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Case Number: T 1480/15 - 3.2.05

Application Number: 09170612.7

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Language of the proceedings: EN

Title of invention:
Poppet valve with sloped purge holes and method for reducing a pressure force therein

Applicant:
Nuovo Pignone S.p.A.

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - yes

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European Patent Office
D-80298 MUNICH
GERMANY
Tel. +49 (0) 89 2399-0
Fax +49 (0) 89 2399-4465

Case Number: T 1480/15 - 3.2.05

D E C I S I O N
of Technical Board of Appeal 3.2.05
of 7 October 2016

Appellant: (Applicant)	Nuovo Pignone S.p.A. 2, Via Felice Matteucci 50127 Florence (IT)
Representative:	William Illingworth-Law GPO Europe GE International Inc. The Ark 201 Talgarth Road Hammersmith London W6 8BJ (GB)
Decision under appeal:	**Decision of the examining division of the European Patent Office posted on 10 February 2015 refusing European patent application No. 09170612.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	M. Poock
Members:	H. Schram
	D. Rogers

Summary of Facts and Submissions

I. The appellant (applicant) filed a notice of appeal against the decision of the examining division,, by which European patent application No. 09 170 612.7 was refused on the grounds that claim 1 of the sole request filed on 12 December 2014 was not clear (Article 84 EPC) and that the subject-matter of claims 1 and 7 of said request did not involve an inventive step (Article 56 EPC).

II. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of any one of the main or auxiliary requests filed under cover of a letter dated 18 June 2015.

III. Claims 1 and 7 of the main request read as follows:

"1. A poppet valve, comprising:

a valve body (52), said valve body having a central axis, a flow inlet, and a flow outlet;

a poppet guide (56) disposed inside the valve body so as to form a first portion of a flow passage (66) from the flow inlet (58) to the flow outlet (60), the guide including at least one hole (68) at the rear thereof, said flow passage being formed between an inside surface of the valve body and an outside surface of the poppet guide and passing through the at least one rear hole (68) in the poppet guide;

a poppet shutter (54) disposed inside the poppet guide so as to form a second portion of the flow passage between an outside surface of the poppet shutter and the inside surface of the valve body; and

a biasing member (58) disposed inside an inner chamber (72) of the poppet guide, said biasing member being configured to bias the poppet shutter toward an inside surface of the flow inlet so as to block the flow passage,

wherein said poppet guide further includes at least one discharge hole (70) placing the inner chamber (72) of the poppet guide in flow communication with a region of the flow passage in which, in use, low static pressure has developed at the at least one rear hole (68) of the flow passage (66), the at least one discharge hole (70) being inclined with respect to the central axis of the valve body (52).”

“7. A method for reducing a closing pressure force acting on a poppet shutter(54)of a poppet valve, said poppet valve having a valve body (52) with a central axis (74), a flow inlet, and a flow outlet, said poppet valve including further a poppet guide (56) and a biasing member (58) configured to bias the poppet shutter (54) disposed inside the poppet guide (56) against the valve body (52) so as to close the poppet valve, the method comprising:

accelerating the flow in a flow passage (66) of the valve so as to reduce the static pressure in a region of the flow passage, said flow passage being disposed so as to place said flow inlet in flow communication with said flow outlet, a portion of said flow passage being formed between the poppet guide (56) and the valve body (52) and passing through at least one rear hole (68) of the poppet guide (56); and

placing an inner chamber (72) of the poppet guide (56) in flow communication with the region of reduced static pressure (68) of the flow passage (66) via at

least one discharge hole (70) that is inclined with respect to a central axis (74) of the valve body and located in the region where the flow is accelerated, at said at least one rear hole (68) of the flow passage (66) to reduce a fluid pressure force acting on an inner surface of the poppet shutter (54) toward an inner surface of the valve body to cause the poppet valve to close."

IV. The documents referred to in the appeal proceedings include the following:

D2 GB-A 2 021 238.

V. In support of its requests, the appellant submitted the following:

Claim 1 of the main request had been clarified to refer to a region of the flow passage in which, in use, low static pressure was developed at the at least one rear hole 68 of the flow passage 66. The clarification addressed the Article 84 EPC objection (see point 13 of the decision under appeal) relating to the feature of 'low static pressure' in claim 1 as a person skilled in the art would understand a region of a flow passage which, in use, developed low static pressure. The last two features of claim 1 of the main request were novel, as acknowledged in point 14.2 of the decision. These novel features solved the problem of unreliable and unstable opening and closing of a valve by accelerating gas flow in the rear portion of the valve, developing a reduced static pressure inside the valve chamber 72 and stabilizing the dynamic process of opening the valve as explained, for example, in paragraph [0020] of the application. These features were neither disclosed nor suggested in any of the prior art documents. For

example, the check valve known from document D2 had openings 8 which, as could be seen from the drawing, were at the front of the housing 1 close to the seal 17. This document neither disclosed nor suggested the novel and inventive features of claim 1 of the main request, namely of the discharge hole 70 placing the inner chamber 72 of the poppet guide in flow communication with a region of the flow passage in which, in use, low static pressure had developed at a rear hole 68 of the flow passage 66 which accelerated gas flow in the rear portion of the valve producing more stable valve opening. This also applied to claim 7 of the main request. The subject-matter of claims 1 and 7 of the main request therefore involved an inventive step with respect to document D2.

Reasons for the Decision

1. *Allowability of the amendments, Articles 84 and 123(2) EPC*

1.1 Claim 1 of the main request differs from claim 1 of the sole request on which the decision was based in that the expression "in which low static pressure has developed" has been replaced by the expression "in which, in use, low static pressure has developed". Claim 7 of the main request corresponds to claim 7 of said sole request.

While the expression "in use" is not disclosed *expressis verbis* in the published version of the application as filed, it is clear from paragraph [0007] thereof, that a reduced static pressure is obtained by accelerating the gas flow in the rear portion of a poppet valve. In other words, it is clear to the person

skilled in the art that the gas flow must be passing through the open valve in order to create a low static pressure – hence "in use", see also paragraphs [0021] and [0024] of the application as filed.

No objections under Article 123(2) EPC were raised in the decision under appeal against claims 1 and 7 of the sole request. Dependent claims 2 to 6, and 8 to 10 correspond to claims 4 to 6, 13, 14, and 8, 11 and 12, respectively. The description has been brought into conformity with the amended claims.

1.2 The amendments thus meet the requirements of Article 123(2) EPC.

1.3 The wording "low static pressure" has been objected to by the examining division from the beginning of the examination proceedings as being "vague and indefinite", contrary to the requirements of Article 84 EPC, cf point 13.2 of the reasons.

The board assumes that the objection of the examining division is directed to the word "low" rather than to the wording "static pressure", since the latter is a well-known term in the art of valves (the static pressure is the actual pressure of the fluid, which is associated not with its motion but with its state).

The person skilled in the art knows that in a region of the flow passage where the flow velocity is high, the static pressure is low. The expression "region of low static pressure" is used in the application to denote a region of flow acceleration, cf for example paragraph [0024]. He or she will understand the term "low" in the expression "region of low static pressure" as a relative term, which merely indicates that in other

regions of the flow passage the static pressure is higher. The person skilled in the art will not seek to define a low static pressure in terms of an upper limit expressed in Pa.

Hence the board comes to the conclusion that claim 1 of the main request is clear.

2. *Inventive step, Article 56 EPC*

2.1 The present invention relates to a poppet valve for use in compressors, more particularly for use in hyper compressors, which are capable of producing gas pressure levels up to or above 300 MPa (3000 bar), and to a method for reducing the pressure force therein, cf paragraphs [0001] and [0002] of the application.

The problem the invention seeks to solve is to provide a poppet valve for a compressor that will be more efficiently opened and kept opened, thus increasing compressor performance and reducing maintenance and downtime, cf paragraph [0006] of the application.

This problem is solved by the subject-matter of claim 1, in particular by the last two features thereof, viz (i) "*wherein said poppet guide further includes at least one discharge hole (70) placing the inner chamber (72) of the poppet guide in flow communication with a region of the flow passage in which, in use, low static pressure has developed at the at least one rear hole (68) of the flow passage (66)*" and (ii) "*the at least one discharge hole (70) being inclined with respect to the central axis of the valve body (52)*".

The method for reducing the closing pressure force acting on a poppet shutter of a poppet valve according to claim 7 comprises the steps of accelerating the flow in a flow passage of the valve so as to reduce the static pressure in a region of the flow passage, and placing an inner chamber of the poppet guide in flow communication with the region of reduced static pressure of the flow passage.

By accelerating the gas flow in the rear portion of a poppet valve, a reduced static pressure inside a purged internal chamber of the valve is achieved, thereby reducing a gas pressure force acting on a poppet shutter to cause the valve to close, reducing the required differential pressure along the valve to open it, and stabilizing the dynamic opening of the valve, cf paragraph [0006] of the application.

2.2 Document D2, which is cited on the penultimate line of amended page 1 of the application as filed, is considered to represent the closest prior art, since it relates to a check valve wherein the fluid medium is accelerated.

Also the problem underlying document D2 is similar to that of the present invention, namely "*to provide a check valve ... in which oscillating movements of the piston in any position are avoided, for which purpose more especially in the interior of the inner housing secondary flows which impair the ejector effect are intended to be avoided*", cf page 1, lines 89 to 94.

In the introductory part of document D2 it is stated (cf page 1, lines 38 to 64, in particular lines 43 to 52) that "*For a piston slide-valve ... to reduce the fluttering motions it has also already been proposed to*

provide the inner housing, in the region of the maximum flow velocity, with one or more openings", and that in accordance with this proposal "*the medium in the closed inner part of the inner housing is exposed to an underpressure as compared with the pressure of the medium in front of or behind the inner housing*". However, on the basis of extensive tests "[It] *became apparent that ... the pressure in the flow passage corresponded to the pressure in the interior of the housing and initially no adequate pressure difference built up*", cf page 1, lines 70 to 74. This failure was attributed to a secondary flow in the interior of the housing behind the openings which was connected with turbulences occurring in the flow passage, cf page 1, lines 74 to 81.

It was found that the disturbing secondary flow can be avoided with the arrangement in accordance with the invention (cf page 1, lines 95 to 101), namely a check valve in the form of a piston slide-valve (see page 1, line 124, to page 2, line 7, the sole Figure and claim 1), the shape of the flow passage thereof being such that the fluid medium is initially accelerated (cf part 5 near the entrance opening) and then decelerated (cf part 7 near the exit opening) in its passage, the piston being provided with at least one radial opening 8 connecting the flow passage in a region 5 of maximum flow velocity with the interior of the inner housing.

2.3 In contrast to document D2, where the radial openings 8 ("discharge holes") are located near the entrance of the valve, ie in the vicinity of the transition between the front part and the jacket part of the piston, corresponding to region 5 (see page 1, lines 107 to 112), the inclined discharge holes 70 of the invention

are located in the region defined by the rear holes 68 ("discharge openings") of the flow passage, ie close to the outlet 60 of the valve.

The subject-matter of claim 1 of the main request differs from the valve known from document D2 in the last two features thereof, see point 2.1 above.

The person skilled in the art, starting from the valve known from document D2, has no incentive to provide discharge holes near the outlet of the valve, since that would go against the teaching of said document to locate discharge holes near the entrance of the valve.

2.4 In the decision under appeal, the examining division held that the poppet valve shown in Figure 1 of the application represented the closest prior art (see point 14.1 of the reasons). In point 14.2 it is stated that "*According to the prior art, the discharge hole is provided at the rear end of the shutter and in line with the central axis of the valve body*", whereas in claim 1 [of the sole request] "*the discharge hole is inclined with respect to the central axis of the valve body and connects the inner chamber with the flow passage in the region of the at least one rear hole of the flow passage (which is configured such that flow of fluid is accelerated, i.e. static pressure is lowered, as can be understood from figure 2 and the corresponding description)*".

Since document D2 already taught (see especially page 1, lines 38 to 64) to arrange the discharge hole 8, which was inclined with respect to the central axis of the valve body, and which connected the inner chamber of the poppet guide with the flow passage in a region of high flow velocity for exactly this purpose, viz in

order to stabilize the dynamic opening of the valve, it would need no inventive activity for a person skilled in this technical field to apply the technical teaching of document D2 with corresponding effect to the valve disclosed in Figure 1 of the application in order to achieve the intended outcome. Consequently, the subject-matter defined in claim 1 lacked an inventive step, cf points 14.3 to 14.5 of the reasons.

It appears from said decision that the examining division saw the *location* and *inclination* of the discharge hole as the only differences between the subject-matter of claim of the sole request and the conventional poppet valve shown in Figure 1 of the application.

By applying the general teaching of the introductory part of document D2 (see in particular column 1, lines 48 to 52), the person skilled in the art starting from the conventional poppet valve merely had to connect the inner chamber with the region of the flow passage indicated by D_{do} in order to arrive at the invention. The examining division thus considered region D_{do}, which corresponds to the rear holes 68 of the invention, as the suitable region to be placed in flow communication with the inner chamber of the poppet guide.

However, it cannot be inferred from Figure 1 of the application showing a conventional poppet valve, or from the description of said valve in paragraphs [0002] and [0003], that the annular discharge opening D_{do} corresponds to the region of the flow passage in which, the flow is accelerated and in use, low static pressure has developed.

The person skilled in the art would rather identify the narrow flow channel at the entrance around the poppet shutter 12 in Figure 1 as the region of accelerated flow, and not the region of the flow passage indicated by D_{do} as the examining division did, since the flow channel at the entrance is much narrower than the flow passage indicated by D_{do}. That in a region of accelerated flow the pressure decreases is known as Bernoulli's principle.

It may be noticed that the region of accelerated flow in said conventional poppet valve, namely at the entrance around the poppet shutter 12 in Figure 1, is in the same area as in the check valve of document D2, which is so designed that in the region 5 immediately after the entrance of the valve the velocity of the flow medium is increased. If the person skilled in the art starting from such a conventional poppet valve would try to implement the teaching of document D2, namely providing the piston with at least one radial opening 8 connecting the flow passage in region 5 of maximum flow velocity with the interior of the inner housing, or would try to apply the general teaching of the introductory part of document D2 (see column 1, lines 48 to 52), he or she would provide discharge holes in the poppet shutter 12 near the *entrance* of the valve, not near the *outlet*, and he or she would therefore not arrive at the invention, see also point 2.3 above, last paragraph.

2.5 Consequently, the subject-matter of claim 1 of the main request is not obvious to the person skilled in the art and therefore involves an inventive step. This holds *mutatis mutandis* for the subject-matter of claim 7 of the main request.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent on the basis of the following documents:

Claims, Numbers:
1 to 10 filed on 18 June 2015 as main request;

Description, pages:
2, 4, 5 and 8 to 13 as originally filed,
1, 1a, 3, 6 and 7 filed on 12 December 2014;

Drawings, sheets:
1/2 and 2/2 as originally filed.

The Registrar: The Chairman:

D. Meyfarth M. Poock

Decision electronically authenticated