurred includes determining whether knocking has occurred on the basis of a relationship between the second POA value and the first POA value."

(c) Claim 11

Claim 11 is directed to a control system to control an ignition timing of ignition comprising a knocking detection part that carries out steps that correspond to the method steps defined by the knocking detection method of claim 1.

(d) Claim 12

Claim 12 is directed to a control system to control an ignition timing of ignition comprising a knocking detection part that carries out steps that correspond to the method steps defined by the knocking detection method of claim 2.

IV. In the present decision, reference is made to the following document, filed by the appellant with the grounds of appeal:

(E3) "Internal Combustion Engine Fundamentals", by John B. Heywood, McGraw-Hill International Editions, 1988.

V. The appellant's arguments can be summarised as follows:

The invention as claimed by the main request is sufficiently disclosed for the skilled person.

Reasons for the Decision

1. The appeal is admissible.

2. Background

The invention is concerned with methods for detecting a knocking occurrence state in an internal combustion engine. It also relates to ignition timing control systems that respond to that detection, cf. description para [0001] of the published application EP 3 392 493 A1. To operate the internal combustion engine as efficiently as possible while avoiding damage due to knocking, it is desirable to detect the knocking occurrence state in the combustion chamber as accurately as possible, cf. paras [0002]-[0003], [0008]. The time range immediately preceding the inner pressure maximum point has a minimum risk of knocking occurrence, while the time range immediately after the pressure maximum has a high knocking risk. The claimed method measures pressure or acceleration oscillations in the combustion chamber in two different time

windows. The first one is immediately before the maximum inner pressure time (period without knocking) while the second time window is immediately after that maximum (knocking period). The method evaluates whether knocking has occurred by comparing a representative value of the second time window to a representative value of the first time window. As a result, the method evaluates a knocking risk period against a reference period without knocking of the same combustion cycle, cf. paras [0009]-[0011]. The frequency components of the signal near the knocking frequency are selected using frequency windows. In a first approach the representative values are the peak values of those frequency components, claims 1 and 11 of the main request and para [0013]. In a second approach the representative values are partial overall values (POA) of the frequency components in the frequency window, claims 2 and 12 of the main request and paras [0014]-[0015] of the published application.

3. Main request - Sufficiency of disclosure

3.1 The appellant contests the division's finding of insufficiency of disclosure of the independent claims (claims 1, 2, 11 and 12).

3.2 The division does not question, neither does the Board, that the skilled person is capable of designing a sensor arrangement and data processing system to obtain the claimed oscillation waveform and to process it in order to obtain the two representative values for the first and second time periods as claimed.

3.3 For the division the invention was not sufficiently disclosed because it was not possible for the skilled person to carry out the last steps of the independent

claims. These require the determination of whether or not knocking has occurred on the basis of a relationship between the first and second representative values. According to the examining division there is no information in the description, so the argument goes, as to what that relationship should be. It acknowledges that e.g. para [0095] discloses the case where the representative values are peak values. Para [0097] of the published application EP 3 392 493 A1 describes that the relationship can be embodied as a peak ratio (P2/P1) and that the system determines that knocking has occurred if the peak ratio is greater than a predetermined threshold α. There is however, according to the division, no indication or example in the description of a case with the non-occurrence of knocking. Case A (corresponding to Figures 6A/7A/8A) shows a relatively low peak rate value P2/P1 (cf. Fig. 8A and pressure values 92A/91A). Case B (corresponding to Figures 6B/7B/8B) shows a relatively high peak rate value P2/P1 (cf. Fig. 8B and pressure values 92B/91B). They both are however described as cases where knocking occurs, cf. p29 ln 17-19, p29 ln 28 and p30 ln 1 (paras [0074] and [0075] in the application as published EP 3 392 493 A1; paras [0072] and [0073] of the corrected description filed on 12.10.2020). Without this teaching, the invention cannot be carried out. As it stands, knocking is always determined. In other words, it is not possible for the skilled person to figure out how to detect a non-occurrence of knocking.

3.4 Contrary to the above conclusion of the examining division, the Board holds that the invention as claimed is sufficiently disclosed in the sense of Art 83 EPC. As variously stated in case law, the disclosure is aimed at the person skilled in the art who may rely on common general knowledge to supplement the information

contained in the patent. Textbooks and general technical literature form part of the common general knowledge, see Case Law of the Boards of Appeal, 10th edition (CLBA), II.C.4.1.

3.5 The description clearly indicates in para [0097] (A1 publication) that non-occurrence of knocking is not equal to an absence of an oscillatory signal component in the knocking frequency range. That paragraph describes determination of absence of knocking when P2/P1 value is below a certain threshold, thus not necessarily equal to zero. It corresponds to a low level measurement (near the knocking frequency range). Para [0097] therefore indicates to the skilled person to select an appropriate threshold value for each particular engine and operating condition that separates knocking occurrence from non-occurrence. The Board is in no doubt that the skilled person, a mechanical engineer with an understanding of the fundamentals of internal combustion engines, will be able to find these values by standard routine testing. Thus the lack of a specific threshold value example in the description does not represent any obstacle for the skilled person to putting the teachings into practice.

3.6 The Board refers here to E3 as evidence that such tests belong to the common general knowledge of the skilled person. E3 is a textbook titled "Internal Combustion Engine Fundamentals", and the Board is satisfied that it can safely be considered as part of the skilled person's common general knowledge for the present application. Chapter 9.6 "Abnormal Combustion: Knock and Surface Ignition" (pages 450-478), describes knock as "the name given to the noise which is transmitted through the engine structure when essentially spontaneous ignition of a portion of the end-gas - the

fuel, air, residual gas, mixture ahead of the propagating flame - occurs", cf. p 450, section 9.6.1, first para. It also describes that the main knocking variant "Spark knock" is recurrent and repeatable in terms of audibility. It is controllable by the spark advance, cf. Fig. 9-58. Thus, engine knocking is readily identifiable and reproducible for the skilled person. Chapter 9.6 also describes methods for knock detection and characterization, cf. p 454, first full paragraph and p 455. It describes a test set up for knock characterization. In the described test the engine operates at fixed conditions for knocking operation, cf. p 455 ln 3-7. With this test set-up, measurements are taken. The results are shown in Fig. 9-60, and relate to inner pressure oscillation maximums in the frequency range that is of interest for knocking. These are similar to the type of measurements required to carry out the invention. The skilled person can also, without undue effort, set the engine conditions to operate without knocking. By carrying out such tests, but with the measurement and data processing of the present application, the skilled person can without undue burden find the particular threshold value that is valid for each given engine and knocking operating condition.

3.7 In this respect, it is immaterial whether case A (the low level pressure oscillation case of the description) is described as a knocking non-occurrence case or a knocking occurrence case in paras [0074] and [0075] (A1 publication). There is disagreement in this respect between the examining division and the applicant. What example cases A and B indicate is that the measuring and signal processing steps of the invention as claimed can properly discriminate higher ratios of oscillation signal levels in the knocking frequency range (high P2/

P1) from lower ratios (low P2/P1). The method thus delivers the steps needed to determine whether or not knocking has occurred and thus carry out the claimed invention. Whether case A signal levels represent an occurrence of knocking or a non-occurrence of knocking for a particular engine and engine operation need not be defined in the application in further detail for putting the invention into practice.

3.8 The above conclusions are valid for both types of representative values, peak values (claim 1 and claim 11) and POA values (claim 2 and claim 12). Para [0097] (application as published) explicitly describes a P2/P1 threshold value where P2 and P1 are peak values. Para [0093] of the description states that the following described embodiments can similarly be implemented using POA values for P1 and P2 instead of peak values. Thus para [0097] also describes, by reference, an embodiment of the invention where the ratio P2/P1 is calculated using POA values. The implementation of POA values is known to the skilled person, for instance by calculating the square sum of the power spectrum density near the knocking frequency, cf. para [0015].

3.9 The Board therefore concludes that the invention as defined by independent claims 1, 2, 11 and 12 is sufficiently disclosed, Article 83 EPC.

The decision under appeal must thus be set aside.

4. Remittal

4.1 Under Article 111(1) EPC the Board may either decide on the appeal or remit the case to the department which was responsible for the decision appealed.

4.2 Under Article 11 RPBA the Board may remit the case to the department whose decision was appealed if there are special reasons for doing so. In the present case, the examining division decided only on the question of sufficiency of disclosure. It left the other substantive issues, for instance novelty and inventive step, undecided.

4.3 The Board considers that in view of the appellate function of the Boards of Appeal it would be inappropriate for the Board to examine these issues for the first time. Thus the Board holds that under the circumstances of the present case special reasons in the sense of Article 11 RPBA are present, and the Board considers it appropriate to exercise its discretion under Article 111(1) EPC by remitting the case to the examining division for further prosecution.

5. Oral proceedings

The request for oral proceedings is conditional on the Board envisaging refusal of the application (grounds of appeal) or finding the main request to be unallowable (notice of appeal).

The Board does not find the main request unallowable and does not refuse the application, but agrees with the appellant that the impugned decision must be set aside because the invention according to the main request meets the requirements of Article 83 EPC. Thus neither condition is met. The Board's decision to remit the case for further prosecution also does not stand in the way for the appellant's substantive request for the grant of a patent. The Board is satisfied that the case can be decided in writing.

Order

For these reasons it is decided that:

1. **The decision under appeal is set aside.**

2. **The case is remitted to the examining division for further prosecution.**

The Registrar: The Chairman:

G. Magouliotis G. Martin Gonzalez

Decision electronically authenticated