MID-SEMESTER EXAMINATION

Course: 7th Sem B.Tech. (Mining Engineering)

Session: 2022-2023 **Semester:** Summer

Subject: Mine Environmental Engineering (MND – 406)

Time: 2 hrs **Max. Mark:** 32

Instructions: *Answer ALL questions.*

Q.No.	Question	Marks
1	a) How does analysis of air samples help in early detection of spontaneous combustion?	2

Solution:

Analysis enables CO/O_2 and $CO2/O_2$ ratios to be found out. These ratios are useful indicators of heating.

CO/O_2 Ratio: (Graham's ratio, GR)

Oxidation of coal takes place all the time and some CO is produced, which varies with the temp. of coal. GR, can be used as an index of oxidation in a mine.

Generally, 0.1 - 0.5 % may be normal to a seam.
1% indicates existence of heating.
2% indicates serious heating approaching active fire.
3 % indicates fire with certainty.

(Any figure above 10 may be due to production of water gas.)

Merit of GR ratio: CO is given off before any other gas and rate of increase of GR ratio far exceeds that of other parameters.

Another *advantage*: The ratio is independent of dilution by leakage of air. The ratio is not to be completely relied upon as (i) absence of CO means active combustion has stopped and does not mean that fire has been extinguished (ii) CO may be lost due to dilution, oxidation by wet coal (iii) In some cases CO produced in goaves may not disappear even after the heating has become extinct. (iv) It is effected if the fire is fed partially by air migrated through old workings.

b) Calculate the CO/O_2 and CO_2/O_2 ratios from the following sample of air collected from an area sealed off due to an outbreak of fire: $CO_2 = 4.8\%$, $CH_4 = 50.01\%$, $O_2 = 0.6\%$, $N_2 = 43.62\%$ and $CO = 0.036\%$. (2+2+2)

State what you would infer from the above sample analysis.

Solution:

CO/O2 ratio = {0.036/(11.55 – 0.60)}*100 = 0.03%

and CO2/O2 ratio = {(4.80 – 0.03)/(11.55 – 0.60)}*100 = 43.56%

...ence from the above sample analysis :

...to be remembered that active fire ceases when the percentage of oxygen ... below 12%; but slow combustion and evolution of heat accompanied by ... CO and CO_2 may continue ... with ... so long as 1% of Oxygen re... in the atmosphere ... may develop further activity if mo... oxyge...

(a) In the present case the oxygen content is only 0.6% ... indicates that active combustion has ceased.

(b) Slow combustion continues since CO_2 and CO are present.

(c) There is no danger of firedamp explosion, as the percentage ... CH_4 is too high (above 15%) and the Oxygen is too low (below 12%).

(d) CO_2/O_2 ratio is high which indicates that slow heating is continuing due to presence of oxygen.

A sufficient time must be allowed to lower down the temperature inside the sealed off area and then it may be reopened after further air sample analysis.

2 **a) Determine the lower limit of the following gaseous mixture: 97% methane, 2% ethane and 1% hydrogen.** 5

Solution:

Example: The lower limit of the following gaseous mixture: 97 per methane, 2per cent ethane, and 1 per cent ethane, and 1 per cent hydrogen may be calculated as follows

Lower limit of methane= 5.4 per cent

Lower limit of ethane = 3.1 per cent

Lower limit of hydrogen= 4.1 per cent

$$L = \frac{100}{\frac{97}{5.4} + \frac{2}{3.1} + \frac{1}{4.1}} = 5.3 \text{ per cent}$$

b) What is the danger associated with gas concentration outside the limits of inflammability of methane? 3

Solution:

By suddenly compressing the gas mixture, both temp. and press. are raised simultaneously, and it has been found possible to ignite in this way a mixture containing as little as 2% and as much as 75% of methane.

If the press of gas mixture raised to 125 atm., the higher limit is about 46%.

1. A methane-air mixture containing less than 5.4% methane may explode when the source temperature is very high.
2. When the mixture in a crack is adiabatically compressed during blasting in a hole, a 2% methane-air mixture may also explode. (under adiabatic compression the upper limit increases from 14.8 to 74%).

221

3. Presence of other inflammable gases like ethane, hydrogen and CO, reduces the lower limit.
4. In presence of fine coal dust, the lower limit of inflammability may reduce from 5.4% to as low as 0% (In presence of $5g/m^3$ fine coal dust, a 3% methane-air mixture may explode; in presence of $10g/m^3$ coal dust, a 2% methane-air mixture may also explode).
5. There is danger when methane content is over 14.8%, because the mixture can get diluted on addition of fresh air and come within the range of inflammability.

3 What are the causes of fire in coal pillars? Suggest the precautions that should be taken to prevent them. 3+5

Solution:

Causes

✓ Pillars that have been standing for a long time are prone to heating, particularly when they are liable to crushing.

✓ Pillar crushing can create air leakage paths leading to the flow of air through the coal. Loose coal is usually produced by pillar spalling or crushing. When associated with sluggish ventilation, these areas are hazardous

Precautions

✓ Pillar size should be sufficient to prevent crushing.

(g) Resources–availability o

1. **Direct Attack** : The best method to extinguish a fire is the direct application of some extinguishing agent on it that will cool down the hot masses, or will seal the surface. Accidental fires having exposed surface e.g. electrial fires, conveyor fires, diesel loco fires involving oily materials, etc. can be put out most easily by application of dust, sand, or by portable fire-extinguishers. The fire should be attacked from fresh-air side.

Spontaneous heating, if detected in early stages, and deep seated, can be extinguished by direct application of water. From a series it has been found that water is the most effective of the twelve different extinguishing agents tested. But the use of water quench a blazing fire is associated with the following disadvantages–

(a) Dense volumes of steam are formed, visibility is imparied, and conditions are rendered very uncomfortable for the men.

(b) It has an adverse effect on the roof.

(c) Water gas may be formed which may cause an explosion.

(d) There is also the danger of carbon monoxide poisoning.

2. **Digging Out & Extinguishing** : The method consists of digging out the hot material and simultaneously cooling it by covering the area with sand or stone-dust, or by the application of water or fire-extinguishers. This is preferred in some districts, where practicable, because it is a more certain cure for the fire trouble. but it is only possible –

(i) If the heating or fire is accessible.

(ii) If it has not attained appreciable dimensions.

(iii) If there is on danger from firedamp.

(iv) If the roof condition is good.

If the heating has occured in the goaf–

In case of fire inside a stowed goaf, it would necessary to driver one or more entries through the sand packs to reach the site of the fire. The ventilation should be a minimum but sufficient to dilute and carry away the noxious gas given off. The air current may be short-circuted outbye the fire, and in extreme cases the main far be slowed down. The possible danger of the atmosphere becoming explosive should always receive a careful consideration.

The heated material should be dug out and simultaneously cooled down by covering with sand or stone-dust or by fire extinguishers. The cooled down mass should then be removed. away from the site by filling into steel tubs. Glowing or burning material should be treated with fire-extinguishers. When the material has all been removed, the dug out fire area should be packed with sand and stone-dust.

4 **a) What are the main characteristics of firedamp explosion which differentiate it from coal-dust explosion?** 4

Solution:

1. A firedamp explosion is limited in extent and usually confined to the face area and return airways because firedamp accumulations are likely to be found in these places only.
2. The explosion is usually confined to one ventilating district because it is unlikely that there will be firedamp accumulations in two districts simultaneously. Coal dust explosion traverses almost the whole mine and the main intake roadways are most affected because they are haulage roadways and contain dust.
3. Firedamp explosion is less violent than a coal dust explosion.
4. Firedamp explosion is always accompanied by two shocks– the forward shock and the 'backlash'.

b) Describe the precautions to prevent occurrence of fireda explosion in a mine.

Solution:

6. **Fires** : Accidental fire... about ignition of flammable firedamp in conta...

PREVENTION OF FIREDAMP EXPLOSION

The precautions that should taken to prevent an explosion in mines may be outlined as follows–

1. To dilute the firedamp to a safe percentage.
2. To prevent the ignition of firedamp, even if present.

1. **Dilution of firedamp** : The essential requirement is to provide and maintain adequate ventilation in all working places and prove its adequacy by daily routine tests by competent persons and by sampling and analysis of the air at the face and in the district returns. No gas explosion will occur if the firedamp always diluted below the lower of inflammabilty. Special attention should be paid to the ventilation of roof cavities, roof rippings, rise places, and deadends where firedamp is likely to accumulate, and to the provision of a sufficient velocity of air in roads of large cross- sectional area to prevent roof layering.

2. **To Prevent Ignition of Firedamp** : The chief causes of ignition are— (a) naked lights, (b) damaged or defective lamps, (c) shot-firing, (d) electricity, and (e) friction. The main precautions required, apart from avoiding friction dangers, are thus –

(a) Searching of workmen for contrabands.
(b) Careful maintanace and use of lamps.
(c) Elimination of shot-firing or use of water ampoules and rigid control of shot-firing by persons.
(d) Strict rules regarding methods of dealing with firedamp.
(e) Installation of good electrical plant with Flameproof casing and good protective devices.
(f) Restriction on the use of oil immersed below ground.
(g) Provision of adequate fire-frghting appliances.
(h) Continuous monitoring of firedamp during coal-getting operation, by means of monitoring instrument mounted on continuous, miners, and other certain types of coal- getting machines to warn the operator of the presence of firedamp and to cut-off the power supply to the machine should the gas accumulation approach the danger level.

The following additional measures should be taken to prevent explosion—

1. The workings should be laid out on longwall system.
2. Only P_5 explosive should be used.
3. Continuous methane recorders along with automatic alarm system should be installed at vulnerable points.

4. Methane drainage system should be practised when the percentage of gas content in the general body of air is high.
5. Independent power supply should be maintained to the auxiliary fans.