AIR POLLUTION AND CONTROL (10CV765)

SOLUTION

1.a. Source categories include:

1.Energy

a.Fuel combustion

Stationary combustion

Industrial combustion

Residential heating

Mobile combustion (transport)

b.Fugitive emissions from (fossil) fuel use

2.Industrial Processes

3.Solvent and other product use

4.Agriculture

5.LULUCF (Land Use, Land Use Change and Forestry)

6.Waste

1. b.PHOTO-CHEMICAL SMOG : Photochemical Smog was first observed in Los Angeles, USA in the Mid1940's and since then the phenomenon has been detected in most major metropolitan cities of the world. The conditions for the formation of Photo chemical Smog are air stagnation, abundant sunlight and high concentration of hydrocarbons and NOx in the atmosphere. It occurs under adverse Meteorological conditions when the air movement is restricted in highly motorized areas and is caused by the interaction of some hydro carbons and oxidants under the influence of sunlight giving rise to dangerous PEROXYACETYL NITRATE [PAN]. Its main constituents are Nox, PANS, hydrocarbons, CO and Ozone. It reduces visibility, causes eye irritation, damage to vegetation and cracking of rubber.

Smog arises from photochemical reactions in the lower atmosphere by the interaction of hydrocarbons and NOx released by the exhaust of automobiles and some stationary sources. This interaction results in a series of complex reactions producing secondary pollutants such as ozone, aldehydes, ketones and peroxyacetyl Nitrate [PAN].

2.a. **EFFECTS ON MATERIALS**

MECHANISM OF DETERIORATION

Air pollution cause damage to materials by 5 mechanisms

1. **ABRASION:** Solid particles of sufficient size and travelling at high velocities can cause abrasive action.

2. **DEPOSITION AND REMOVAL:** Solid and liquid particles deposited on a surface may not damage the material itself but it may spoil its appearance
3. **DIRECT CHEMICAL ATTACK:** Some air pollutants react directly and irreversibly with materials to cause deterioration.
   Eg: The bleaching of marble by SO_2, tarnishing of silver by H_2S, etching of metallic surface by an acid mist
4. **INDIRECT CHEMICAL ATTACK:** Certain materials absorb some pollutants and get damaged when the pollutants undergo chemical changes.
5. **CORROSION:** The atmospheric deterioration of metals is by an electrochemical process i.e. corrosion. This is due to the action of air pollutants facilitated by the presence of moisture

FACTORS INFLUENCING ATMOSPHERIC DETERIORATION:

1. **MOISTURE:** The presence of moisture in the atmosphere greatly helps the process of corrosion. In case of SO_2 and various particulars, the rate of corrosion of metals will increase as relative humidity in the air increases.
2. **TEMPERATURE:** Affects the rate of chemical reaction and consequently affects the rate of deterioration.
3. **SUNLIGHT:** In addition to producing damaging agents such as ozone, PAN through a series of complex photo chemical reactions, sunlight can cause direct deterioration of certain materials.
4. **AIR MOVEMENT:** Wind direction is an important factor to be considered in places where deterioration is caused by pollutants released from nearby factories. Similarly wind speed is also an important factor in determining the impact of air pollutants on the receiving surfaces.

AIR POLLUTION DAMAGE TO VARIOUS MATERIALS

MATERIALS	PRINCIPAL AIR POLLUTANTS	EFFECTS
1. Metal	SO_2 Acid Gases	Corrosion, loss of metal, spoilage of surface, tarnishing
2. Building Materials	SO_2, Acid gases, particulates	Discoloration, leaching
3. Paint	SO_2, H_2S, Particulates	Discoloration
4. Textiles and Textile dyes	SO_2, Acid gases, NO_2, ozone	Deterioration reduced textile strength and fading
5. Rubber	Oxidants, ozone	Cracking, weakening
6. Leather	SO_2, acid gases	Disintegration, powdered surface

7. Paper	SO_2, acid gases	Embrittlement
8. Ceramics	Acid gases	Change in surface appearance

2.b. **BHOPAL GAS TRAGEDY**

Modern Technological developments have multiplied the hazards to which human beings are exposed, Nearly 5 million chemicals have been synthesized in the world during the last 40 years and some 50,000 to 70,000 chemicals are used extensively in millions of different commercial products without the availability of proper information on the majority of the chemicals.

On the fateful night on 2-12-1984, and in the early hours of 3-12-1984 more than 1 million residents of Bhopal, Capital of M.P India reported irritation of eyes that quickly became unbearable, followed by the death dancing in their residences. A cloud of poisonous gas was released from the Union Carbide Factory. The plant was a pesticide manufacturing unit owned by Union Carbide India Ltd, a subsidiary of Union Carbide, a leading company based in the USA. The factory was licensed to produce Methyl Isocyanite (MIC) i.e CH_3NCO, an extremely hazardous chemical which is used in the manufacture of several pesticides. The carbide plant has three storage tanks for MIC, each capable of holding 45 tonnes. The Union Carbide manual on standard operating procedure warns that if water leaks into the system, it results in the evolution of a lot of gas and liberation of heat. This is precisely what had happened on the fateful day of 2nd December1984

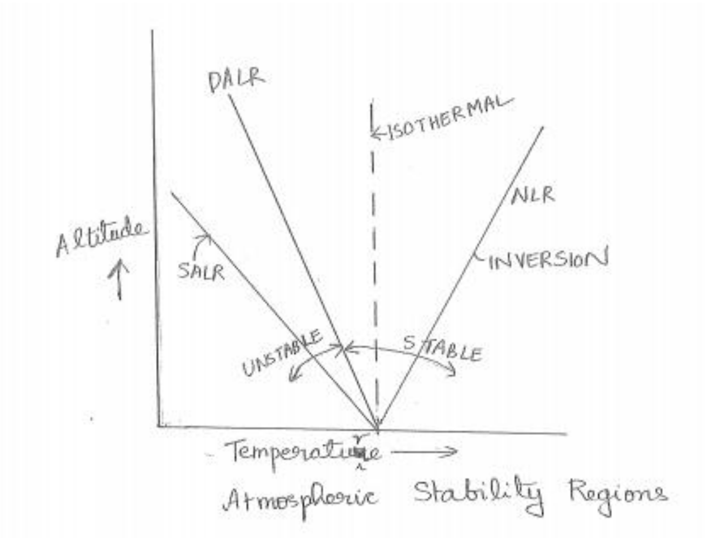
3.a. Topographical features

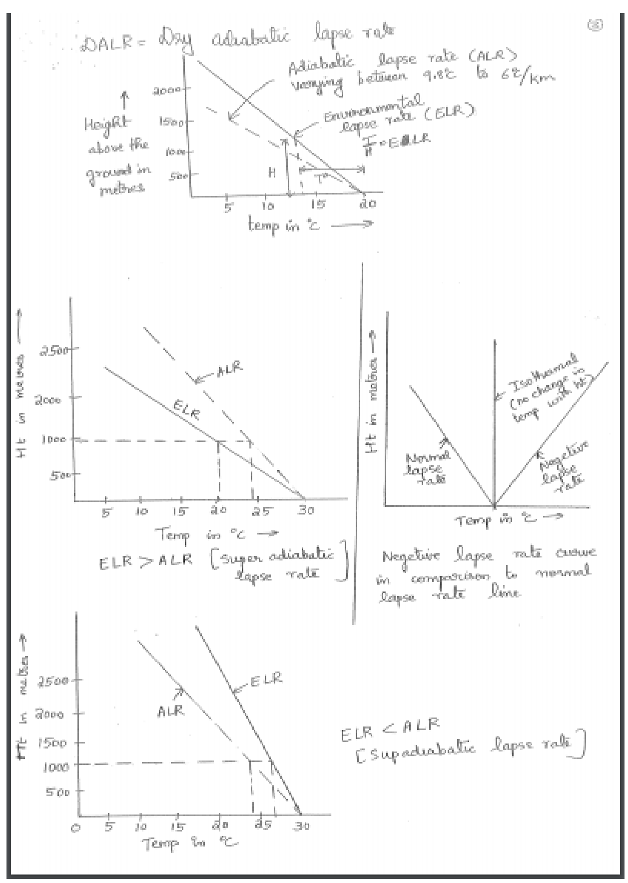
Air movement is greatly influenced by the topography in the neighbourhood of the site under consideration, like valleys, mountains, sea, oceans. In fact more attention has to be given for air pollution control in valleys than in level terrain. Especially when the average wind velocity is less than 16km/hr.

The location of industries in valleys, mountainous areas and undulating terrain present difficult problem from the point of air pollution control. Air pollution disasters in Meuse valley (Belgium) and at Donora, Pennsylvania are good examples. If an industrial plant is located at the bottom of a narrow valley with mountains rising fairly steeply on either side the situation become very critical probably one of the worst site conditions one can think off.

3.b. When ALR exceeds DALR, the ALR is said to be SUPER – ADIABTIC and the atmosphere is highly unstable. When the two lapse rate are exactly equal, the atmosphere is said to be neutral. When the ALR is less than the DALR, the ALR is termed SUB-ADIABATIC and the atmosphere is stable. If air temperature is constant throughout a layer of atmospheric, ALR=O, the atmospheric layer is described as isothermal and the atmosphere is stable.

When temperature of the ambient air increases rather than decrease with attitude, the lapse rate is negative or inverted from the normal state. Negative lapse rate occurs under conditions, commonly referred to as an INVERSION, a state in which warmer air blankets colder air.





3.c.

$$C(x,y,z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \times$$

$$\left[\exp-\left(\frac{y^2}{2\sigma_y^2}\right)\right]\left\{\exp\left(\frac{-(z-H)^2}{2\sigma_z^2}\right) + \exp\left(\frac{-(z+H)^2}{2\sigma_z^2}\right)\right\}$$

C = Concentration of the chemical in air. $[M/L^3]$
Q = Rate of chemical emission. [M/T]
u = Wind speed in x direction. [L/T]
σ_y = Standard deviation in y direction. [L]
σ_z = Standard deviation in z direction. [L]
y = Distance along a horizontal axis perpendicular to the wind. [L]
z = Distance along a vertical axis. [L]
H = Effective stack height. [L]

4.a.FACTORS TO BE CONSIDERED FOR INDUSTRIAL PLANT LOCATION

While selecting a site from the point of air pollution and control, the following factors should be taken into consideration to avoid costly control measures, improve public relations and prevent litigation, there are 6 factors to be considered.

i) Existing levels of air contaminants
ii) Potential effects on the surrounding area.
iii) Meteorological factors and climate
iv) Topographical features
v) Clean air available
vi) Planning and zoning

Existing levels of air contaminants

If the new plant is to be located in an area which is already industrialised, it is a good practice to undertake a pre operational survey to know the existing levels of contaminants under prevailing meteorological conditions. This type of survey gives an idea regarding the nature of pollution due to existing industries i.e whether the existing level of pollution is high, medium or low. The results of such a survey with respect to known operational data on the magnitude of emissions from the new sources, would provide information on the extent to which waste products could be safely discharged into the atmosphere without resulting in too much contamination.

Potential effects on the surrounding

Another important factor from the point of site selection is to have a knowledge of the specific effects of the major pollutants likely to be discharged into the atmosphere in relation to the population and land use of the area surrounding the site. For example, whether the pollutants will have any effect on the health of people, whether it causes damage to vegetation, whether it effects the farm animals in that area is to be considered. A rural and predominantly agricultural area is more affected by fluorides and SO_2 than in urban population. This is because certain pollutants are more toxic and harmful to vegetation and animals than to people. H_2S has little effect on vegetation but is obnoxious and even dangerous to human life in comparatively low concentration.

Meteorogical factors and climate

The prime factors which have to be considered in order to minimise air pollution problems are the climate and meteorology of the location under consideration. It is important to know the prevailing wind direction, wind speed and factors favourble for stable atmosphere is inversion conditions. The dispersive ability of the air at each possible site has to be determined. This can be done on the basis of the average values for wind movement and inversion conditions. Wind roses for each possible site have to be constructed and studied. Metrological factors should be favourable for the air to dilute the pollutional load down to acceptable levels of contamination.

Topographical features

Air movement is greatly influenced by the topography in the neighbourhood of the site under consideration, like valleys, mountains, sea, oceans. In fact more attention has to be given for air pollution control in valleys than in level terrain. Especially when the average wind velocity is less than 16km/hr.

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Clean air available

The requirement if many industrial processes for supplies of clean air produces another important aspect of air pollution into the problem of site selection. For example, Industries requiring clean air for manufacture are factories dealing with manufacture of anti biotic electronic components and life saving vaccines, also clean air is required for cooling the reactors of atomic energy plants since if polluted air were used, the impurities present would become radioactive above and their escape would create a hazard in those cases, location of industries in areas of heavy air pollution will add maternally to the cost of cleansing the air.

Planning and zoning

Proper planning and zoning of industrial areas and residential areas can play an important role in the control of Air pollution. Residential areas and heavy industries should not be located too close to each other. It is always better to have green belt between industrial areas and residential areas. If there are any municipal laws and regulations regarding this aspect, they should be strictly enforced.

Recently scientists have identified a dozen species of trees which have a capacity to absorb industrial pollutants from the air. Many of these trees grow in our county for example, tamarind and margosa trees.

4.b. A sound level meter is used for acoustic (sound that travels through air) measurements. It is commonly a hand-held instrument with a microphone. The diaphragm of the microphone responds to changes in air pressure caused by sound waves. That is why the instrument is sometimes referred to as a Sound Pressure Level (SPL) Meter. This movement of the diaphragm, i.e. the sound pressure deviation (pascal Pa), is converted into an electrical signal (volts V).

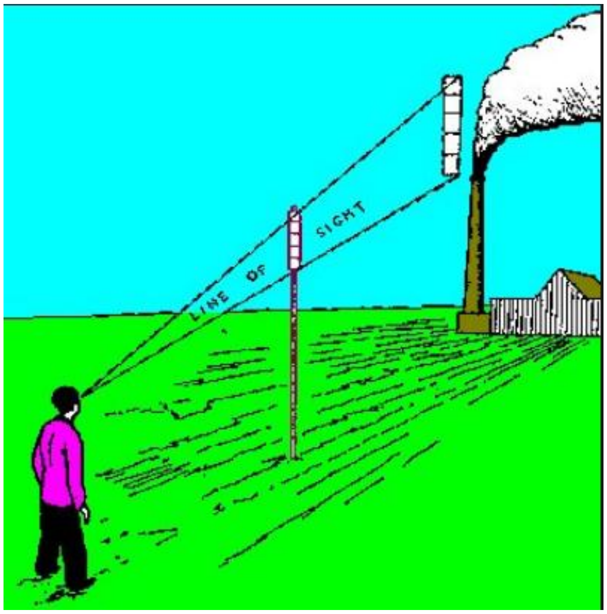
A microphone is distinguishable by the voltage value produced when a known, constant sound pressure is applied. This is known as the microphone sensitivity. The instrument needs to know the sensitivity of the particular microphone being used. Using this information, the instrument is able to accurately convert the electrical signal back to a sound pressure, and display the resulting sound pressure level (decibels dB SPL).

Sound level meters are commonly used in noise pollution studies for the quantification of different kinds of noise, especially for industrial, environmental and aircraft noise.

5. The Ringelmann scale is a scale for measuring the apparent density of Smoke. It was developed by Maximilien Ringelmann of La Station d'Essais de Machines in Paris in 1888. It has a 5 levels of density inferred from a grid of black lines on a white surface which, if viewed from a distance, merge into known shades of grey. There is no definitive chart, rather, Prof. Ringelmann provides a specification; where smoke level '0' is represented by white, levels '1' to '4' by 10mm square grids drawn with 1mm, 2.3mm, 3.7mm and 5.5 mm wide lines and level '5' by all black. A popular version is that published by the U.S. Bureau of Mines in circular 8333 of 1967. The British Standard version (BS2742:1969) alters Ringelmann's specification to give a chart similar, on modern paper with modern ink, to the probable appearance of charts produced on earlier, possibly darker, paper, with paler ink.

The data obtained has definite limitations. The apparent darkness of a smoke depends upon the concentration of the particulate matter in the effluent, the size of the particulate, the depth of the smoke column being viewed, and natural lighting conditions such as the direction of the sun relative to the observer while the accuracy of the chart itself depends on the whiteness of the paper and blackness of the ink used.

In use, the observer views the plume at the point of greatest opacity and determines the corresponding Ringelmann Number. A Ringlemann 0, 1, 2, 3, 4 and 5 are equivalent to an opacity of 0, 20, 40, 60, 80 and 100



Ringelmann 0	0% opacity – clear	
Ringelmann 1	20% opacity – barely visible	
Ringelmann 2	40% opacity – clearly visible	
Ringelmann 3	60% opacity – somewhat transparent	
Ringelmann 4	80% opacity – barely transparent	
Ringelmann 5	100% opacity – black	

Figure 2: The Ringelmann scale

6.a. COLLECTION OF PARTICULATE POLLUTANTS (SAMPLING METHODS)

Particulate pollutants are classified generally into dust that settles in air and dust that remains suspended. The particles of size greater than 1μm diameter, can be collected using sedimentation techniques while for the second category containing particles of smaller size more sophisticated techniques like filtration, impingement and electrostatic and thermal precipitation are used.

Sedimentation is one of the simplest techniques for the collection of particulate matter. This method is adopted in general for particles whose diameter exceed about 10μ.

FILTRATION:

Particulates having a diameter of less than 10μ tend to remain entertained in an air stream such particulates are referred to as suspended particulates.

IMPINGEMENT METHODS:

Separation of particulates from air stream by abrupt collision against a flat surface forms the basis of these methods

6.b. Some of the operating problems of filters are,

1) Cleaning
2) Rupture of cloth
3) Temperature
4) Bleeding
5) Humidity
6) Chemical attack

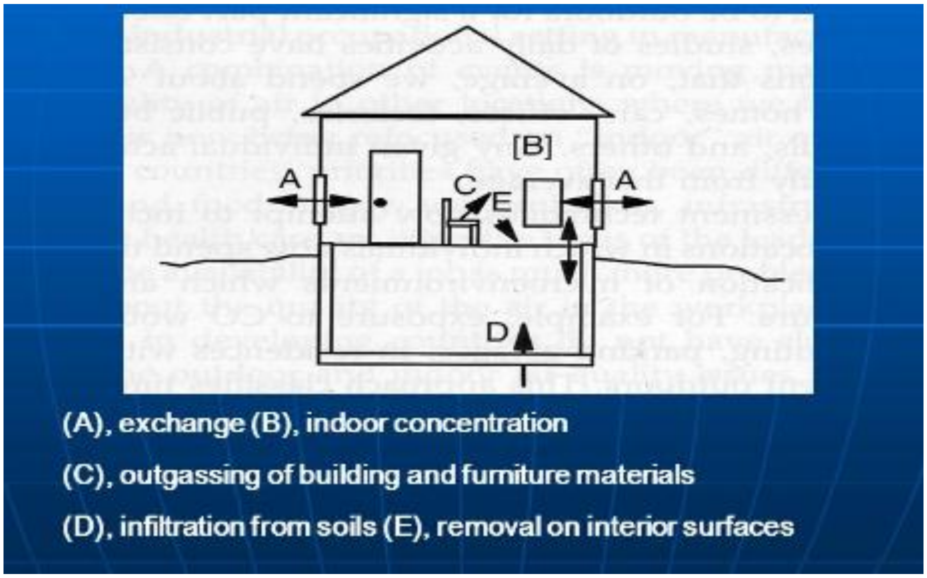
Factors Affecting Efficiency during pre-coat formation :

1) Excessive filter ratios
2) Improper selection of filter media

7.a. OZONE DEPLETION IN STRATOSPHERE:

The ozone layer serves as a shield, protecting the earth's surface from most of the ultra violet radiation found in the sun's radiation. However this layer may be depleted by reactions involving a variety of compounds, which reach the stratosphere, main compounds of concern are the water vapour and nitrogen oxides released by high altitude aircrafts, nitrous oxide produced by the action of bacteria in soils. Combined effect of aircraft engine effluents, nitrate fertilizers and halogens would cause considerable depletion of the ozone layer and could result in an increase in ultraviolent radiation reaching the earth leading to crop damage and skin cancer. The recent reports of the ozone hole in the atmosphere over the Antarctica is a cause for great concern.

7.b.



The inside environment of houses often has a higher level of air pollution than the surroundings in cities and towns. Unfortunately, indoor air pollution has not been given much importance, although most people spend as much as 80-90% of their time indoors. The various causes of indoor pollution are use of traditional fuel for cooking, tobacco smoke, temperature, humidity, micro organisms and allergies. The use of formaldehydes in construction materials and poor ventilation due to energy conservation measures in new homes and offices area also responsible for indoor pollution.

Due to burning of traditional fuels:

About 50% of the world's households are using traditional fuels such as fire wood, animal dung, coke etc for cooking. The common pollutants which cause indoor air pollution problems due to combustion of fuel are particulate matter, oxides of sulphur, oxides of nitrogen, carbon monoxide, hydrocarbons and organic and odour causing chemicals. The emission quantity of these pollutants depends upon the type of fuel used, type of stove or furnace used, feed rate amount of additional air and operating conditions.

Due to pollens:

Studies have revealed that pollens, frugal spores and various types of dusts pollute indoor air and cause allergic all gases especially asthma.

Due to artifical building materials and poor ventilation:

Indoor air pollution, especially in new energy efficient homes and offices is making many people around the world sick. The most serious problems so far have been reported in new and remodeled office buildings and homes with energy saving features, and in mobile homes. Most involves formaldehyde in construction materials, such as particle board and indoor plywood and in urea formaldehyde foam insulation.

Formaldehyde vapours leak into the air when the temperature rises and they combine with other contaminants into a mix that can cause headache, respiratory irritations, watery eyes, nausea, diarrhea, skin irritations and heart problems.

Remedy:

The following precautionary measures should be taken to overcome this special problem of indoor pollution.

ii) Cautionary labels should be attached to construction materials that contain formaldehyde resins.

iii) Municipal health authorities should be authorized to test air within homes when a physician suspects formaldehyde or other vapours might be damaging residents health.

iv) The air pollution control regulatory should have provision for compulsory testing of products at the point of manufacture to assure that they will not pollute indoor air.

v) Architects and construction engineers must make sure that air flow is not reduced to a danger point in the quest for energy efficiency.

8.a.

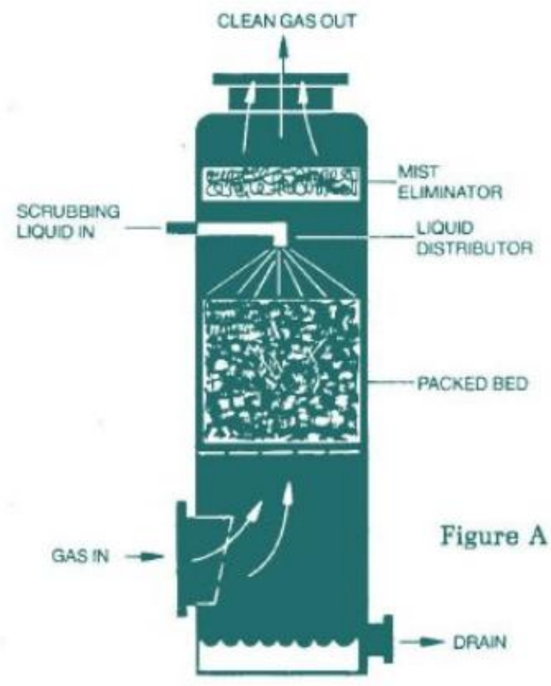


Figure A

In packed fixed bed scrubber fibre glass (fine glass filaments) or other packing (coke or broken stone) are used as the collection material. The polluted gas stream moves upward in a counter current flow and comes in contact with the scrubbing liquid stream which is moving downward over the packing in a film. The gas stream pass through the packing pore spaces and captures the particles by inertial impaction. Because of the good mass transfer characteristics of the packing, efficient collection of the fine particles by diffusion is also possible. Similar packing increases the efficiency of collection but its shape does not appear to affect the collection efficiency.

8.b. CONTROL OF EXHAUST EMISSIONS IN VEHICLES:

Two main approaches to minimize exhaust emissions are

1. Modifications in the engine design and operating variables.
2. Treatment of exhaust gases after emission from the engine.

1. The following modifications may help in cleaner exhaust.
    a. Use of cleaner idle mixtures.
    b. Use of cleanest possible mixture and maximum spark retard compatible with good power output and drivability
    c. Use of minimum valve over tap necessary.
    d. Pre treatment of the mixture to improve vaporization and mixing of fuel with air.
    e. Low quench combustion chambers
    f. Piston and ring variables
2. Exhaust treatment devices

    The basic techniques is to promote oxidation of HC and CO after emission from the engine. Exhaust oxidation devices fall into two categories

    a. Promotion of after burning of the pollutants by exhaust heat conservation and introduction of additional air and by providing sufficient volume to ensure adequate reaction time
    b. Use of catalytic converters. In after burners air from an engine driven blower is injected into the exhaust stream just after the exhaust valve. Sometimes an additional source of ignition is provided in the exhaust passage to initiate the after burning under certain engine conditions.

    Other methods

    1) Petrol injection
    2) Stratified charge engine

CONTROL OF EVAPORATIVE EMISSIONS:

Insulation of the fuel tank to reduce temperature, sealed and pressurized fuel systems, and vapour collection systems have all been explored to reduce tank emissions.

CONTROL OF CRANK CASE EMISSIONS:

Designers are shifting crank-case exhaust vents from simple open ending to a feed back. New engines equipped with the positive crank-base ventilation (PVC) system return crank-case vapours through a vacuum valve, back to downstream side of the carburetor.