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File Number: T 263/89 - 3.2.3

Application No.: 80 901 094.5

Publication No.: 0 028 637

Title of invention: Method of fabricating a composite structure

Classification: B29C 43/56

D E C I S I O N
of 22 January 1992

Applicant: ROCKWELL INTERNATIONAL CORPORATION

Opponent: BASF Aktiengesellschaft, Ludwigshafen

Headword:

EPC Article 56

Keyword: "Inventive*step (yes)"

Headnote



Case Number : T 263/89 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 22 January 1992

Appellant :
(Proprietor of the patent)

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Decision under appeal :

Decision of Opposition Division of the European
Patent Office dated 13 December 1988 revoking
European patent No. 0 028 637 pursuant to
Article 102(1) EPC.

Composition of the Board :

Chairman : C.T. Wilson
Members : K.W. Stamm
L.C. Mancini

Summary of Facts and Submissions

I. European patent No. 0 028 637 was granted on 23 October 1985 with twelve claims in response to the European application No. 80 901 094.5, filed on 28 April 1980.

II. Claim 1 of the granted patent reads as follows:

"A method of fabricating a composite structure comprising the steps of: positioning in an evacuable chamber (76) a solid laminate (50) comprising a plurality of plies of fibrous material in an uncured resin matrix, the laminate (50) having air entrapped therein; applying vacuum to the chamber (76) to create a partial vacuum environment in the chamber; heating the laminate (50) to within a temperature range wherein the resin matrix exhibits a viscosity which allows for substantially all the entrapped air to migrate through the resin matrix; maintaining the laminate (50) within the temperature range and partial vacuum environment while also substantially precluding compressive pressure on the laminate (50) for a time duration sufficient to cause substantially all the entrapped air in the laminate (50) to be expelled; and curing the laminate (50)."

III. Notices of Opposition were filed against the European patent on 10 (OI) and 22 July 1986 (OII) requesting the revocation of the patent in view of the following documents:

A: Harro Hagen: "Glasfaserverstärkte Kunststoffe",
2. Auflage, Springer Verlag 1961, Seiten 394-397;

B: DE-A-2 104 585;

C: Report on the 21st National SAMPE Symposium,
April 1978, Los Angeles, pp. 444-447 and 457;

D: GB-A-1 081 911.

IV. By letter filed on 1 August 1988, Opponent I withdrew his
opposition.

V. In its decision of 13 December 1988, issued on
3 February 1989 the Opposition Division revoked the patent
on the grounds that the subject matter of Claim 1 lacked
an inventive step having regard to documents C and D.

VI. A Notice of Appeal was filed on 13 April 1989 by the
Proprietor of the patent against this revocation. The
appeal fee was payed on the same day. The Statement of
Grounds was filed on 13 June 1989.

VII. The Appellant is of the opinion that the subject-matter of
Claim 1 involves an inventive step having regard to
documents C and D. He insists on the claimed invention
being completely different from the teaching of
document C: contrary to the conventional practice, the
vacuum bag compression of the laminate is not used until
the curing cycle. In his view the combination of
documents C and D is of fortuitous character. In D only
air entrapped by the membrane 13 is to be released - and
not air included within layers of a laminate. No reason
would exist to use the teaching of D in addition to the
one of C.

Responding to a communication issued by the Board
according to Article 110 (2) EPC the Appellant upholds
that the subject-matter of Claim 1 is not obvious to the
skilled man having regard to the state of the art and his
general knowledge.

VIII. The Respondent is of the opinion that the combination of document C with D was obvious. In particular, reduction of the compression was already used in C; D would additionally present the appropriate range of temperatures resulting in a mechanism of degassing equivalent with the one of the contested invention.

IX. During oral proceedings which took place on 22 January 1992, the parties confirmed their positions in detail. The Respondent came to the conclusion that the only difference between the claimed method and the one taught by document D consisted in the substitution of a single layer by a composite made of several layers comprising a plurality of plies of fibrous material. He considered such a substitution as not being inventive. The Appellant was of the opinion that such an obviousness-argumentation was based on the knowledge of the invention.

X. The Appellant requested to set the revocation aside and to maintain the patent in its granted form.

The Respondent requested to dismiss the Appeal.

Reasons for the Decision

1. The Appeal is admissible.

2. Novelty

None of the cited documents presents all the features of Claim 1. Since novelty is not contested, further observations are dispensed with.

3. Prior art, problem and solution

3.1 No available prior art document appears appropriate for forming a first portion of Claim 1. As the description states, it has long been desired in the field of fiber reinforced composite laminates to replace the use of an autoclave by vacuum furnaces in order to expell entrapped air within the laminate. Attempts at vacuum curing composite materials have not been successful, even in high vacuum. The problem to be solved remained therefore the provision of an easier method of fabricating composite structures with minimal porosity and at less cost, by the use of vacuum but without the use of an autoclave.

3.2 The features of Claim 1, in particular the heating of the laminate within a specific temperature range allowing the entrapped air to migrate through the resin matrix under the vacuum effected by an evacuable chamber, solve the mentioned problem.

4. Inventive step

4.1 Document C, regarded as the one closest to the invention in the contested decision, is based on the assumption of using an autoclave. The problems arising during the sequences of the test stages led to various modifications in the constitution of materials and methods. The individual teachings to be taken from this document will have to be interpreted in relation to the framing technical situation characterized in particular by the following:

- (a) "The program plan was to explore state-of-the-art addition reaction-type polyimide resin matrices in composite with selected graphite fibers that potentially could meet the Shuttle orbiter's 500°F

maximum temperature requirements and near-term development schedules" (p. 440). Special criteria were used in selecting candidate graphite/polyimide systems, such as: costs of commercially available resin matrices; best performance after subjection to isothermal aging environment of 500°F in air for 125 hours; Shuttle orbiter requirements to determine adequacy of material properties.

- (b) Under the heading "Development of composite cure cycles" (p. 444) it is mentioned that such cycles "required 100 psi maximum pressure, applied in an autoclave. Curing temperatures do not exceed 360°F while the composite is in the autoclave, thus permitting the use of standard, high-temperature nylon vacuum bag pressure membranes." Table 4 (p. 445) describes optimum cure cycles, Figures 1, 2 and 3 (page 446) show the bag-autoclave tooling.

In Table 4 the following remarks concern the Autoclave Curing Process for the Resin Matrix DuPont 3003:

- (1) Seat under vacuum,
- (2) raise temperature to 225°F at 3-5°F per minute, hold 4 hours,
- (3) apply 100 psi pressure,
- (4) raise temperature to 360°F, hold 2 hours,
- (5) release 100 psi pressure, raise temperature to 400°F, cure 1 hour.

As Postcure Process is mentioned:

- 18 hours at 400°F, 450°F, 500°F.

(c) Approximately 24 composite materials were screened. The definition of the substances to be used as a matrix was evidently one of the main results. The conclusions refer to a special composite (HX580/Thornel 300-UC309) having optimal thermal, mechanical and physical properties. In particular it was found that "essentially zero-void laminates could be achieved, with fiber volumes of 60 to 70 percent." (page 457).

4.2 Document C, as follows from the above, does not itself suggest to the skilled man to work without an autoclave. There are no indications at all that use of an autoclave was considered as a parameter which could be varied within the tests. The autoclave appears, on the contrary, to be regarded as a conditio sine qua non.

But even if it is assumed that the desire to work without an autoclave was the leading thought of the skilled man when studying the document, C does not give sufficient information to arrive at the claimed method in an obvious way. The importance of the relationship between voids, viscosity, temperature-range, time-range together with vacuum is not explicitly mentioned in C and is not deducible therefrom. On the contrary, the relationship of voids and used types of fibre volumes was found to be decisive (cf. above under 4.1 c)). The skilled person was lead rather in the direction of optimizing the composition of the materials to be used - away from the direction underlying the contested claim.

Hence, even if diminishing of the autoclave-pressure also appeared as a further parameter to be investigated, it still remains completely open what results were achievable then. No sufficient reason is perceivable that the skilled person would necessarily arrive at the claimed definition on the basis of document C.

4.3 (a) Also document D does not lead closer to the invention. In the described process for moulding a reinforced plastics article a membrane - covering the reinforcing material and the resin - and a moulding base together form a moulding tool. Impregnation of the reinforcing material with the resin is achieved by evacuation of air or other gas from the interior of the moulding tool under a high pressure outside the membrane. After heating the resin to a first temperature below the curing temperature and reducing the pressure outside the membrane, the resin flows freely through the reinforcing material. Then the membrane is pressed against the resin and finally the resin is heated to a higher temperature to cure it.

(b) On page 1, lines 71 to 80, the following is said:
".. to allow the rubber membrane 13 to lift from the reinforcing material 12, thereby releasing bubbles of air or other gas which may be trapped by the membrane 13. The resin is thus allowed to flow freely through the reinforcing material and bubbles of air or other gas are removed through means 14. The viscosity of the resin is decreased by raising the temperature, thus enabling the resin to flow more freely."

On page 2, lines 14-17, is mentioned: "It is to be understood that the other gas removed from the interior of the moulding tool may include vapours formed during the polymerising process."

(c) These observations relate to bubbles under the membrane and in free contact to the means 14 (evacuation). They do not, however, mention or disclose the movability of bubbles within the fluidized resin itself.

(d) From both documents C and D, singly and in combination, no sufficient reason is perceivable which may suggest the fully different claimed method which renders the use of autoclave superfluous by applying a specific technical interrelationship between a specific time range, a specific temperature range, and a specific vacuum interrelated by the function: allowing sufficient migration of the entrapped air through the resin matrix.

4.4 The Respondent is of the opinion that since document C shows the way for reduction of the compression (in the autoclave) it would have been obvious to the skilled man to make use of the total reduction of the compression according to document D, in particular since the degassing in D takes place under vacuum and a raised temperature. In his view not only the chosen temperature conditions are to be taken from D, but the degassing mechanism is also the same as in the contested invention. The Respondent refers in this respect to p. 1, lines 41-80, and p. 2, lines 14-17.

The Board cannot follow this argumentation. The exact information given by the cited passages is only directed to the space "below the membrane" and to the "interior of the moulding tool."

Even if it were proved - which is not the case - that special temperature-viscosity-vacuum-time conditions according to C and D would fall exactly under those of contested Claim 1 and thus migration of the voids would necessarily arise in the claimed sense - this would only prove that a partial embodiment of an example of the claimed teaching could be comprised by the documents.

The step from such a special embodiment to the claimed general teaching would, however, also not appear to be obvious.

According to document D no composite structures having a plurality of plies were used - as admitted by the Respondent. It is already questionable, therefore, whether the skilled man regarded at all the documents as interesting in view of his problem. In particular the voids and bubbles in his case did not occur primarily within the resin matrix, but were concentrated near the fibres - according to the explanations of the Appellant during oral proceedings. Document D referred to structures comprising only one reinforcing layer, the main bubbles being formed within the resin matrix itself. Document D presents, therefore, a technical situation not simply comparable with the claimed one.

- 4.5 The decisive idea integrated in the invention, viz. taking account of the mobility of voids within the resin as a definable function of its viscosity in cooperation with a particular time and temperature range and an appropriate vacuum, is neither mentioned nor suggested to the skilled man by the citations. However, once this physical cause-effect relationship is recognized, the features of Claim 1 may appear as merely "logical" consequences in view of documents C and D and then support an obviousness argumentation. Such an assumption would, however, necessarily be based on the knowledge communicated by the invention itself, thus on an unallowable assumption ex post. The movability of voids within the resin due to an appropriate viscosity is not mentioned in any of the cited documents. They are in fact based on the perception of voids only between surfaces and enveloping membranes or

other enclosures. No mention is evidenced of taking account of the situation inside a solid laminate comprising a plurality of plies of fibrous material in relation to any parameters at all.

The teaching of arriving at a minimal porosity by means of a combination of cooperating ranges of parameters as defined in Claim 1 was not subject-matter of any identifiable considerations in the mentioned documents and not deducible in an obvious way therefrom.

4.6 Document A was presented by Opponent I who withdrew his opposition; it was not anymore discussed during the following proceedings. It corresponds to the prior art discussed in the description. Documents A and B are not more relevant than documents C and D.

4.7 In view of the above, the Board comes to the conclusion that the citations, even combined, did not suggest in an obvious manner the method according to Claim 1 to the person skilled in the art.

4.8 The subject-matter of Claim 1 accordingly involves an inventive step.

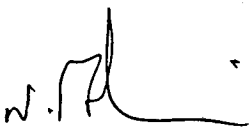
5. Dependent Claims 2 to 12 are directed to preferred embodiments of the method of Claim 1 and are also therefore allowable.

Order

For these reasons, it is decided that

1. The contested decision is set aside.
2. The case is remitted to the first instance with the order to maintain the patent as granted.

The Registrar



N. Maslin

The Chairman



C.T. Wilson

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