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Datasheet for the decision of 7 November 2017

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Application Number: 05804330.8

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Title of invention:
SLURRY PHASE POLYMERISATION PROCESS

Patent Proprietor:
INEOS Manufacturing Belgium NV

Opponents:
Chevron Phillips Chemical Company
Borealis AG
Total Research & Technology Feluy

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (no) all requests

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Case Number: T 0560/14 - 3.3.03

D E C I S I O N
of Technical Board of Appeal 3.3.03
of 7 November 2017

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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted on 7 January 2014 revoking European patent No. 1827677 pursuant to Article 101(3)(b) EPC.**

Composition of the Board:

Chairman D. Semino
Members: M. C. Gordon
R. Cramer

Summary of Facts and Submissions

I. The appeal lies from the decision of the opposition division posted on 7 January 2014 revoking European patent No. 1 827 677.

II. The patent was granted with a set of 20 claims, whereby claim 1 read as follows:

"A process comprising polymerizing in a loop reactor an olefin monomer optionally together with an olefin comonomer in the presence of a polymerization catalyst in a diluent to produce a slurry comprising solid particulate olefin polymer and the diluent wherein the Froude number is maintained at or below 20."

III. Three notices of opposition against the patent were filed in which revocation of the patent was requested.

The following documents, *inter alia*, were cited in support of the oppositions:

D2: US-A-3 248 179
D4: Report 19-C of SRI: "High Density Polyethylene, Supplement C", March 1979, contents pages ix-xi, pages 209-225, 304 and 305
D6: WO-A-2003/070365
D11: WO-A-2006/003144
D13: US-A-3 324 093
D31: WO-A-2004/024781

IV. The decision was based on amended sets of claims forming a main request and two auxiliary requests.

Claim 1 of the main request differed from claim 1 of the patent as granted by specifying that:

- the Froude number was maintained in the range 3 to 10
- the internal diameter of the loop reactor was 600 mm and
- the solids concentration in the reactor was above 20 vol% and
- if the polymer produced was polyethylene and the diluent was an alkane the solids content was above 40 wt% based on the total weight of the slurry.

Claim 1 of the first auxiliary request differed from claim 1 of the main request by specifying that the internal diameter was in the range 600 to 750 mm.

Claim 1 of the second auxiliary request differed from claim 1 of the main request by restricting the claim to the alternative that the polymer produced was polyethylene with the corresponding definition of the diluent and solids content and deleting the limitation on the volume % of the solids concentration in the reactor.

According to the decision, the main request met the requirements of Articles 123(2), 83, 84 and 54 EPC but lacked an inventive step (Article 56 EPC) over document D31 as the closest prior art because no criticality or unexpected effect had been shown to be associated with the claimed range of Froude number which was the distinguishing feature. The skilled person would as a matter of course seek to operate a process at conditions of fluid velocity high enough to ensure stable flow in order to avoid settling and fouling, but as low as possible to save energy costs. This requirement was reflected by the specified Froude number. The combination of the teachings of D31 with D13 rendered the claimed process obvious.

The first auxiliary request shared the same fate since the further features were considered conventional and no effect was shown to arise as a result of the defined reactor loop diameter.

The second auxiliary request was likewise found to lack an inventive step since the further restrictions were considered conventional and there was no evidence to support the patent proprietor's contention that there existed a prejudice against operating slurry polymerisations with high solids contents in relatively large internal diameter loop reactors.

Consequently the patent was revoked.

V. The patent proprietor (appellant) lodged an appeal against the decision.

With the statement of grounds of appeal four sets of claims were submitted whereby the main request and the first and second auxiliary requests corresponded to those on which the decision was based.

Claim 1 of the third auxiliary request corresponded to claim 1 of the second auxiliary request with the limitation of the internal diameter as in the first auxiliary request.

VI. All three opponents (respondents) replied, maintaining *inter alia* objections of lack of inventive step.

VII. The Board issued a summons to oral proceedings and a communication in which, *inter alia,* the preliminary view was expressed that no inventive step could be recognised for any of the sets of claims on file for essentially the same reasons as those on which the decision under appeal had been based.

VIII. Oral proceedings were held before the Board on 7 November 2017.

IX. The arguments of the appellant, insofar as relevant for the decision, can be summarised as follows:

The closest prior art could be seen as the process of D31 from which the subject-matter claimed was distinguished by:

- the Froude number;
- the internal diameter of the reactor
- the solids content.

It was surprising that polymerisation processes could be operated stably for long periods at the claimed solids content in the defined reactors at the Froude numbers claimed without fouling.

The claimed subject-matter represented a departure essentially running contrary to developments in the technical field. Over the years there had been a development from relatively large reactors with low solids content and hence low Froude number as represented by the teachings of D2, D6, D11, D13, towards reactors of generally smaller diameter operating at significantly higher solids content and higher fluid velocities and hence higher Froude number. Closest prior art D31 was an example of this more recent technology.

In general the drive to push reactors harder resulted in the use of higher solids content but in association with diameters of less than 600mm and at high flow rates. With larger volume reactors operating under such high solids content there were increased challenges regarding thermal, compositional and particle distribution which resulted in a move towards reactors of 22"-24" (558-610 mm) and high mass transfer (circulation) rates.

Regarding the internal diameter, D31 disclosed that the diameter was in the range of 4"-48" (101.6 mm - 1219.2 mm). However D31 did not disclose the diameter over the major part of the reactor. On the contrary, reactors generally had varying diameters, so it was possible that the maximum diameter mentioned applied only to a very limited portion of the reactor, for example in the zones where the product was withdrawn, but that over the remainder of the reactor the diameter was smaller and below 600mm. In contrast the operative claims required that the diameter over the entire length of the reactor be above 600mm.

The technical problem solved over D31 was to allow stable operation of the reactor while minimising energy consumption.

The Froude number of the reactor of D31, even at the largest diameter, would in view of the solids content, and the volumetric flow rates be significantly higher than the range required by the claim, even though the solids content of D31 was lower than that specified in the operative claims. At lower diameters or higher solids content the Froude number would become even higher. Therefore D31 led away from the specified range of Froude number.

It would not be expected that a large diameter reactor could be operated at high solids content and at low Froude number, as defined according to the operative claims, in particular in view of the need to avoid fouling and ensure adequate heat management. Hence a combination of the teachings of closest prior art D31 with older documents such as D2, D6, D11 or D13 would not be contemplated by the skilled person except in the light of the patent in suit, i.e. with hindsight. D6 showed for example that even for a moderate increase in solids content, at comparable circulation rates, a significant increase in power input was required.

The skilled person would have expected in the light of the teachings of the prior art that under the conditions as defined in the claim problems of fouling and heat management would arise rendering the process inoperable or at least difficult to manage. That this was not the case was surprising.

On that basis an inventive step should be acknowledged.

These arguments applied to all requests.

X. The arguments of the respondents, insofar as relevant for the decision can be summarised as follows:

The closest prior art was D31. Regarding the diameter of the reactor of D31 there was no basis for the position of the appellant that the largest diameter would only be exhibited in a limited part of the reactor. Similarly the wording of operative claim 1 did not require that the specified diameter of 600mm be present over the entirety of the system. The minimum diameter according to the claim was substantially in the middle of the range covered by D31. The specified diameter could not be seen therefore as a distinguishing feature.

No technical problem could be identified as being solved over D31 beyond the reduction of the power consumption obtained by operating at lower velocities.

The distinction of "old" and "new" technology postulated by the appellant was artificial. There had been a continuous development in loop slurry reactor technology and no cut-off or "watershed" between two fundamentally different technologies existed.

The specified Froude number range was well within those conventionally known to permit stable reactor operation. There was no hindsight in referring to the teaching of documents such as D2, D6, D11 or D13 when considering D31 as closest prior art. Furthermore D2 disclosed reactor diameters which overlapped with the range now claimed. It would be obvious to operate under conditions resulting in a Froude number within the claimed range in view of the problem as set out in the patent in suit, i.e. reducing the energy needs of the system, and no unexpected effect was shown to be associated with the specified Froude number range, because the patent had no comparative examples.

D6 showed that for solids contents in the range of the patent an increase in circulation rate with high solids content resulted in a doubling of the energy input required to the pump. In the light of this teaching the skilled person would, in order to solve the technical problem underlying the patent, as a matter of course, select a lower circulation rate, thus automatically arriving at a Froude number in the claimed range.

The period of stable operation shown in the example of the patent - 6 days - did not provide evidence for a technical effect. Conventionally such reactors operated stably for months, as shown for example by D2. Other documents such as D4 showed that at least over the time period covered by the example of the patent fouling was not a problem.

The auxiliary requests, insofar as they introduced further distinguishing features, did not give rise to a different conclusion on inventive step.

XI. The appellant requested that the decision under appeal be set aside and the patent be maintained in amended form on the basis of one of the sets of claims according to the main request or the first to third auxiliary requests, all as filed with the statement of grounds of appeal.

XII. The respondents requested that the appeal be dismissed.

Reasons for the Decision

1. Main request - inventive step

1.1 The patent in suit - technical problem

The patent relates to olefin polymerisation in slurry phase loop reactors (paragraph [0001]).

According to paragraph [0006] plant capacities have increased and the development has been towards

operation at increasingly higher slurry and monomer concentrations. This has been achieved by higher circulation velocities, by higher pump head or by employing multiple pumps. This however resulted in increasing complexity of design and increased energy consumption as slurry concentrations increased.
It is explained that the trend had been to increase circulation velocity to ensure good thermal, compositional and particle distribution across the reactor and so provide stable flow characteristics (paragraph [0007]).

According to paragraphs [0009] and [0010] a process as set out in claim 1 of the patent was developed to allow reduction of specific energy consumption of the reactor whilst maintaining a given residence time and avoiding fouling, particularly at high solids loadings.

The patent contains a single example which shows stable operation for a period of 6 days.

1.2 Closest prior art

The decision held that D31, which relates to a slurry loop polymerisation process for polyolefins, represented the closest prior art. All parties, at least in one approach, followed this. The Board, in particular in view of the outcome of the analysis starting from D31, sees no reason to take a different view.

D31 relates to a loop slurry polymerisation process for olefin monomers (page 1, line 11) in a reactor of internal diameter 4"-48" (102-1219 mm - page 8, line 15). The reactor has an internal volume of greater than 20,000 gallons and operates at a solids content of greater than 40 weight percent (page 4 lines 1-7). According to page 5 lines 20-23 the reactor can have an internal volume of up to 100,000 gallons and operate at solids contents of greater than 50 weight percent.

1.3 Identification of the distinguishing feature(s)

The solids content in the reactor of D31 is, according to page 4 lines 3 and 4 greater than 40% weight. It was not disputed by the respondents that the specified solids content of above 20% by volume of operative claim 1, for the general case was not directly disclosed, could not be derived from the weight % and represented a distinguishing feature compared to D31 where this volume was unknown.

The upper limit of the range of reactor diameter disclosed in D31 - 4"-48" (102-1219mm) - is within the range of "over 600mm" required by operative claim 1.

The appellant argued that D31 did not disclose that the specified diameter was constant around the entire length of the reactor and hence left open the possibility that the largest diameter was present only in certain regions thereof, e.g. in the vicinity of the settling legs.

There is however no basis for this reading in D31. In the discussion at page 8, lines 13-15 it is stated that the reactor is "typically a pipe loop reactor with an inner diameter of from about 4 inches to about 48 inches". At page 9, lines 5-8 it is indeed stated that the region where the take-off assembly is located can be of larger diameter to slow down the flow. However this statement does not indicate whether the adjective "larger" is with respect to the upper limit of 48" for the reactor or indicates values towards the upper part of the range of between 4" and 48" for the reactor.

However, regardless of the precise meaning of this disclosure of D31, significantly, operative claim 1 also does not include any restriction as to the extent or length over which the reactor is to exhibit a diameter of "over 600mm". The wording of the claim is, similarly to that of D31, such that it is not required that the entirety or even a particular (major) part of the reactor have a diameter above this limit. All that the claim requires is that a portion of the reactor has a diameter in this range. In this respect the definition of the diameter in the patent is no more precise or limiting than that of D31.

Accordingly the Board is unable to recognise a distinguishing feature arising from the specification of a diameter of "over 600mm" with respect to the disclosure of a diameter of 48" in D31.

D31 does not disclose the Froude number. According to calculations presented in the statement of grounds of appeal - which have not been disputed - the Froude number would be at least 152 for the flow rate and the largest reactor diameter disclosed. A larger flow rate or a smaller diameter would result in a higher Froude number.

Consequently the subject-matter of operative claim 1 is distinguished from the disclosure of D31 by the volumetric solids content and by the Froude number (notwithstanding that these two properties are to an extent linked).

1.4 The technical problem

There is only a single example in the patent which shows polymerisation of ethylene in a reactor of inner diameter 711mm, volumetric capacity 62 m^3 being operated at a Froude number maintained below 10. Over the period of 6 days reported, the process ran stably with no evidence of fouling.

There are no comparisons with the process of D31 and no comparisons with processes operating under any different conditions either with respect to the operational parameters of the reactor as used in the examples, e.g. solids content, circulation speeds or in different reactors, e.g of different internal diameters. The evidence available therefore does not allow the presence of an effect related to the identified technical differences to be acknowledged.

On the other hand the respondents acknowledged that operation at low Froude numbers corresponds to operation at low velocities and low flow rates and therefore results in the reduction of the energy consumption. On that basis the problem solved by the claimed process over the disclosure of D31 is the provision of a process with reduced energy consumption.

1.5 Obviousness

It is apparent from the secondary documents cited, in particular the teachings of D6, examples 3 and 4 on page 34 that solids content and in particular circulation speed are major factors in determining the energy requirements of a reaction system. These data show that even a small increase in circulation rate and solids concentration leads to a major increase - of the order of a doubling - of energy requirements (cf. reactor circulation, pump power, solids concentration and circulation rate). It is also known that the circulation speed is a major factor in ensuring stable reactor operation, i.e. in order to maintain the polymer in suspension thus preventing settling or fouling (see e.g. D2, column 5, lines 10-16). D13, sentence bridging columns 3 and 4 teaches that there exists a "minimum flow velocity" which is the velocity below which the solids settle and are not suspended. D13 defines a value - the "limiting velocity" - which is the minimum flow rate at which the entire mass of solids is carried in near homogeneous flow with no settling.

What emerges from the prior art is that there are in effect two competing constraints on the flow rate and solids content. On the one hand there is the requirement to provide a stable dispersion and flow without settling to permit the reaction to take place at a suitable rate and for the reactor to operate stably and continuously. On the other side there is the constraint imposed by the necessary energy input.

It is thus apparent that it is necessary to operate the reactor above a particular threshold of flow velocity, which is influenced by the solids content and that as the velocity increases there is a trade-off between the stability, degree of dispersion and efficiency of the system and the required energy input. In particular, if the main interest resides in minimising the energy consumption, the system will be operated at around the lowest possible circulation rate (and therefore flow velocity).

The Froude number reflects the flow velocity, being an indication of the relative settling and suspending tendencies of the particles and thus being related to the solids content of the system.

Consequently the definition of a Froude number in a given range amounts to defining a set of conditions at which an optimum or compromise is found between the competing requirements on the reaction system, having in mind the constraints of the design (here in particular minimising the energy consumption).

The appellant has not shown that any technical challenges needed to be overcome, or particular requirements on the reactor system or its operating conditions had to be identified and developed in order to operate under the specified conditions. Nor are there any features in the claim which reflect measures intended to overcome such obstacles, should they exist.

Also the restriction on the solids concentration (above 20 vol.%) does not appear to relate to an unusual range or one in which operation is problematic.

In the light of the foregoing, with no evidence, and no corresponding submissions, of any particular technical difficulty involved either in identifying the necessary conditions or in operating under the conditions reflected by the defined Froude number, the Board can come to no conclusion other than that the necessary operating conditions as defined in the claim can be arrived at by routine experimentation and optimisation with the aim of reducing energy consumption of the system.

The period of stable operation shown by the example of the patent - 6 days - is also unexceptional as demonstrated by D2, example 1 showing stable operation times of 21 or 33 days. Similarly D4 demonstrated that loop reactors could operate stably for at least a week (page 219, second paragraph).

Under these circumstances the Board can come to no other conclusion than that the process conditions defined by the claim are the result of a routine optimisation within the known parameters and process constraints in order to identify the conditions required to provide a stably operating reaction system with minimum or reduced energy needs.

Consequently an inventive step cannot be recognised.

2. First auxiliary request

Claim 1 differs from claim 1 of the main request by defining the diameter as lying in the range of 600-750mm. Insofar as this can be seen as providing a distinguishing feature over the disclosure of D31, the effect is to restrict the diameter (of a part of the reactor - see above) to a region around the central part of the range defined in D31. No technical effect has been demonstrated to be associated with this diameter of reactor and no further arguments have been provided by the appellant.

Accordingly the conclusions as indicated for the main request also apply to the first auxiliary request with the consequence that no inventive step can be recognised.

3. Second auxiliary request

Claim 1 is restricted to a process for producing

polyethylene in an alkane diluent whereby the solids concentration in the reactor is above 40 wt%.
D31 discloses at page 7, line 15 that the process thereof is particularly suitable for the homopolymerisation of ethylene. At page 7, lines 22-27 diluents are discussed, all the named examples being alkanes. Furthermore in claim 17 of D31 it is specified that the concentration of solid polymer particles in the slurry is greater than 40 weight percent based on the weight of the olefin polymer particles and weight of the liquid medium. This means that the total content of solids of all types - including catalyst particles - will be higher. Consequently the second auxiliary request does not introduce any additional distinguishing features with respect to D31 compared to the main request.

The second auxiliary request therefore does not meet the requirements of inventive step for the same reasons as explained for the main request.

4. Third auxiliary request

Claim 1 corresponds to a combination of the features of claim 1 according to the first and second auxiliary requests and for the reasons indicated above does not meet the requirements of inventive step.

5. In the light of the conclusions reached in respect of inventive step for all requests, it is not necessary to consider the other matters raised by the respondents and the decision to revoke the patent is to be confirmed.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

B. ter Heijden D. Semino

Decision electronically authenticated