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PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Process for Effecting Chemical Reaction in the Interior of Compressors.

I, MARKUS BRUTZKUS, Engineer, of 6, rue Beloy, Paris, France, a Russian subject, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

It is well known to carry out chemical reactions by heating the reacting substances by compression in the interior of compressors or internal combustion engines.

The employment of compressors for effecting chemical reactions is, however, of still greater importance from the standpoint of the laws of equilibria of the chemical reacting substances. The piston mechanism permits of effecting variations in volume and temperature which correspond to the needed volume and temperature variation of the substances during the reaction under consideration. Employing compressors, it is possible by the aid of these adjustments favourably to promote chemical reactions.

According to the invention chemical reactions are carried out in compressors as follows—

All or a portion of the co-operating substances are adapted to be placed into a compressor and brought to a pressure and temperature condition (it may be a vacuum and low temperature), which is suitable for the reaction in view. The quantity of substances used must be so chosen according to the law of masses of the chemical reaction that the highest possible yield can be obtained. As the reaction must be carried out in a short time, the highest possible temperature of the reaction in view will be chosen as the temperature condition. After reaching the necessary pressure and temperature condition the reaction either starts automatically or is initiated by the addition of the substances previously omitted, or by a physical agency such as catalysts, electric arcs, sparks and other discharges, and ultra-violet light.

When the reaction takes place the piston may carry out such a movement that the volume of the substances is increased or reduced according as to whether the number of molecules is increased or reduced by the reaction. During the procedure of the chemical reaction the pressure must be kept as uniform as possible. This also applies to reactions wherein the number of molecules remains the same. The temperature must also remain constant irrespective of the release or combination of heat. The pressure line during the chemical operation must be as near as possible isobaric and at the same time the temperature line isothermic. In any case the volume of the enclosed reacting substances may increase, but the pressure must not increase in reactions where the number of molecules increases but in reactions where the number of molecules decreases the volume may be reduced, but the pressure must not decrease. Also in exothermic reactions the temperature must not rise, in endothermic reactions the temperature must not fall.

In carrying out the invention the desired constancy of pressure can be determined by means of the usual indicator diagram; and from this the complementary temperature diagram can be derived by calculation.

The following means should serve for the fulfilment of these conditions:—

1. A suitable choice of the direction of the piston during the reaction.

2. The gradual introduction of one or more reacting substances into the reaction chamber.

3. And finally, should these two means be insufficient, then a corresponding amount of heat should be added to or removed from the reacting substances during the reaction.

The process will be carried out differently according to the nature of the reaction in question.

In this respect all chemical reactions may be divided into six groups.

1st Group: Exothermic reactions with increase in the number of molecules.

These reactions must be carried out during the expansion stroke.

The necessary quantity of substances are compressed to the most favourable temperature and pressure condition for carrying out the reaction during the compression stroke. A short time before the piston commences its return stroke the reaction is started. The increase in volume in proportion to the increase in the number of molecules and the conversion of the heat set free into work will tend to maintain the constancy of temperature and pressure required. The quantity of the reacting substances and the speed of the piston must be so chosen that the pressure line approximates to isobaric and the temperature line to isothermic, so that in any case an increase in pressure and temperature will not occur.

After the termination of the reaction the products can be still further expanded so as to be removed from the apparatus in the usual way.

2nd Group: Exothermic reactions with a constant number of molecules.

The same process as for Group 1 may be used for this group of reactions. During the outward movement of the piston the heat set free is converted into work. No increase in temperature must take place as this would affect the favourable course of the reaction.

3rd Group: Exothermic reactions with a reduction in the number of molecules.

These reactions must be carried out during the compression stroke and the heat which is formed by the compression after the reaction has started and the heat, which is set free by the reaction, must be carried away.

The necessary quantities of substances are compressed and the reaction must be started during the compression stroke. The heat produced by the further compression and the heat set free must be conducted away in any suitable manner. The products obtained can be removed when the piston is in its innermost position or better they may be utilised to increase the efficiency at the expansion stroke, as in such reactions a retardation of the reaction is hardly to be expected.

4th Group: Endothermic reactions with a reduction in the number of molecules.

These reactions must be carried out during the compression stroke.

The substances must be compressed to the necessary temperature and pressure condition, then the action must be started whilst still in the compression stroke. A reduction in temperature in these reactions is not permissible. If the heat produced by the compression should not be sufficiently evident the substances must be heated by other means. The products obtained can be removed when the piston is in its innermost position or when a retardation of the reaction is not to be feared it can be used for obtaining work during the expansion stroke.

5th Group: Endothermic reactions with a constant number of molecules.

These reactions must be carried out during the compression stroke similar to the reactions of Group 4 and a reduction in temperature must not take place during the operation.

6th Group: Endothermic reactions with an increase in the number of molecules.

These reactions must be carried out during the expansion stroke. The heat which is necessary to meet the consumption of heat of the reaction and the heat converted into work must be supplied to the substances in any manner during the course of the reaction. A reduction in temperature must not take place in these reactions.

The substances introduced in the necessary quantity are compressed during the compression stroke to the most favourable pressure and temperature condition for the course of the reaction. Shortly before the turning point of the piston the reaction is started. Such a quantity of heat is then added to the substances in any suitable manner during the reaction so that the conditions as regards temperature and pressure condition are maintained. After the reaction has ended the gases expand doing work so as to be subsequently removed from the compressor in the usual manner.

In order to prevent any injurious variation in temperature and pressure in all the above described processes these can to a certain extent be provided against, as already above described, by introducing one of the reacting substances gradually into the cylinder so that the course of the reaction is spread over a larger or shorter stroke of the piston.

As has been described above, it will be necessary when carrying out some of the above process, to add or remove heat from the reacting substances in the cylinder. For this purpose many known means may be employed such for example as the introduction into the cylinder of heating or cooling liquids and vapours, heating by electric flaming arcs, heating and cooling by means of a liquid circulating through the jacket of the compressor and so forth. The following means, however, may also be employed:—

1. Spiral tubes can be mounted in the end compression space in which cooling or heating liquids circulate.

2. The end compression space may be provided with surfaces which are directly heated or cooled from the exterior.

3. Electrical heating bodies may be provided in the end compression space.

The necessary catalysts for the chemical operation may be introduced into the end compression space. These catalysts may be heated for example by electrical heating bodies or cooled by means of tubes placed close thereto so that they may be brought to the necessary temperature for their operation.

The processes here described in general are to be applied to the most important technological reactions such as syntheses, condensations (or polymerizations), cracking, hydrogenations, saponifications, oxidations, and double decompositions. Of all these reactions the most important are described below.

I. Production of Ammonia synthetically.

The piston sucks in a mixture of nitrogen and hydrogen in the stochiometrical proportions and compresses it up to about the middle of the compression stroke, when the pressure will be about 50 atmos. and the temperature about 500° C., this result being attained by starting the operation with a suitable initial temperature and pressure. From now onwards the pressure must not decrease, but simultaneously the temperature must not increase. The control of temperature is effected by introducing into the cylinder, during the reaction, a stream of a cooled mixture of hydrogen and nitrogen which is in the form of a highly compressed gas or liquid. Any other gas, or even water, could be used for the purpose. The stream of cooled gas or liquid must be introduced into the cylinder gradually at a high pressure, so as to expand inside the cylinder and strongly cool the gases therein. At the end of the compression stroke, the product of the reaction is discharged from the cylinder. The catalysts used are placed into the compression space.

III. Cracking.

The most important technological cracking reactions are the cracking of mineral oils and coal tar. In cracking reactions, the number of molecules increases. Some reactions are exothermic and others are endothermic. The first belong to Group 1, the second to Group 4. They all can be carried out during the expansion stroke.

The compressor sucks in a gas or vapour, as for example, overheated water vapour, of 12 atmos. pressure and 320° C. and compresses it to an end pressure of 50 atmos.; the end temperature will then be 550° C. The material to be cracked is introduced into the cylinder in a finely divided state by a high over-pressure (10—15 atmos.) at the commencement of the expansion stroke. In consequence of the high temperature, the oil is easily cracked. Thanks to the expansion, the pressure will not rise. If the process is exothermic, the expansion will, generally, be sufficient so as to prevent a rise of temperature. If the process is endothermic, the mixture must be heated by external means, for example, by means of glowing surfaces, heated from the exterior. When the expansion is finished, the mixture is pushed out and subjected to fractional cooling.

Hydrogenations.

These reactions are exothermic with a reduction in the number of molecules. They belong to Group 3, and must therefore be carried out during the compression stroke, whilst cooling. The most important, technologically, of these reactions is the hydrogenation of unsaturated into saturated fatty acids. The operation is as follows:

The piston sucks in hydrogen and compresses it to the necessary degree of pressure and temperature for each oil, for instance, 12 atmos. and 180° C. During the compression, the unsaturated fatty acid is introduced into the cylinder of the compressor in a finely divided form under excess pressure of hydrogen and the mixture is further compressed in order that the pressure does not fall. In order to prevent the temperature from rising, the gas introduced (hydrogen) is of such high excess pressure that by expanding a rise of temperature is prevented. The catalyst, if needed, can be mixed with the oil in a finely divided state, or it may be retained in the end compression space. The temperature at which the operation is carried out is preferably such that the fatty acid remains in a liquid state.

I do not claim in this specification such chemical processes as result from the thorough or substantially complete combustion of hydrocarbon and like fuels in a Diesel or other internal combustion engine, whether or not such processes are accompanied by the production of nitric oxide.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A process for carrying out chemical reactions in the interior of compressors, characterised by the fact that the substances received are first brought to a suitable pressure and temperature condition for the reaction by compression or expansion or by the employment of other means, and the reaction then carried out whilst maintaining the pressure and temperature as constant as possible, subject to the limitation mentioned in the preceding disclaimer.

2. A process for carrying out chemical reactions in the interior of compressors, characterised by the fact that the substances received are first brought to a suitable pressure and temperature condition for the reaction by compression or expansion or by the employment of other means and the reaction carried out in such a manner that in the case of exothermic reactions the temperature will not increase nor fall in endothermic reactions and that the pressure does not increase in reactions with an increase in the number of molecules and that the pressure does not fall in the case of reactions with a reduction in the number of molecules, subject to the limitation mentioned in the preceding disclaimer.

3. A process according to Claim 2, characterised by the fact, that for fulfilling the conditions specified therein for the purpose of carrying out chemical reactions sufficient quantities of heat or cold, pressure or vacuum are stored in the substances before they enter into reaction.

4. A process according to Claims 1 and 2, characterised by the fact that for obtaining the course of the reaction specified therein one or more of the reacting substances are added only gradually during a larger or smaller portion of the piston stroke to the other reacting substances.

5. A process according to Claims 1 and 2, characterised by the fact, that if the required course of the reaction cannot be obtained by the compression or expansion of the reacting substances and the gradual introduction of additional substances heating and cooling by other means must be employed.

6. A method of carrying out chemical reactions in the interior of compressors according to Claims 1 and 2, characterised by the fact that the addition or withdrawal of heat is effected directly by exteriorly heated or cooled surfaces of the end compression space.

7. A process for the production of ammonia from the gases in the interior of a compressor, according to Claims 1 and 2, characterised by the fact that the reaction is carried out during the compression stroke, substantially as described.

8. A process for carrying out cracking reactions in the interior of the compressor according to Claims 1 and 2, characterised by the fact that they are carried out during the expansion stroke, substantially as described.

9. A process for carrying out endothermic cracking reactions in the interior of compressors according to Claims 1 and 2, characterised by the fact that they are carried out during the expansion stroke with the addition of heat.

10. A process for carrying out hydrogenation reactions in the interior of compressors according to Claims 1 and 2, characterised by the fact that hydrogen is compressed alone and that when the necessary temperature and pressure con-

dition is reached the substance to be hydrogenated is added in a finely divided condition during the compression stroke.

11. A process for the hydrogenation of unsaturated fatty acids to saturated fatty acids in the interior of compressors according to Claims 1 and 2, characterised by the fact that the vapours produced are exposed to the action of catalysts in the end compression space.

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