PATENT SPECIFICATION

Convention Date (Germany): Jan. 24, 1936.

474,191

Application Date (in United Kingdom): Jan. 22, 1937. No. 1938/37.

Complete Specification Accepted: Oct. 27, 1937.

1211

COMPLETE SPECIFICATION

Improvements in the Cooling of Gases

We, I. G. FARBENINDUSTRIE AKTIENGESELLSCHAFT, of Frankfort-on-Main, Germany, a Joint Stock Company organized under the Laws of Germany, 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:—

A method frequently used for cooling hot gases or vapours consists in causing atomised water or other liquid to evaporate in the gases. This method of working succeeds with comparative ease if the cooling temperature to be attained lies considerably above the boiling point of the evaporating agent. Difficulties arise, however, when the gases have to be cooled down to a temperature which is near the boiling temperature of the injected cooling agent, for example when hot gases are, by means of injected water, to be brought to a temperature of 150° Centigrade. Even if the water be most finely atomised by means of appropriate nozzles and large evaporation spaces be provided, it is no longer possible to evaporate the water completely when approaching the said low temperature. In these cases it is necessary to employ a large excess of water and to collect and remove the non-vaporised portion. The difficulties attending the said cooling method are such as to exclude the use of the simple injection method for the cooling of gases in many cases, and it is therefore necessary to use complicated indirect processes. For example, if the gases to be cooled contain constituents which are liable, in the presence of liquid water, to attack the constructional materials of the apparatus, such as is the case for example with gases obtained by roasting pyrites, care must be taken that no liquid water separates at any place of the apparatus because otherwise the constructional materials would be destroyed. The injection water, if it is introduced between two superimposed contact layers, must also be completely evaporated, because otherwise it would infringe on the lowermost layer and damage the same. The separation of liquid water must finally be avoided in all cases where at the desired cooling temperature there are to be recovered from the gases products which would solidify at still lower temperatures, as for example at 100° Centigrade, and then clog the separator.

We have now found that the liquids used for cooling gases or vapours or mixtures thereof by the injection method can be rapidly and completely vaporised if the liquids (preferably water), the chemical nature of which should be in all cases different from the chemical nature of the medium to be cooled, have a boiling temperature under the prevailing gas pressures which is below the gas temperature to be obtained by the cooling, and are released from pressure, while in a finely distributed state, into the medium to be cooled at a temperature equal to or above their boiling temperature at the pressure of the gases to be cooled but below the temperature of these gases.

Since, for the atomisation of the injection liquid, it is usually forced through narrow nozzles, it must be subjected to increased pressure, and therefore it is possible to heat the liquid, as for example water, to temperatures above the boiling point corresponding to the pressure of the gas. Where injection nozzles are used, the water supply conduit of which is under no increased pressure or under only too small an increased pressure, the necessary pressure must be produced by the provision, directly in front of the nozzles of a throttle valve.

The water may be heated in any appropriate manner, i.e., either indirectly by means of steam or flue gases or directly by leading steam into the water contained in a suitable mixing device. If the injection is to be performed within reach of a boiler, the superheated pressure water required is generally available in the form of the feed water of the boiler or the boiler water itself. When special heating devices are used, these are preferably arranged close to the place where the injection is performed, to avoid as far as possible any loss in temperature after superheating.

When cooling gases or vapours under

[*Price* 1/-]

ordinary pressure it is sufficient for the water to be vaporised supplied to the injection nozzles to have a temperature above 100°, preferably at least 105° to 130° Centigrade. Whereas higher temperatures merely require somewhat larger amounts of water to be vaporised, the lowering of the temperature to below the boiling temperature of the injection water immediately effects such a retardation of the speed of evaporation that it is no longer possible to cool the gases to low temperatures, more particularly below 200° Centigrade.

If the gases to be cooled are under pressure, higher temperatures of the water must be maintained corresponding to the pressure of the gas. On the other hand, however, when cooling gases under a pressure lower than atmospheric pressure water temperatures of less than 100° Centigrade may be used. In each case the temperature of the liquid under pressure should be some degrees Centigrade above the boiling point at the prevailing gas pressure; preferably this difference should at least be about 5° Centigrade.

The present invention is not restricted to the use of water, but it is capable of use quite generally in the case of any liquids which are vaporised into gases or vapours for the purpose of cooling gases and do not exert any other undesired influence on these gases.

In carrying out the process according to this invention it is advantageous to assist the vaporisation for example by using atomising nozzles producing the finest possible degree of atomisation, arranging a plurality of nozzles, atomising towards various directions within the vaporiser or other well known means.

The process may be used with advantage in any case where gases and vapours are to be cooled rapidly and within a narrow space down to low temperatures without any separation of the injected liquids. It is eminently suitable for use in exothermic catalytic reactions, in which the main part of the gases or vapours involved is converted by means of a first contact layer, whereas the final conversion is effected by means of a second contact layer and in which the gases or vapours are cooled between the said two stages. Processes of the said kind are used for example for producing hydrogen and carbon monoxide from hydrocarbons and steam or for oxidising sulphur dioxide to sulphur trioxide, in the synthesis of ammonia from nitrogen and hydrogen, liquefied ammonia being preferably injected in this case between the contact layers for cooling the gas, or in the synthesis of hydrocarbons from carbon monoxide and hydrogen, superheated hydrocarbons being preferably injected in this latter case between two or more contact layers. The process is also valuable when products formed are to be prevented from decomposing by cooling them rapidly, as for example in the production of oxides of nitrogen by combustion of ammonia in the production of unsaturated hydrocarbons by thermal decomposition and other cases. The process is also of special importance because it offers the possibility of cooling such gases by the injection of water as contain substances which are aggressive in the presence of water and in the case of which the formation of liquid water must therefore be carefully avoided as for example gases obtained by roasting pyrites.

The speed of evaporation of the water in the said method of working is so high that the process is even applicable to the cooling of gas mixtures which, as is the case for example with the sulphur-containing gases obtained by the well known Claus process, consist of substances, in the latter case of sulphur, which would immediately solidify if cold water were injected. The process according to this invention is therefore of great advantage for use in the production of sulphur by the Claus process which gives rise to gases of relatively high temperatures between about 200° and 500° Centigrade containing substantial amounts of elemental sulphur.

The present invention, however, is not confined to cooling down to low temperatures alone. It may be employed with the same result in order to obtain any desired gas temperature. In all cases the superheating accelerates the vaporisation to such an extent that the dimensions of the vaporisers may be greatly reduced and considerable saving in apparatus may be realised.

The following Example will further illustrate how the said invention may be carried out in practice but the invention is not restricted to this Example.

EXAMPLE

10000 cubic metres per hour of Claus furnace contact gases having a temperature of 400° Centigrade and containing 110 grams of sulphur per cubic metre (measured at 400° Centigrade) are to be cooled down to 150° Centigrade for the purpose of converting the gaseous sulphur into the liquid phase in order to separate it. The said gases are led downwards through a cylindrical vaporiser having a diameter of 3 metres and a height of 4 metres. At the top of the vaporiser three water supply pipes are introduced radially and in a symmetrical arrangement. Each of the said pipes extends nearly to the centre of the vaporiser and has screwed thereto at equal intervals six atomiser nozzles with a spraying aperture of a width of 0.9 millimetre, the said nozzles being so arranged in a downward direction that their central lines deviate from the vertical direction by an angle of 30° either to the right or to the left. Before their arrangement all of the nozzles are carefully adjusted so as to ensure the finest possible atomisation of the water. Through the said nozzles 900 litres of water are injected per hour into the vaporiser at a temperature of about 125° Centigrade.

The injected water is completely vaporised in the vaporising space. The gases leaving the vaporiser at the bottom above the vaporiser sump are cooled down to 150° Centigrade, the whole of the sulphur which was previously in the gaseous state being condensed into the liquid phase. One third of the sulphur precipitates as a liquid in the vaporiser sump and is continuously withdrawn therefrom by means of a heated overflow pipe; the bulk of the sulphur is practically completely separated on an electro-filter arranged behind the cooler.

If the injection water be atomised at a temperature of 90° instead of 125° Centigrade the other conditions remaining unchanged, the gases leaving the vaporiser still have a temperature of 250° Centigrade, so that a considerable part of the sulphur remains in the gaseous phase and cannot be completely recovered by means of the electro-filter. Moreover, the water which has not been vaporised collects in the vaporiser sump and there causes the sulphur to solidify which in turn leads to incrustations and stoppages, so that neither the complete recovery of the sulphur nor a regular operation is possible.

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

1. A process for cooling hot gases, vapours or mixtures thereof, by injecting and evaporating therein a liquid the chemical nature of which is different from the chemical nature of the medium to be cooled, which comprises injecting the said liquid, preferably water, in a finely distributed state and at a temperature which is (a) equal to or above its boiling temperature under the pressure of the gaseous medium to be cooled and (b) below the temperature of the said gaseous medium and thus completely evaporating the said liquid.

2. A process for cooling hot gaseous mixtures at atmospheric pressure obtained by the well known Claus process having a temperature between about 200° and 500° Centigrade and containing substantial amounts of elementary sulphur by injecting and evaporating water therein which comprises injecting the said water in a finely distributed state and at a temperature of about 125° Centigrade and thus completely evaporating the said water.

3. The process for cooling hot gases, vapours or mixtures thereof substantially as described in the first two paragraphs of the hereindescribed Example.

Dated this 22nd day of January, 1937.

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Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

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