APPLICATION FOR A STANDARD PATENT

I\We, INSTITUT FRANCAIS DU PETROLE

of 4 AVENUE DE BOIS-PREAU
92502 RUEIL-MALMAISON
FRANCE

hereby apply for the grant of a standard patent for an invention entitled:

PROCESS AND APPARATUS FOR THE PRODUCTION OF AROMATIC HYDROCARBONS FROM AN ALIPHATIC HYDROCARBON CHARGE IN A REACTOR HEATED BY A FLUIDIZED PARTICLE BED.

which is described in the accompanying complete specification

Details of basic application(s):

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<th>Number of basic application</th>
<th>Name of Convention country in which basic application was filed</th>
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My/our address for service is care of GRIFFITH HACK & CO., Patent Attorneys, 601 St. Kilda Road, Melbourne 3004, Victoria, Australia.

DATED this 29th day of November 1990

INSTITUT FRANCAIS DU PETROLE

GRIFFITH HACK & CO.

TO: The Commissioner of Patents.
AUSTRALIA
PATENTS ACT 1952

DECLARATION IN SUPPORT OF AN APPLICATION FOR A PATENT

In support of an application made by:

INSTITUT FRANCAIS DU PETROLE

for a patent for an invention entitled: PROCESS AND APPARATUS FOR THE PRODUCTION OF AROMATIC HYDROCARBONS

1. FRANCOIS ANDREEFF PLUIDIZED PARTICLE BED.

of

4 AVENUE DE BOIS PREAU

92500 RUEIL MALMAISON CEDEX FRANCE

do solemnly and sincerely declare as follows:

1. I am authorised by the above mentioned applicant for the patent to make this declaration on its behalf.

2. The name and address of each actual inventor of the invention is as follows:

GERARD MARTIN 34 BIS AVENUE DE COLMAR 92500 RUEIL MALMAISON

PIERRE RENARD 8 ALLEE DES ROMARINS 78860 SAINT NOM LA BRETECHE

3. The facts upon which the applicant is entitled to make this application are as follows:

The said applicant is the assignee of the actual inventors.

4. The basic application(s) as defined by Section 141 of the Act was (were) made as follows:

Country FRANCE on 1er décembre 1989

in the name(s) INSTITUT FRANCAIS DU PETROLE

and in FRANCE on 1er décembre 1989

in the name(s) INSTITUT FRANCAIS DU PETROLE

5. The basic application(s) referred to in the preceding paragraph was (were) the first application(s) made in a Convention country in respect of the invention the subject of this application.

Declared at RUEIL MALMAISON

this 12nd day of NOVEMBER 1990

Signed FRANCOIS ANDREEFF

Position Ingénieur Principal

GRIFFITH HACK & CO
PATENT AND TRADE MARK ATTORNEYS
MELBOURNE · SYDNEY · PERTH
The present invention relates to a process for the production of aromatic hydrocarbons from an aliphatic hydrocarbon charge having 2 to 12 carbon atoms in the presence of a zeolitic crystalline catalyst composition. It more particularly relates to the synthesis of a mixture mainly consisting of benzene, toluene and xylene, which can improve the octane rating of petroleum products. It also relates to a hydrocarbon conversion apparatus in particular for performing the aforementioned process.
1. Process for the production of aromatic hydrocarbons in a reaction zone incorporating a plurality of reaction tubes, said process comprising a stage a) of contacting a charge of at least one aliphatic hydrocarbon with 2 to 12 carbon atoms and a zeolitic catalyst composition optionally containing at least one metal, under appropriate reaction conditions such that a mixture is recovered containing aromatic hydrocarbons and a spent zeolitic catalyst is obtained with a minimum of coke deposited during the reaction, said reaction zone being heated by an at least partial immersion in an enclosure containing a fluidized particle bed, characterized in that the said bed is at least partly heated by a heat supply resulting from the injection of hot gases produced in an area outside the said enclosure and introduced into the fluidized bed under conditions such that the reaction temperature is 400 to 600°C.
AUSTRALIA
PATENTS ACT 1952
COMPLETE SPECIFICATION
(ORIGINAL)
FOR OFFICE USE

Short Title:
Int. Cl:
Application Number:
Lodged:
Complete Specification-Lodged:
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Lapsed:
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Priority:
Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant: INSTITUT FRANCAIS DU PETROLE
Address of Applicant: 4 AVENUE DE BOIS-PREAU
92502 RUEIL-MALMAISON
FRANCE

Actual Inventor:
Address for Service: GRIFFITH HACK & CO.,
601 St. Kilda Road,
Melbourne, Victoria 3004,
Australia.

Complete Specification for the invention entitled: PROCESS AND APPARATUS FOR THE PRODUCTION OF AROMATIC HYDROCARBONS FROM AN ALIPHATIC HYDROCARBON CHARGE IN A REACTOR HEATED BY A FLUIDIZED PARTICLE BED.

The following statement is a full description of this invention including the best method of performing it known to me:-
AUSTRALIA

PATENTS ACT 1952

COMPLETE SPECIFICATION

(ORIGINAL)

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Name of Applicant: INSTITUT FRANCAIS DU PETROLE

Address of Applicant: 4 AVENUE DE BOIS-PREAU

92502 RUEIL-MALMAISON

FRANCE

Actual Inventor:

Address for Service: GRIFFITH HACK & CO.,

601 St. Kilda Road,

Melbourne, Victoria 3004,

Australia.

Complete Specification for the invention entitled:

PROCESS AND APPARATUS FOR THE PRODUCTION OF

AROMATIC HYDROCARBONS FROM AN ALIPHATIC HYDROCARBON CHARGE IN A REACTOR HEATED BY A FLUIDIZED PARTICLE BED.

The following statement is a full description of this invention including the best method of performing it known to me:-
The present invention relates to a process for the production of aromatic hydrocarbons from an aliphatic hydrocarbon charge having 2 to 12 carbon atoms in the presence of a zeolitic crystalline catalyst composition. It more particularly relates to the synthesis of a mixture mainly consisting of benzene, toluene and xylenes, which can improve the octane rating of petroleum products. It also relates to a hydrocarbon conversion apparatus in particular for performing the aforementioned process.

The valorization of low boiling point aliphatic fractions, such as LPG's, justifies the interest attached to processes for the conversion of said hydrocarbons, which are efficient, selective and economic, whilst also contributing to the formation of hydrogen as a byproduct.

The aromatic hydrocarbon production reaction has in particular been described in US Patents 3760 024, 3756 942 and 3855 980 in the presence of a silica and alumina-based crystalline zeolitic catalyst of the MFI type, such as ZSM5 or ZSM12, optionally with a metal such as gallium in the skeleton or in the presence of a zeolitic catalyst containing a metal outside the skeleton and as described in French Patent 2374 283 and US Patent 4175 057.

The elementary processes involved in the transformation of
aliphatic hydrocarbons into aromatic hydrocarbons are mainly the dehydrogenation of paraffins, the oligomerization of unsaturated hydrocarbons and the cyclization of oligomers. The reaction is highly endothermic, the reaction rate being sensitive to temperature variations and said successive reactions are accompanied by a deposition of coke on the catalyst and a reduction of the metallic oxides contained in said catalyst, which very rapidly deactivates it and reduces the cycle time.

It is known from US Patent 4224 298 to use a fluidized particle bed for heating the tubes in which the reforming of hydrocarbons takes place with a view to obtaining synthesis gas at a temperature of 750 to 800°C. In this case, the external temperature of the skin of the reaction tubes is approximately 975°C. The fluidized bed is heated by the combustion of a fuel and a combustion supporter directly in the particle bed. This apparatus suffers from the disadvantage of only being able to operate at high temperatures, i.e. it lacks the flexibility to enable it to be used in all reforming procedures. Moreover, it suffers from all the disadvantages resulting from combustion in fluidized bed.

There can firstly be problems of the dispersion of the fuel within the bed, particularly when the diameter of the latter exceeds e.g. 3 metres and when it is occupied by a large number of tubes. Under these conditions, the distribution of heat
over the tubes is no longer homogeneous and there are risks of post-combustion beyond the fluidized bed.

It can also be difficult to check and control the bed operating at above 1000°C, particularly during transient phases. In this case, there is a risk of the solidifying of the complete bed linked with local overheating in poorly fluidized areas. Thus, for example, in the case of an emergency stoppage of the apparatus, if the fuel supporter flow has not been completely stopped, the oxidation of the fuel present in the bed can continue in a fixed bed. This leads to a significant bed temperature rise through the absence of an exchange with the tubes, which may lead to the melting of the bed.

In addition, French Patent 2531944 describes a reforming process using the vapour of a hydrocarbon charge, so as to obtain a hydrogen-containing gas as the essential constituent. The reaction zone is heated via a fluidized particle bed, which is in turn heated by burners mounted directly on the reactor wall, so that combustion takes place within the fluidized bed to the extent that the temperature thereof is at least 750°C.

In addition, French Patent 2374283 proposes a gallium zeolite composition used in a process for the production of aromatic hydrocarbons from an aliphatic hydrocarbon charge.
One of the problems to be solved consists of ensuring a uniformity of the heating of the reaction zone at approximately 500 to 600°C making it possible to obtain a very flat or shallow temperature profile throughout the zone knowing that the catalyst is sensitive to a temperature rise and can be destroyed when the critical temperature is exceeded.

Another problem to be solved relates to the regeneration of the catalyst, which must be fast and of variable frequency as a function of the temperature of the reaction directly dependent on the charge to be treated. This regeneration must be sufficiently gentle to preserve the performance characteristics of the catalyst and minimize its renewal rate.

The object of the present invention is to solve the problems referred to hereinbefore, in such a way as to improve the conversion rates into aromatic hydrocarbons and the life of the catalyst.

The present invention more particularly relates to a process for the production of aromatic hydrocarbons comprising a stage of contacting a charge of at least one aliphatic hydrocarbon with 2 to 12 carbon atoms and a zeolitic catalyst composition optionally containing at least one metal in a reaction zone under appropriate reaction conditions for recovering a mixture incorporating aromatic hydrocarbons and a spent zeolitic
catalyst is obtained with a minimum coke deposition during
the reaction, said reaction zone being heated by an at least
partial immersion in an enclosure containing a fluidized part-
icle bed, characterized in that the said bed is at least partly
heated by heat supply resulting from the injection of hot
gases produced in a zone outside said enclosure and introduced
into the fluidized bed under conditions such that the reaction
temperature is 400 to 600°C.

According to a feature of the process, the reaction zone can
comprise at least one reaction tube located vertically or
horizontally in the enclosure containing the fluidized bed.

This fluidized bed generally comprises particles having a
grain size normally between 20 and 5000 micrometres, prefer-
ably between 50 and 200 micrometres and with a density between
1000 and 6000 kg/m³ and preferably 1500 and 3000 kg/m³. Their
shape can be of a random nature, but is advantageously spher-
ical.

The bed generally comprises inert particles, e.g. at least
partly sand and is generally heated to a temperature well
above the reaction temperature in the tubular reaction zone,
e.g. 480 to 600°C, under heating conditions such that the
temperature variation between the heating fluidized bed and
the catalyst is normally between 5 and 100°C and advantageously
between 20 and 40°C.

According to another feature of the invention, the particle bed is normally fluidized by means of a fluidization gas e.g. injected by tubes provided with orifices and which are known to the Expert, being located at the base of the preferably cylindrical enclosure. The fluidization gas flow rates are such that the surface velocity is between 0.01 and 1.00 m/s and is preferably between 0.1 and 0.3 m/s. Under these conditions, the quasi-isothermicity of the bed is ensured and due to good heat transfer coefficients between the bed and the inner wall of the tube, the life of the catalyst is increased and the selectivity of the reaction improved. These fluidization gases can be recovery gases from a furnace or boiler, preheated air or turbine effluents.

The fluidized particle bed can in part be heated by fluidization gases injected at a sufficiently high temperature and preferably by injections of hot gases directly into the bed. It is also possible to at least partly recycle particles drawn off from the enclosure and then reheated outside the latter, e.g. during the regeneration of the catalyst, if the latter takes place outside the enclosure where reactions leading to aromatization take place.

According to a feature of the process, the regeneration stage
of the catalyst can be carried out in the same reaction tube disposed in the enclosure containing the fluidized bed in which the reaction stage has taken place.

At least part of the heat given off during said regeneration by the combustion reaction is then exchanged with the fluidized bed. The catalyst regeneration reaction, which is exothermic, then significantly contributes to the thermal balance of the process, because it at least partly compensates the heat loss due to the endothermicity of the aromatization reaction. Thus, the fluidized bed acts as a thermal steering wheel removing the catalyst regeneration heat from the reaction tubes.

It is possible to envisage any combination of heat supply to the fluidized bed of the type described hereinbefore. Thus, it has been possible to obtain excellent results through the heat supply due to the regeneration of the catalyst and at least one injection of gases heated to a temperature between 1200 and 2200°C by fuel gas burners and directly introduced into the fluidized bed, preferably at the side wall thereof.

According to a preferred embodiment of the process according to the invention, the reaction zone can comprise a plurality of parallel reaction tubes grouped into bundles, the latter being supplied in parallel. At least part of them is adapted to carrying out the aromatization of the charge, whilst the
other part carries out the catalyst regeneration stage. When the regeneration is substantially ended, the tubes previously functioning in regeneration, then function as an aromatization reactor. This alternating operation using a set of valves is very flexible.

The catalyst can be under moving or fixed bed conditions, but preferably fixed bed. Under fixed bed conditions, there is a reduction of the mechanical wear phenomena mainly due to the circulation of the catalyst, which lead to the formation of a large quantity of fines, to disturbances in the operation of the unit, to the entrainment of these fines by reaction products and consequently deterioration to the downstream product treatment units, as well as to an increase in catalyst consumption.

The process according to the invention leads to the following advantages. As a result of its temperature uniformity and excellent heat exchange coefficients, the fluidized bed ensures a substantially constant temperature over the entire length of the tube, as well as over all the tubes constituting the reaction zone, even if the bundles incorporate several hundred, or even thousand tubes. The radial temperature profile is then substantially flat. As a result of this temperature uniformity over the entire catalyst volume, there is a better catalyst utilization. The temperature uniformity
of the bed is also an advantage during the regeneration of
the catalyst in the enclosure. It makes it possible to easily
start the oxidation of the coke and carry out said regeneration
more rapidly than in other configurations, because the calories
given off by the oxidation are rapidly transferred to the
bed.

The temperature variation between the heating medium and the
catalyst is preferably between approximately 20 and 40°C,
so that the catalyst will be at the temperature of the bed
in the case of a total or partial closing or blocking of one
of the tubes by excessive coke deposition and therefore under
conditions will not lead to the destruction thereof.

When several tube bundles are immersed in the same fluidized
bed, part of the heat supply can come from the regeneration
when the bundles operate in alternating manner, the process
then becoming more energy economic.

The thus described technology also makes it possible to reduce
the passage time between the reaction cycle and the regenera-
tion cycle, because the bed temperature is the same in both
cases.

For a given capacity, the overall dimensions of the bundle
are much smaller than required e.g. for radiant furnaces.
This greater compactness obviously reduces the investment costs.

This technology, which has a very flexible form as a result of its modular nature can be adapted to both large and small capacities. It can be used both with a cyclic regeneration and with a continuous regeneration of the catalyst.

Generally the inert particles used as the fluidized bed are chosen from among refractory materials such as aluminium oxides, silicon oxides (sand), natural magnesium or calcium carbonates or mixtures thereof. Preference is given to the use of sand due to its ready availability and low price.

The reaction is generally performed in an inert atmosphere at a pressure between 0.2 and 10 bars and a temperature of 400 to 600°C as a function of the nature of the charge. The temperature is advantageously 480 to 550°C for the LPG fraction and 450 to 530°C for the naphtha fraction, whilst a preferred pressure is 1 to 5 bars absolute. Preferably, said temperature is 500 to 530°C for the LPG fraction and 480 to 510°C for the naphtha fraction.

The catalyst used is generally a crystalline zeolite of the MFI type, such as ZSM zeolites, e.g. ZSM5, ZSM8, ZSM11, ZSM12, and ZSM35 described in US Patent 3970 544. These zeolites
could advantageously contain at least one metal. Reference is made in exemplified manner to zinc and gallium, preference being given to gallium. These metals can be inside or outside the skeleton.

It is also possible to use synthesized zeolites in a fluoride medium with or without metal.

The catalyst is preferably used in fixed bed form, which reduces attrition phenomena.

The spatial velocities recommended are normally 0.5 to 5 h\(^{-1}\) and preferably 1.5 to 2.5 h\(^{-1}\).

The aliphatic hydrocarbon charge generally comprises 2 to 12 carbon atoms. It advantageously contains LPG or naphtha, whereby the operating conditions can vary as a function of the nature of the charge. For example, in the case of a charge like LPG, it is possible to operate at a temperature above that which would be used for a charge such as naphtha. Therefore the unit makes it possible to very rapidly and by an easy control of the fluidized bed temperature, to accept charges having a variable composition.

In general terms, the operating conditions are optimized in such a way to convert at least 60% of the charge, particularly
with LPG and advantageously at least 80% with an aromatic hydrocarbon level of at least 65% compared with the initial charge. Thus, the unconverted part of the charge can be recycled after separating the effluents. Higher conversion rates or levels can be obtained with heavier charges, e.g. at least 95%.

Regeneration is generally carried out after a purging stage in the presence of a gas containing oxygen and in accordance with a known method (e.g. a $N_2 + O_2$ mixture). It is conventional practice to operate at a temperature between 450 and 650°C and preferably between 480 and 560°C.

The following apparatus can be used for performing the process. It comprises an enclosure lined by an insulating material with an upper face, a lower face and a lateral envelope and it contains a reactor filled with an appropriate catalyst, said reactor being at least partly immersed in a fluidized bed of hot and preferably inert particles, the bed exchanging heat with said reactor and with bed fluidization means connected to the lower face of said enclosure. The reactor also comprises a plurality of substantially parallel and parallel-supplied reaction tubes, charge supply means connected to one end of said tubes and means for the recovery of the effluent containing aromatic hydrocarbons connected to the other end of the said
tubes. Said enclosure is connected to at least one hot gas supply means, such as a hot gas generator located outside the said enclosure. The latter is advantageously connected to said envelope or is advantageously mounted on said envelope.

According to a feature of the apparatus, the enclosure can be cylindrical and the plurality of tubes constitutes an overall cylindrical or overall polygonal volume.

According to another feature, the hot gas supply means has an inlet of its transfer line in the lateral envelope, whose distance to the upper face of the enclosure is generally between quarter and half of the height of the lateral envelope which aids the temperature uniformity in the bed.

According to another feature, the hot gas supply means, e.g. a furnace containing at least one burner can be directly in contact with the wall of the enclosure and the hot combustion gases are introduced into the bed by means of an orifice made in the wall.

According to another feature, complementary fluidization means connected to the lower face of the enclosure can be added so as to fluidize the volume of the fluidized particle bed located between the lateral envelope of the enclosure and the fictional envelope determined by the plurality of reaction
tubes with a higher fluidization rate than that supplied by the fluidization means of the bed at the reaction tubes. This arrangement favours the circulation of particles from the peripheral ring towards the centre and therefore a better heat distribution and better heat exchange.

According to another feature, the apparatus generally comprises regeneration means suitable for regenerating the spent catalyst in the same tubes and in the same reaction enclosure where the aromatics production reaction has taken place. These regeneration means generally comprise a regeneration gas supply at one end of the bundle of tubes and a regeneration effluent discharge at the other end.

The apparatus can also have means suitable for connecting the reaction tubes alternately to the regeneration means and then to the means necessary for carrying out the reaction, in particular connecting one end of the tubes to the charge supply means and the other end to the means for discharging the effluent produced.

The process can also be performed using another variant of the apparatus according to the invention and which is described hereinafter. The apparatus comprises a plurality of reaction tubes and a plurality of regeneration tubes immersed in the fluidized bed and appropriate for regenerating the spent catalyst. These regeneration tubes are connected at one end to
The elementary processes involved in the transformation of

Fig. 2 in cross-section a fluidized bed reaction and regeneration zone in one and the same enclosure.

Fig. 3 a modular assembly, where the tubular reactors and tubular regenerators are located in the same enclosure.

According to fig. 1, a cylindrical reaction enclosure 1 having a wall 2 covered by an insulating material comprises a tight reactor 40 immersed in a fluidized sand bed 13. This reactor has a plurality of stainless steel tubes 3 (e.g. 100 such tubes), which are cylindrical or cylindrical overall and are arranged vertically and secured by supporting elements 22. Their internal diameter is between 10 and 200 mm, preferably between 50 and 100 mm and their length is 2 to 20 m, preferably 3 to 10 m.

The tubes can be internally provided with transverse ribs in order to increase the heat transfer to the catalyst. These tubes are generally parallel to the enclosure axis and are grouped into cylindrical bundles with an inter-axis distance between 1.5 and 6 times the external diameter of the tube and preferably between 2 and 3 times the external diameter.

At their ends, the tubes are connected via upper and lower tubular plates 4 and 5 to a chamber 6 supplying the tubes with a charge introduced by the line 9 controlled by a valve 10 and to a chamber 7 recovering the reaction effluent.
within the bed, particularly when the diameter of the latter exceeds e.g. 3 metres and when it is occupied by a large number of tubes. Under these conditions, the distribution of heat

a regeneration gas supply and at the other end to a regeneration effluent discharge means. The apparatus also comprises means for connecting the reaction tubes alternately to the charge supply means by their first end and to the effluent recovery means by their second end, then to the regeneration gas supply by their first end and to the regeneration effluent discharge means by their second end. Moreover, said same means can connect the regeneration means alternately to the regeneration gas supply by their first end and to the regeneration effluent discharge means by their second end and then to the charge supply means by their first end and to the aromatic hydrocarbon effluent recovery means by their second end. These reaction tubes operate in the so-called reaction phase (production of aromatics), whilst the regeneration tubes operate in the so-called regeneration phase during a first stage and then the reaction tubes become regeneration tubes, whilst the regeneration tubes become reaction tubes during a second stage.

The invention is described in greater detail hereinafter relative to the drawings illustrating in diagrammatic manner the process and apparatus according to the invention and in which show:

Fig. 1 the apparatus in longitudinal section.
In addition, French Patent 2374283 proposes a gallium zeolite composition used in a process for the production of aromatic hydrocarbons from an aliphatic hydrocarbon charge.

Discharged by the line 8 controlled by a valve 17. These tubular reactors contain a fixed zeolitic catalyst bed, e.g. ZSM5 and which can contain gallium in or outside the skeleton. This catalyst is introduced into the tubes in accordance with known methods.

The charge, e.g. LPG, is introduced by line 9 into the upper part of the reactor 40. It has e.g. been preheated by gases from the reactor in a convection zone located downstream of the outlet 11 of the enclosure 1. The volume occupied by the tubes represents 10 to 35% of the total volume of the fluidized bed in expansion.

The fluidized bed is constituted by sand particles of e.g. 0.1 mm. The fluidization gas is introduced into the base of the enclosure 1 by fluidization tubes 14 positioned in an adequate and substantially horizontal manner over the entire base of the reactor and the enclosure 1, substantially level with the lower end of the tubes 3 by which the reaction effluents are discharged. These fluidization beds have orifices directing the fluidization gas flow towards the bottom of the reactor and are in the form of an easily detachable comb which can be slid between the tubes 3 containing the catalyst. The fluidization tubes are connected to a collector 15. The number and shape of the orifices are such that there are no defluidized zones, where the heat transfer between the tubes
optionally containing at least one metal in a reaction zone
under appropriate reaction conditions for recovering a mixture
incorporating aromatic hydrocarbons and a spent zeolitic

and the bed could not be ensured.

The effluents from the reactor pass through diffusers 16 located at the bottom of the tubes 3 before passing out of the reactor by the line 8 and a control valve 17 directing them to a separation unit, which is not shown in the drawings.

The peripheral part 13a of the reactor not occupied by the reaction tubes generally represents between 5 and 40% of the total volume of the bed.

This bed ring directly in contact with the heating gases described hereinafter has a higher fluidization speed, which makes it possible to more rapidly balance the temperature of the bed, due to an intense circulation of particles induced by apparent density differences of the medium between the centre and the periphery.

This circulation of particles from the periphery towards the centre of the enclosure 1 can be accentuated, if desired, by fluidization means 14a disconnected from the means 14 and located at the base thereof, which makes it possible to fluidize the particles at a higher speed at the periphery than in the centre.

Heating of the fluidized bed is essentially brought about by injections of hot gases at a temperature between 1200 and
temperature variation between the heating fluidized bed and the catalyst is normally between 5 and 100°C and advantageously

2200°C resulting from the total combustion of a fuel and a combustion supporter and obtained from e.g. fuel gas burners 18 located in at least one furnace 23 internally lined with refractory materials. The latter are located outside the enclosure 1 and are preferably connected to the cylindrical lateral envelope, being positioned in such a way that the hot gas flow resulting from the total combustion is introduced by a transfer line 19 in countercurrent with respect to the fluidization gases at a point located between a half and a third higher than the fluidized bed height. This transfer line is normally inclined towards the bottom of the reactor, so as to prevent particle accumulation. It would not pass outside the scope of the invention to use a transfer line or an orifice issuing at another point of the enclosure.

A protection device 24 prevents direct contact between the hot gases and the tubes.

Thus, there is a better contact between the heat and the particles and the fluidized bed can be kept at a given temperature as a function of the type of charge, which is essentially the same throughout the reaction zone volume, e.g. close to 520°C with a temperature variation between the sand bed and the catalyst of approximately 20°C.

The gases constituted by the mixture of heating and fluidization
gases are recovered in the upper part of the reactor and discharged by the line 11 with a view to recovering the available heat. Obviously, they are never in contact with the charge. In the same way, the charge or the effluents are never in contact with the fluidized bed.

A device 21 at the bottom of the reactor is a sand joint, which makes it possible for the tubular bundle to expand downwards during the expansion of the tubes.

When the catalyst is deactivated, it is directly regenerated in the tubes where the reaction has taken place and in the same enclosure without modifying the fluidized bed operating conditions. To this end, the supply of charge by the valve 10 is stopped and the tubes are supplied with regeneration gases introduced by the line 12 provided with a valve 60. As the temperature of the fluidized bed is at an appropriate level, regeneration starts instantly. The regeneration effluent gases are discharged by the line 61 controlled by the valve 62.

It is optionally possible to modify the heating intensity of the burner in the furnace or optionally stop the supply of hot gases.

Prior to each passage from the reaction phase to the regeneration
phase and from the regeneration phase to the reaction phase, there is generally an inert gas flow circulation for purging the apparatus.

Thus, the apparatus functions discontinuously, both in the reaction phase and in the regeneration phase with phase durations which may be the same or different.

According to fig. 2 illustrating an example of the reaction and regeneration of the catalyst in the same fluidized bed, the enclosure 1 contains the sand fluidized bed 13 heated by the aforementioned heating means 18. This enclosure contains a plurality of vertical tubes, like those described hereinbefore relative to fig. 1 and which are supplied in parallel. These tubes can be alternately supplied by appropriate supply means from the aromatics production reactors 40,41,42,43,44 as a function of the process and post-reaction, spent catalyst regenerators 45,46.

Fig. 3 shows reactors 40,41,42 and regenerators 45,46. A set of open valves 70,71,72 makes it possible to bring about a parallel supply of the reactors with charge, whilst another set of closed valves 73,74 prevents the circulation of the charge in the regenerators 45,46, but allows the supply of a regeneration gas such as nitrogen and air. The function of the discharge valves 31,32, 33,34,35 of the two effluent types is identical to that of the
ile is then substantially flat. As a result of this temperature uniformity over the entire catalyst volume, there is a better catalyst utilization. The temperature uniformity

The heat given off by the combustion of the spent catalyst in the tubes operating in regeneration supplies part of the energy consumed by the reaction. All the said valves of the supply and discharge means are controlled by control means 50 enabling the bundles of tubes 40, 41 and 42 to be alternately aromatic hydrocarbon production reactors and then regenerators and to the bundles 43 and 44 to be regenerators and then aromatic production reactors following a purging period. After the regeneration period said regenerators become reactors, whilst other reactors become regenerators.

For illustration purposes are shown five tube bundles operating as a reactor and two functioning as a regenerator. Any other combination could obviously be realized and would remain within the scope of the invention.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Process for the production of aromatic hydrocarbons in a reaction zone incorporating a plurality of reaction tubes, said process comprising a stage a) of contacting a charge of at least one aliphatic hydrocarbon with 2 to 12 carbon atoms and a zeolitic catalyst composition optionally containing at least one metal, under appropriate reaction conditions such that a mixture is recovered containing aromatic hydrocarbons and a spent zeolitic catalyst is obtained with a minimum of coke deposited during the reaction, said reaction zone being heated by an at least partial immersion in an enclosure containing a fluidized particle bed, characterized in that the said particle bed is at least partly heated by a heat supply resulting from the injection of hot gases produced in an area outside the said enclosure and introduced into the fluidized bed under conditions such that the reaction temperature is 400 to 600°C.

2. Process according to claim 1, wherein the reaction temperature is 480 to 550°C for a LPG fraction.

3. Process according to claim 1, wherein the reaction temperature is 450 to 530°C for a naphtha fraction.
In general terms, the operating conditions are optimized in such a way to convert at least 60% of the charge, particularly

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4. Process according to one of the claims 1 to 3, wherein the particle bed is at least partly heated by at least one injection into the bed of hot gases from at least one hot gas generator, such as a furnace equipped with at least one burner.

5. Process according to one of the claims 1 to 3, wherein the particle bed is at least partly heated by fluidization gases injected at a sufficiently high temperature.

6. Process according to one of the claims 1 to 5, wherein a catalyst regeneration stage b) is carried out in the same reaction zone as that of stage a) under appropriate conditions, the particle bed being at least partly heated by the heat generated by the regeneration of the catalyst.

7. Process according to one of the claims 1 to 6, wherein the fluidized bed exchanges heat with the said reaction tubes under conditions such that the temperature variation between the fluidized bed and the catalyst is 5 to 100°C and advantageously 20 to 40°C.

8. Process according to one of the claims 1 to 7, wherein, following the recovery of the hydrocarbon mixture, the following sequence is carried out: stage a) of contacting the charge with the catalyst is stopped, the reaction
tubes and means for the recovery of the effluent containing aromatic hydrocarbons connected to the other end of the said zone is purged under appropriate conditions, a catalyst regeneration stage b) is performed in the same reaction zone as that of stage a), a regeneration effluent is discharged, the reaction zone is purged under appropriate conditions, stage a) is repeated and then the stages of the sequence given hereinbefore.

9. Process according to one of the claims 1 to 8, wherein the reaction zone comprises a plurality of tubes arranged in parallel, at least part being intended for performing stage a), whilst the other part is intended to perform stage b) and vice versa.

10. Process according to one of the claims 1 to 9, wherein the catalyst is in the form of a fixed bed.

11. Process according to one of the claims 1 to 10, wherein the external heat supply is introduced by a transfer line connected to a point located between the upper quarter and half the height of the enclosure.

12. Process according to one of the claims 1 to 11, wherein the fluidized bed comprises a direct contact zone with the reaction zone and a peripheral zone with respect to said reaction zone and in which the zone of the bed on the periphery of the reaction zone is fluidized at
so as to fluidize the volume of the fluidized particle bed located between the lateral envelope of the enclosure and the fictional envelope determined by the plurality of reaction

13. Hydrocarbon conversion apparatus comprising an enclosure (1) with an upper face, a lower face and a lateral envelope (2) and containing a tight reactor (40) filled with an appropriate catalyst, said reactor being at least partly immersed in a fluidized bed (13) of hot and preferably inert particles, the bed exchanging heat with the said reactor, fluidization means (14) for the bed connected to the lower face of the said enclosure, the reactor also having a plurality of reaction tubes (3) substantially parallel to one another and supplied in parallel, means (9) for supplying a charge connected to one end of the said tubes and means (8) for the recovery of an effluent connected to the other end of said tubes (3), said enclosure being connected to at least one hot gas supply means (18,23), such as a hot gas generator and located outside the enclosure.

14. Apparatus according to claim 13, wherein the hot gas supply means is connected to the lateral envelope or is mounted on the said envelope.

15. Apparatus according to claims 13 or 14, wherein the length of the tubes is 2 to 20 m, their internal diameter
hereinafter. The apparatus comprises a plurality of reaction tubes and a plurality of regeneration tubes immersed in the fluidized bed and appropriate for regenerating the spent catalyst. These regeneration tubes are connected at one end to

is 10 to 200 mm, the tubes being grouped into at least one bundle, the inter-axis distance of each tube being between 1.5 and 6 times its external diameter.

16. Apparatus according to one of the claims 13 to 15, wherein the hot gas supply means (18,23) has a transfer line (19) for directing the hot gas flow in counter-current to the fluidization gas flow.

17. Apparatus according to one of the claims 13 to 16, wherein the enclosure is cylindrical and the plurality of tubes constitutes an overall cylindrical or overall polygonal envelope.

18. Apparatus according to one of the claims 13 to 17, wherein the hot gas supply means issues at a point located at a distance from the upper face of the enclosure between quarter and half the height of the lateral envelope.

19. Apparatus according to one of the claims 13 to 18, wherein the volume of the fluidized bed located between the lateral envelope of the enclosure and the envelope defined by the plurality of tubes is fluidized by complementary fluidization means (14a) connected to the lower face of the enclosure (1) and able to supply a fluidization gas rate higher than that supplied by the
with a charge introduced by the line 9 controlled by a valve 10 and to a chamber 7 recovering the reaction effluent.

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fluidization means (14) of the bed at the tubes.

20. Apparatus according to one of the claims 13 to 19, wherein it comprises means (12,61) for regenerating spent catalyst and able to regenerate the catalyst in the said tubes and which are connected to the reaction tubes and means (50) which can connect the reaction tubes alternately to the charge supply means (9) and to the effluent recovery means (8) and then to the said regeneration means (12,61).

21. Apparatus according to one of the claims 13 to 20 comprising a plurality of reaction tubes (40,41,42) and a plurality of regeneration tubes (45,46) immersed in the fluidized bed and able to regenerate the catalyst, said regeneration tubes being connected at one end to a regeneration gas supply (12) and at the other end to a regeneration effluent discharge (61) and also having means (50) for connecting the reaction tubes alternately to the charge supply means (9) and to the effluent recovery means (8), then to the regeneration gas supply (12) and to the regeneration effluent discharge (61), said means (50) being able to also connect the regeneration tubes alternately to the regeneration gas supply (12) and to the regeneration effluent discharge (61) and then to the charge supply means (9) and to the aromatic
hydrocarbon effluent recovery means (8), the reaction tubes operating in a so-called reaction phase, whilst the regeneration tubes operate in the so-called regeneration phase during a first stage and the reaction tubes then become regeneration tubes, whilst the regeneration tubes become reaction tubes in a second stage.

22. Use of the apparatus in a process for the production of aromatic hydrocarbons from a charge of at least one aliphatic hydrocarbon having 2 to 12 carbon atoms.
Heating of the fluidized bed is essentially brought about by injections of hot gases at a temperature between 1200 and
The gases constituted by the mixture of heating and fluidization.