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D E C I S I O N
of 27 January 1998

Case Number: T 0114/96 - 3.2.4

Application Number: 88118127.5

Publication Number: 0318706

IPC: F02C 3/30

Language of the proceedings: EN

Title of invention:
Water spray ejector system for steam injected engine

Patentee:
General Electric Company

Opponent:
Asea Brown Boveri AG

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes"

Decisions cited:
-

Catchword:
-

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Case Number: T 0114/96 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 27 January 1998

Appellant: (Opponent)
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Representative:
-

Respondent: (Proprietor of the patent)
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Decision under appeal:
Decision of the Opposition Division of the European Patent Office posted 29 November 1995 rejecting the opposition filed against European patent No. 0 318 706 pursuant to Article 102(2) EPC.

Composition of the Board:

Chairman: C. A. J. Andries
Members: H. A. Berger
J. P. B. Seitz

Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal, received on 29 January 1996, against the decision of the opposition division, dispatched on 29 November 1995, rejecting the opposition against the patent No. 0 318 706. The fee for appeal was also paid on 29 January 1996. The statement setting out the grounds of appeal was received on 2 April 1996.

Opposition was filed against the patent as a whole and based on Article 100(a) EPC. The following prior art documents were cited during the opposition proceedings and have again been taken into account in the appeal proceedings:

D1: DE-A-3 419 560

D2: GB-A-2 187 273

D3: Report of the ASME COGEN-TURBO, International Symposium on Turbomachinery, held in Montreux, Switzerland, 2 to 4 September 1987, G. Jungers et. al.: "AES PLACERITA-ECONOMICAL POWER GENERATION WITH MINIMUM ENVIRONMENTAL IMPACT", pages 17 to 20.

II. The independent claims 1 and 15 as granted read as follows:

Claim 1:

"A method of increasing the power output of a steam injected gas turbine engine having a compressor, a combustor (40), said combustor comprising a dome (42) receiving fuel and steam from a dual flow nozzle (44) providing fuel in the center and steam coaxially around the fuel port, and a turbine in series combination with a gas flow path passing therethrough, and having a system for injection of superheated steam into the gas

flow path, the method comprising spraying water into the steam injection system whereby the water is evaporated by the superheated steam, and characterized by
mixing the evaporated water with the existing steam in the steam injection system so that the resultant steam is at a temperature of at least 28°C (50°F) superheat and additional steam is added to the dome from the dual nozzle, to obtain a resultant increased mass flow of superheated steam mixture for injection into the gas flow path."

Claim 15:

"A gas turbine engine comprising in series flow relationships, a compressor, a combustor (40), and a turbine, a gas flow path through the engine, a fuel and steam system and having a dual flow nozzle (44) for providing fuel in the center and steam coaxially around the fuel port to the dome (42) of the combustor, and characterized by
a water spray ejector and mixer means (52, 66) coupled to the dual flow nozzle, for spraying water into the superheated steam for vaporization of the water by the superheated steam flowing therein, and for mixing the water vapor with the superheated steam to produce a resultant superheated steam mixture of greater mass flow for injection into the gas flow path, said superheated steam mixture having a resultant steam temperature of at least 26°C (50°F) superheat."

III. Oral proceedings were held on 27 January 1998.

IV. The appellant argued that the method of the impugned claim 1 lacked novelty having regard to document D1. He explained both methods on the basis of a diagram and maintained that they both deal with the same problem, i.e. increasing the power output by steam supply and

injection of water into the steam, and that they both solve their problem in the same way. In particular the description in column 8, lines 27 to 32 of the impugned patent shows that it is only possible to drive a given engine at full power if there is a steam injection provided. All features of the preamble of claim 1 were known from document D1.

Although in document D1 it is not expressly mentioned that the lowest temperature limit must be 28°C (50°F), it is clear that the resulting steam after being mixed with water would still have a temperature of at least 28°C superheat, since according to claim 6 of document D1 the superheated steam has a temperature as high as possible and according to the description the steam supplied to the gas flow of the combustor is still superheated. The lowest temperature of 28°C (50°F) would be necessary as a safety margin to prevent the formation of water droplets, which could damage the perforation of the liner of the combustor. The temperature of 28°C (50°F) cited in the patent is only a rough limit which could be something lower or higher without influencing the functioning of the device. The advantage of the exact temperature limit is not disclosed in the patent.

The appellant further argued that according to the impugned claim 1 only the combination of the injected fuel surrounded by the steam in general would be essential in the dual system, since no details of the nozzle are indicated in claim 1 or in other parts of the patent. This combination however is known from Figure 2 of document D1, in which the dual system is built by the central fuel supply (34) and the openings (29) in the dome surrounding the fuel supply, through which steam is supplied and coaxially surrounds the fuel spray.

The last feature of Claim 1, "to obtain a resultant increased mass flow of superheated steam mixture for injection into the gas flow path" is only a result and not a method step which influences the subject-matter. This increased mass flow of the superheated steam has the same purpose, i.e. to increase the power output as in the method of document D1 (see page 7, lines 28 to 31).

The appellant is of the opinion that all the features of Claim 1 are known from document D1 and that the method of Claim 1 lacks novelty.

The appellant further argued that even if the dual flow nozzle were considered as a new feature, claim 1 would not be patentable because of lack of inventive step. It would be not perceivable which advantages are attainable by the claimed method compared with the method of document D1. The advantage claimed that more water can be added by injecting the steam directly into the dome on the one side and by injecting it into the diluent bypass air on the other side is not relevant, since according to document D1 steam is directly supplied into the dome through the openings (29) around the fuel nozzle and also is supplied into the diluent air and therewith into the combustor through the additional openings (28) in the combustion chamber wall. By injecting steam the power of the engine is only increased in so far as to make it possible therewith to run the system at full power. This is also the case with the system of document D1.

Furthermore, there is no inventive configuration of the air/fuel/steam-flow. The air is not even mentioned in Claim 1 and the supply of fuel/steam flow is only disclosed in the drawing and the description with regard to the supply to the nozzle without an explanation of the nozzle outlet. No indication is

given how the air arrives at the fuel nozzle and it is not known how the fuel is ignited if it is surrounded by the steam.

The appellant further drew attention to the prior art document D3, which discloses a power plant with water injection into the steam, constructed by the appellant. Although not shown in document D3, the nozzle used in this gas turbine engine would be similar to that of the impugned patent. Steam would be supplied by tubes with outlet openings around the fuel nozzle. The appellant however did not explicitly claim prior use. No documents showing the nozzle device were filed.

The appellant alleged that the method of claim 1 was not inventive.

In the written statement the appellant also expressed the opinion that the arguments against claim 1 also apply to independent claim 15.

V. The respondent pointed out that the dual flow nozzle indicated in claim 1 is shown in Figure 2 and unequivocally described in column 6, lines 14 to 19 of the granted patent. It is clear from claim 1 that the dual flow nozzle provides fuel in the centre and steam coaxially around the fuel port, exactly as described and shown in the patent. The added steam will not obstruct or otherwise prevent the formation of a combustible mixture. The necessity of supplying air to the combustion process is self evident and therefore is inherent in Claim 1, while the direct injection of steam into the combustor is not known and therefore carefully defined in the claim.

The additional steam added to the dome from the dual flow nozzle, contained in the characterizing portion of claim 1 must be understood with regard to the other

features of claim 1. This additional steam is the steam generated from the water sprayed into the steam injection system.

The respondent argued that the invention has found a way to increase mass flow through the gas turbine system by injecting steam directly into the combustor and increasing the mass flow of the steam by injecting water into the steam line provided that the resultant mixture is at at least 28°C (50°F) superheat. While document D1 discloses all the features of the preamble of claim 1 except the dual flow nozzle, the problem solved with this known method would be different from that of the impugned patent. The object according to document D1 is to adjust the temperature of superheated steam by the measured addition of water so that, in the range of full load and an adjacent range of partial load of the gas turbine system, the working medium will be held at an approximately constant high entrance temperature at the gas turbine inlet in order to obtain high efficiency, whereas in the present invention water is added for the purpose of increasing mass flow even if efficiency is decreased.

The respondent further argued that although the method of document D1 presumably also is carried out with a superheated steam of a temperature above 28°C (50°F) no indication is given in this document D1 to prevent the steam temperature falling below the limit claimed in the impugned claim 1. According to Figure 2 of this document D1, enhanced steam is injected into the space between the flame tube and the housing but not directly into the flame tube. In this space the steam and air are mixed and the mixture is injected through holes (28, 29) into the combustor. Claim 6 of the present patent however specifies a mixture of steam and air into the combustor in addition to the steam introduced by the dual flow nozzle.

With regard to document D3 and the nozzle which was discussed by the appellant in connection with this document D3, the respondent drew attention to the fact that no pieces of evidence had been brought forward by the appellant. The respondent further stated that the dual flow nozzle of the patent does not comprise steam tubes which end in openings around the fuel nozzle but is a dual flow nozzle with fuel provided in the centre and steam coaxially around the fuel port, i.e. through an annular flow passage.

The respondent maintained that the method of Claim 1 therefore is novel and provides an inventive step.

VI. Requests

The appellant (opponent) requested that the decision under appeal be set aside and that the patent be revoked.

The respondent (patentee) requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

2. *Interpretation of independent claims 1 and 15*

2.1 The board understands claim 1 as follows:

The feature concerning the dome "receiving fuel and steam from a dual flow nozzle providing fuel in the center and steam coaxially around the fuel port", expresses, having regard to the description (column 6, lines 14 to 22; column 5, lines 1 to 3) and the drawing

(Figure 2), that steam injected from an annular outer passageway ending adjacent to the fuel port surrounds the injected fuel at the fuel nozzle outlet.

The feature "and having a system for injection of superheated steam into the gas flow path" indicates a system supplying superheated steam to the dual flow nozzle from which it is injected into the gas flow path. This is supported by the description in column 5, lines 39 to 48 (steam could be added to the fuel port, it could be added also to the bleed port) in conjunction with granted claim 8 which is dependent on claim 1 ("the injection system also feeds a bleed port", i.e. in addition to the dual flow nozzle).

The feature "the method comprising spraying water into the steam injection system whereby the water is evaporated by the superheated steam" concerns water sprayed into the superheated steam.

The characterizing portion of claim 1 comprising the feature "and additional steam is added to the dome from the dual nozzle" takes into account the additional steam generated from the water sprayed into the superheated steam.

2.2 Claim 15 is to be interpreted analogously to claim 1.

In this claim 15 it is more clearly expressed that "a water spray ejector and mixer means (52,66)" are "coupled to the dual flow nozzle".

The "resultant steam temperature of at least 26°C" indicated at the end of claim 15 should be read in conjunction with the indicated temperature 50°F as 28°C.

3. *Novelty*

The method of Claim 1 and the gas turbine engine of Claim 15 differ from the state of the art disclosed in document D1 at least by a dual flow nozzle providing fuel in the centre and steam coaxially around the fuel port. The fuel nozzle (32), the openings (29) in the wall of the dome part of the combustion chamber and the opening (90) of the superheated steam channel, shown in document D1, do not form a dual flow nozzle providing fuel in the centre and steam coaxially around the fuel port. Furthermore, the fluid supplied through the openings (29) into the combustion chamber is not superheated steam but is a mixture of superheated steam and air.

In the gas turbine of document D2, only air is supplied directly around the fuel nozzle and steam is introduced at the zone of the flame boundaries. Document D3 also does not disclose a dual flow nozzle with fuel in the centre and steam coaxially around the fuel port.

The method of claim 1 and the engine of claim 15 therefore are new in the meaning of Article 54 EPC.

4. *Closest State of the Art*

4.1 The appellant considers that document D1 represents the closest state of the art. Since documents D2 and D3 do not come closer to the subject-matter of the impugned claims 1 and 15, the board takes document D1 as the starting point for assessing inventive step.

4.2 Document D1 (Figure 2) discloses a method of increasing the power output of a steam injected gas turbine engine (see page 7, last paragraph) having a compressor (12), a combustor (20), said combustor comprising a dome (24) receiving fuel from a nozzle (burner 32), and a mixture

of steam and air (through openings 28,29), and a turbine (38) in series combination with a gas flow path passing therethrough, and having a system (110,112) for injection of superheated steam into the gas flow path. The method comprises spraying water (nozzle 128) into the steam injection system whereby the water is evaporated by the superheated steam, mixing the evaporated water with the existing steam in the steam injection system (126) so that the resultant steam is at a temperature of superheat and additional steam (generated from the water, which is injected into the steam) is added to the dome (inlet 90, openings 28, 29), to obtain a resultant increased mass flow of superheated steam mixture for injection into the gas flow path.

Document D1 furthermore discloses a gas turbine engine for carrying out the method with the above stated features.

5. *Problem and Solution*

5.1 Problem

The problem of the invention having regard to document D1 is to provide a method and a system to reduce nitrous oxide emissions (see column 4, lines 54 to column 5, line 3) and to allow an increase in mass flow as far as possible.

5.2 Solution

By supplying steam through the dual flow nozzle directly around the injected fuel the flame temperature can be reduced, thereby lowering the formation of nitrous oxides. Furthermore, the superheated steam entering through this dual flow nozzle increases the mass flow already at the fuel inlet side of the

combustor, and gives the possibility of adding further steam mixed with air at the downstream side of the combustor. A given superheated steam flow can be increased by water injection to an extent which is limited by the particular minimum temperature.

The appellant argued that no air is supplied at the fuel/steam nozzle and therefore ignition of the fuel would not be possible.

In conventional gas turbine engines however the combustor is provided with air inlet holes in the vicinity of the fuel nozzle and around the further part of the combustion chamber wall for adding primary and secondary air. Although in the impugned patent only steam flow lines are indicated in the drawing (Figure 2) and holes are not shown, the holes are necessary parts for normal functioning and are to be considered to be present in the subject-matter of the patent.

It is true that the patent only discloses a dual flow nozzle providing fuel in the centre and steam coaxially around the fuel port (also see Figure 2) without further details of the nozzle device but it is clear at least that the steam surrounds the injected fuel at the fuel nozzle outlet. Of course, ignition of the fuel only is possible with air mixed with the fuel in a particular air/fuel ratio range and in a stabilized flame zone. These details however are not part of the invention. The impugned patent deals essentially with the supply of steam, which is clearly enough defined in Claim 1.

6. *Inventive Step*

6.1 Although document D1 is cited in the introductory part of the impugned patent as the closest state of the art it does not disclose a dual flow nozzle as contained in the preamble of the impugned claim 1, and there is furthermore no reason to interpret the content of document D1 in the sense that this known device would be understood as comprising this missing feature.

6.2 The method of claim 1 differs in particular from the method known from document D1 in that it is carried out with a dual flow nozzle for providing fuel in the centre and steam coaxially around the fuel port, in that the steam in addition with the steam generated from the water sprayed into the superheated steam is added to the dome from the dual nozzle and in that the resultant steam is at a temperature of at least 28°C (50°F) superheat.

6.3 It is clear from the wording of claim 1 (column 9, line 3: "so that...") that means and a corresponding processing step must be present to guarantee the lower limit of 28°C (50°F) superheat. Therefore a system to control this minimum temperature is necessarily provided according to the claim. It is true that, although not mentioned in document D1, the temperature of the superheated steam, supplied to the combustor according to document D1 is presumably in a range above 28°C, i.e. of at least 28°C superheat. Document D1 however does not disclose the necessity of a lower temperature limit but deals in particular with keeping constant the inlet temperature of the **gas** flow into the gas turbine as far as possible in order to obtain high efficiency. Steam therefore is added to the combustor

with respect to this necessary turbine inlet temperature and water is injected to the superheated steam with regard to this temperature demand (see page 11, lines 1 to 11).

According to the impugned patent, however, the given superheated steam flow is increased by injecting water as much as possible (see column 7, lines 9 to 29) with the prevailing aspect of increasing power output, which could lead to a considerable decrease of the steam temperature. The danger of the steam temperature falling below the indicated level of 28°C (50°F) is here therefore relevant. Such a situation is not disclosed in document D1, so that the method according to document D1 and the impugned patent comprise different control systems, having different functions. Document D1 therefore could not lead a person skilled in the art to a method ensuring that the temperature of the used steam will not fall below a predetermined minimum.

However even if the feature of preventing the steam temperature from falling below this lower temperature limit were obvious for the skilled person, document D1 could not lead to the method of the impugned patent.

6.4 According to document D1 steam supplied to the combustor is mixed with air from the compressor (12) and this mixture is introduced into the dome and the other part of the combustion chamber via openings (28,29) in the combustion chamber wall. No hint is given to supply only superheated steam directly around the fuel nozzle, let alone to supply the steam immediately through a dual flow nozzle coaxially around the injected fuel.

6.5 Documents D2 and D3 which are not as relevant as document D1 also could not lead to the method of claim 1.

6.6 Since there is no prior art available in the appeal proceedings disclosing a dual flow nozzle in combination with a gas turbine engine, providing a specific flow, namely fuel in the centre and steam coaxially around the fuel port, the method of claim 1 cannot be considered to be obvious.

6.7 Claim 15 mainly comprises the features of claim 1 in terms of an embodiment and can also be maintained according to the reasons given for claim 1 (Article 56 EPC).

7. Claims 1 and 15 therefore are patentable in the meaning of Article 52 EPC. Claims 2 to 14 and 16 to 19 which are to be understood as claims dependent on claim 1 and claim 15, can also be maintained.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

N. Maslin C. Andries