Coal Gasification

Coal gasification is the method of transforming coal and water into syngas, which is a mixture of carbon monoxide (CO), hydrogen (H2), carbon dioxide (CO2), methane (CH4), as well as water vapour (H2O). Coal gas, commonly known as "town gas", was once produced by gasifying coal. Before the introduction of large-scale extraction and processing of natural gas from oil wells, coal gas was utilised for warming and municipality lighting. Large-scale coal gasification plants are currently used largely for electricity generation (both in traditional thermal power plants and molten carbonate fuel cell power plants) or chemical feedstock manufacturing. The hydrogen produced by coal gasification could be used to make ammonia, drive a hydrogen economy, or upgrade fossil fuels, among other things. Furthermore, supplementary treatment helps turn coal - derived syngas into automotive fuels such as gasoline and diesel, or even into methanol, which could be used as a fuel for transportation or fuel supplement, or turned into gasoline. Natural gas produced by coal gasification could be cooled till it liquefies, allowing it to be used as a transportation fuel.
The topic has a very high chance of being asked as a UPSC Prelims Environment and Ecology Question under Human Geography topic or as a Current Affairs Question, as it has been in the news recently.

History of Coal Gasification

Each medium and small town or city in the 1850s used to have a gas plant for street illumination. Customers that subscribe to the service may also have piped lines installed in their homes. Gas lighting had become popular by this time. Gaslight made its way into the middle class, followed by gas ovens and stoves. Coal gas development was at its peak in the 1860s. Scientists such as Kekulé and Perkin deciphered organic chemistry's mysteries to show how gas is created and its constituents. Better gas plants as well as Perkin's purple dyes, such as Mauveine, resulted from this. Processes for producing Producer gas and Water gas from coke were discovered in the 1850s. Blue water gas is a term used to describe unenriched water gas (BWG).

Ludwig Mond invented Mond gas in the 1850s, which was a producer gas created from coal rather than coke. It was treated to obtain useful components such as ammonia and coal tar. The non-luminous flame of blue water gas (BWG) makes it impractical for lighting applications. BWG is enriched with gases acquired by spraying oil into a scorching retort. Carburetted Water Gas (CWG), created in the 1860s, is BWG supplemented by gases generated by pouring oil into a hot retort. This has a higher calorific value and produces a bright flame when burned. Thaddeus S. C. Lowe improved the carburetted water gas technique in 1875. The gas oil was thermocracked into the BWG inside the CWG generator set's carburettor as well as superheater. From the 1880s through the 1950s, coal gasification was the dominating technique in the countries such as the United States.

Coal Gasification Process

During gasification, oxygen and steam (water vapour) are blown through the coal while it is still being heated (and in a few cases pressurised as well). "Allothermal" refers to a procedure in which the coal is heated by external heat sources, whereas "autothermal" refers to a process in which the coal is heated by exothermic chemical reactions that occur within the gasifier itself. It is critical that the amount of

oxidizer provided is inadequate to completely oxidise (combust) the fuel. The coal is oxidised by oxygen and water molecules, resulting in a mixture of gases of carbon dioxide (CO_2), carbon monoxide (CO), water vapour (H_2O), as well as molecular hydrogen (H_2) during the reactions indicated. Based on the gasification process used, some by-products such as tar, phenols, and other chemicals may also be viable end products.

Underground Coal Gasification

Underground coal gasification (UCG) is just an industrialised gasification process that takes place in coal seams that haven't been mined. It entails injecting a gaseous oxidising agent, often oxygen or air, and transporting the resultant product gas to the surface via production gas wells drilled from the surface. The gas produced could be utilised as a chemical feedstock or as a source of energy. The method can be used to extract resources that would otherwise be too expensive to extract. It also provides a viable alternative to traditional coal mining techniques. UCG has a lower environmental and social impact than conventional coal mining with gasification, yet environmental issues exist, including the possibility for aquifer pollution.

Carbon Capture Technology

To solve the greenhouse gas emissions risk connected with the usage of coal as well as carbonaceous fuels, carbon capture, utilisation, and sequestration (storage) is progressively being used in advanced coal gasification plants. In this regard, gasification has a substantial advantage over traditional coal combustion, wherein the CO_2 produced by combustion is significantly diluted by nitrogen as well as leftover oxygen inside the near-ambient pressure combustion exhaust, making Carbon capture tough, energy-intensive, as well as expensive (this process is popularly known as "post-combustion" CO_2 capture).
During gasification, on the other side, the gasifiers are usually supplied with oxygen, and only enough fuel is burned up to give the heat needed to gasify the rest; additionally, gasification is frequently carried out at high pressure. The resultant syngas is often higher in pressure and nitrogen-free, making Carbon dioxide elimination much simpler, more efficient, and less expensive. One of the major advantages of gasification as well as integrated gasification combined cycles over traditional coal usage systems is their capacity to efficiently separate Carbon dioxide from syngas before its combustion in a gas turbine (known as "pre-combustion" CO_2 capture) or use in fuels or chemical syntheses.

Coal Gasification By-products

Coke, coal tar, sulphur, and ammonia all are by-products of syngas production, and they're all beneficial items. Coal gas is used to make dyes, medications (including sulfa drugs), saccharin, and a variety of chemical compounds. Coke is a smokeless fuel that is also used to make water gas as well as producer gas. Fractional distillation is used to extract several compounds from coal tar, including

- For road surfacing, **tar** is used
- **Benzole**, is an automotive fuel
- **Creosote**, is a wood preservative
- **Phenol**, used in the manufacturing of polymers
- **Cresols**, disinfectants

Sulphur is utilised in the production of sulfuric acid, and ammonia is often used in fertiliser production.

Environmental Impact

The following contaminants have been linked to former manufactured gas plants:

- BTEX
  - Diffusely emitted from coal/gas tar deposits
  - Carburetting oil/light oil leaks
  - Drip pots that gathered condensable hydrocarbons from the gas had leaks.
- Sludge/waste from coal tar
  - Gas holders' sumps and decanting ponds are common places to find it.
  - Because coal tar sludge has little resale value, it has always been discarded.
- Organic substances that are volatile
- Polycyclic aromatic hydrocarbons (PAHs) are a type of polycyclic aromatic (PAHs)
  - At considerable concentrations, it can be found in coal tar, gas tar, and pitch.
- Heavy metal is a genre of music that is characterised by
  - Lead solder, lead piping, and coal ashes are all used in the construction of gas mains.
- Cyanide
  - Large levels of complicated ferrocyanides can be found in purifier waste.
- Lampblack
  - Only where crude oil was employed as a gasification fuel was it discovered.
- Emulsions of tar

Coal tar as well as coal tar slurries are often denser than that of water and exist as a dense non-aqueous phase liquid in the environment.

Modern coal gasification has the following negative influence on the environment:

- Ash and slag
  Non-slagging gasifiers generate dry ash comparable to that released by normal coal combustion, which might be an ecological disaster if the ash (which often contains heavy metals) is leachable or caustic and must be kept in ash ponds.
- Carbon Dioxide (CO_2)
- Mercury
- Arsenic
- Particulate Matter (PM)
  Gasification produces ash, which is made up of inorganic contaminants in the coal. Some of these contaminants react to make tiny particulates that can be suspended in gasifier syngas.
- Sulphur Dioxide (SO_2)
  Because of the high temperatures as well as low oxygen levels in the gasifiers, coal usually contains some sulphur, which transforms to H2S and COS. Acid gas elimination equipment is used to remove such "acid gases" out from syngas produced by the gasifiers before it is burnt inside the gas turbine to generate power or used in fuel synthesis.
- Nitrogen oxides (NO_x)
  Nitric oxide (NO) as well as nitrogen dioxide (NO2) are referred to as (NOx). Coal typically includes some nitrogen, the majority of which decomposes into harmless nitrogen gas. As during syngas cooling procedure, small amounts of ammonia as well as hydrogen cyanide are created, which must be eliminated. NOx can also be produced downstream in power plants by the burning of syngas in turbines.

Latest News

- The Indian government sets a target to achieve production of 100 metric tons of coal gas by the year 2030.
- The Union government of India allowed 50% of concession in revenue share to encourage coal gasification.