Table 1: Engine specifications.

Engine	Four-Stroke Multi-cylinder SI Engine	Compression ratio	7.3:1
Make	Premier Automobile Limited, India	Number of cylinders	Four
Rated power	7.5 kW	Cycle	Four
Maximum speed	4500rpm	Cooling	Water
Bore diameter	68mm	Lubrication	Forced Lubrication
Stroke	75mm	Starting system	Battery Ignition Sys.
Displacement volume	1089cc		

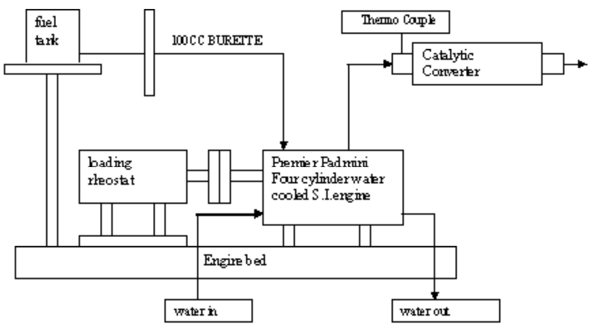

Fig 1: Layout of test engine.


Fig. 2: Test engine.

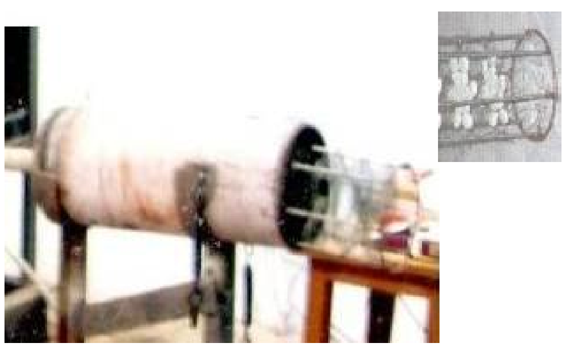
Fig. 3: Catalytic coated filter with pellets.


Fig. 4: Full arrangement of die.

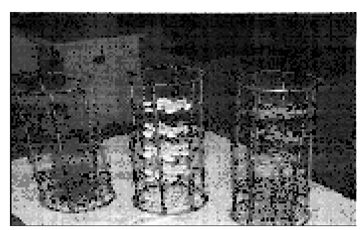
Fig. 5: Pellets.

taking all measurements. Subsequently, the experiments were repeated by keeping different metal oxide pellets catalytic filter in the exhaust. A multi cylinder four stroke petrol engine was used. Engine details are given in Table 1. The experimental set up is shown in Fig 1. An electrical dynamometer was used for loading the engine; the specification of which is shown in Table 2. Schematic diagram of the test engine with catalytic pellet filter are shown in Fig. 2 and Fig. 3.

Die design and manufacturing: In order to make metal oxide pellets a suitable die has to be used. A special die has been designed and manufactured from two mild steel plates of 30 × 30 × 2.5 cm,

Table 2: Alternator specification.

Loading device	Electrical Dynamometer
Rated power	7 kW
Rated speed	1500 rpm

which contain 132 grooves (Fig. 4) for pouring the powder of metal oxide and ejection pins are provided to remove the formed metal oxide pellets. Formed die has undergone various machining process such as turning, facing, drilling, reaming and chamfering. Guide pins are provided to guide upper and lower plates of the die.

Preparation of proportionate mixture and pellets: For making metal oxide pellets, magnesium oxide, ferric oxide and cobalt oxide with alumina were mixed in the proportion of 10:90, 20:80 and 30:70 as given in Table 3. For the preparation of proportionate mixture, aluminium hydroxide acts as base and steric acid acts as binder which accounts to about 300g. For thorough mixing of metal oxides, aluminium hydroxide and steric acid, the mixture was diluted with water and kept under mechanical stirrer for about 6 hrs. After stirring the mixture was filtered out from water with the help of filter paper and kept inside an electric oven at 300°C for 12 hrs until it becomes dried powder.

Table 3: Base: Aluminium hydroxide binder: Steric acid 2%

S.No.	Name of the metal oxide	Ratio		
1	Ferric Oxide (Fe_2O_3)	10:90	20:80	30:70
2	Cobalt Oxide (CoO)	10:90	20:80	30:70
3	Magnesium Oxide (MgO)	10:90	20:80	30:70

Formation of metal oxide pellets: The dried powdered mixer was poured into the cavity of die, and a load of 200 KN was given to the upper plate with the help of a compression testing machine (CTM). The formed metal oxide pellets (Fig. 5) were removed from the cavity with help of ejector pins provided at the bottom plate. The dimensions of formed metal oxide pellets were: diameter -18 mm, thickness-5 mm and weight-3 g.

Table 4: Max. reduction of pollutants with magnesium oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	55.44 (30:90)
HC	54.17 (30:90)
CO_2	52.53 (30:90)
NO_x	65.22 (30:90)

Table 5: Max. reduction of pollutants with ferric oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	71.24 (30:70)
HC	43.59 (30:70)
CO_2	67.59 (30:70)
NO_x	26.09 (30:70)

Table 6: Max. reduction of pollutants with cobalt oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	27.27 (30:70)
HC	64.26 (30:70)
CO_2	31.27 (30:70)
NO_x	64.28 (30:70)

RESULTS AND DISCUSSION

The data on load v/s various air pollutants emitted with different combinations of metal oxides are given in Fig. 6a,b.

Emission after using magnesium oxide pellet as the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when magnesium oxide pellet catalytic filter was used in the exhaust line, is given in Table 4 with maximum percentage reduction of each pollutant. Results obtained from the experiments show that the magnesium oxide pellet catalytic filter effectively controls the emission of NO_X and CO_2 when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

Emission after using ferric oxide pellet as the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when ferric oxide catalytic filter was used in the exhaust line, is given in Table 5 with maximum percentage reduction of each pollutant. Results obtained from the experiments show that the ferric oxide filter effectively controls the emission of HC when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

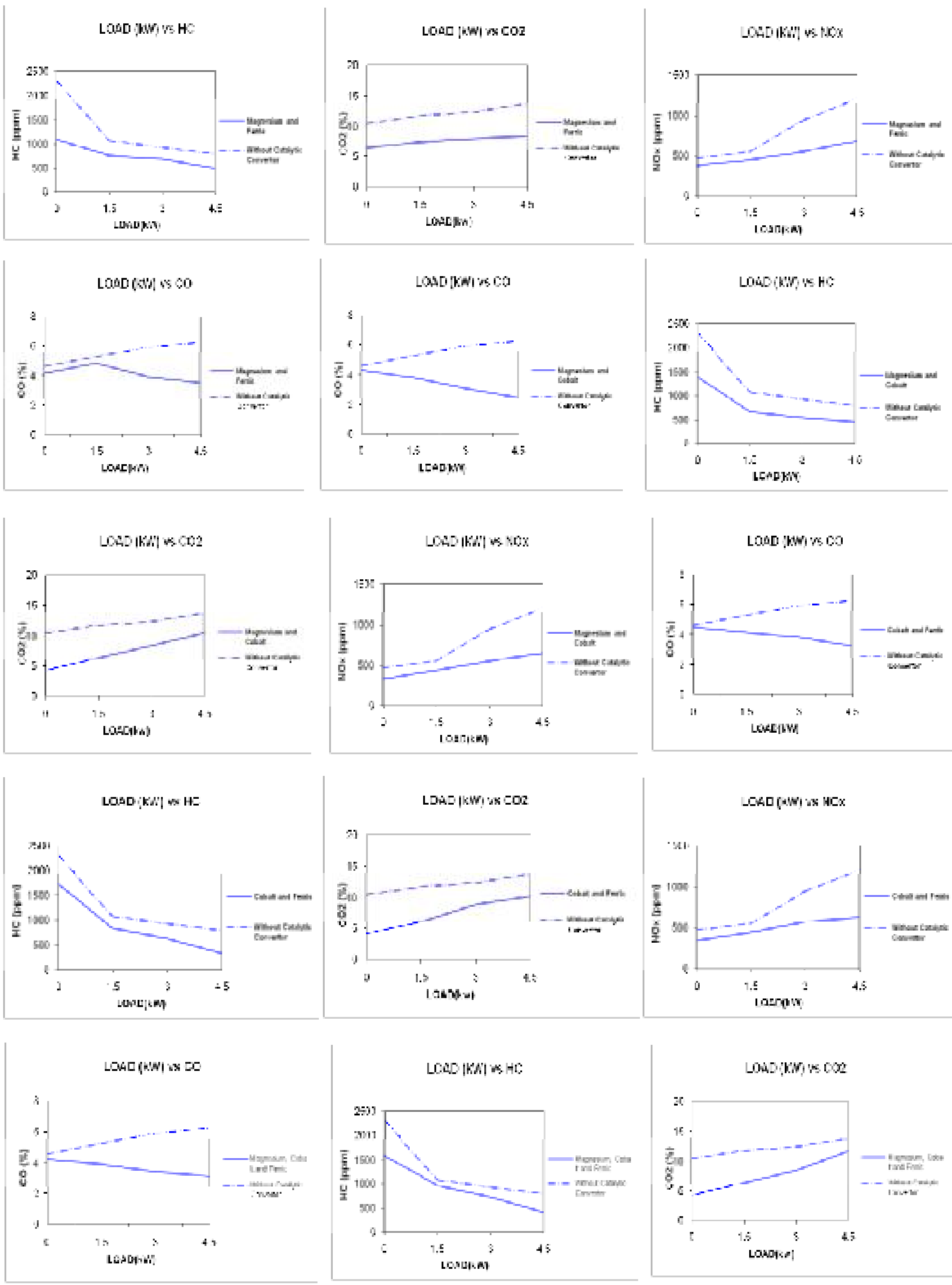

Fig. 6a: The data on load v/s various air pollutants emitted with different combinations of metal oxides.

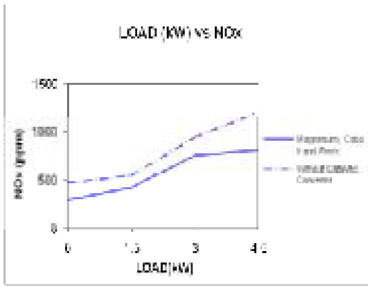

Fig. 6 b: Load v/s NO_x with metal oxides.

Table 7: Max. reduction of pollutants with magnesium oxide and ferric oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	43.27
HC	52.20
CO_2	38.77
NO_x	43.23

Table 8: Max. reduction of pollutants with magnesium oxide and cobalt oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	60.10
HC	42.28
CO_2	59.71
NO_x	46.13

Table 9: Max. reduction of pollutants with ferric oxide and cobalt oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	48.08
HC	58.35
CO_2	60.29
NO_x	47.71

Table 10: Max. reduction of pollutants with magnesium oxide, ferric oxide and cobalt oxide.

Pollutants	Maximum Reduction in Percent @ optimum load
CO	48.88
HC	47.97
CO_2	59.71
NO_X	37.42

Emission after using cobalt oxide pellet as the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when cobalt oxide pellet catalytic filter was used in the exhaust line, is given in Table 6 with maximum percentage reduction of each pollutant. Results obtained from the experiments show that cobalt oxide pellet catalytic filter effectively controls the emission of CO and CO_2 when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

By using the metal oxide pellets of MgO, FeO and CoO with different proportions, the pellets made using 30:70 of metal oxide and aluminium hydroxide was more effective and gives maximum reduction of pollutants. From the results obtained it was found that the combinations of these three pellets used simultaneously reduce all the pollutants.

Emission after using the combination of magnesium oxide and ferric oxide in the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when magnesium oxide and ferric oxide were used in the exhaust line, is given in Table 7. Results obtained from the experiments show that magnesium oxide and ferric oxide catalytic filter effectively controls the emission of HC and CO_2 when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

Emission after using the combination of magnesium oxide and cobalt oxide in the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when magnesium oxide and cobalt oxide catalytic filter was used in the exhaust line, is given in Table 7. Results show that magnesium oxide and cobalt oxide catalytic filter effectively controls the emission of CO and CO_2 when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

Emission after using the combination of ferric oxide and cobalt oxide in the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when ferric oxide and cobalt oxide catalytic filter is used in the exhaust line, is given in Table 8. Results show that ferric oxide and cobalt oxide catalytic filter effectively controls the emission of HC, CO and CO_2 when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

Emission after using the combination of magnesium oxide, ferric oxide and cobalt oxide in the catalytic converter: The variation in emission of NO_X, CO_2, HC and CO when all the three metal oxides were used in the catalytic convertor, is given in Table 7. Results obtained from the experiments show that this filter effectively controls the emission of HC, CO and CO_2 when the engine runs at the optimum load of 4.5 kW. The conversion efficiency is also more at this optimum load.

CONCLUSION

Following conclusions based on the experimental results can be drawn.

- The use of magnesium oxide pellet filter reduces the emission of NO_X by 65.22 percent.
- The use of cobalt oxide pellet filter reduces the emission of HC by 64.26 percent.
- The use of ferric oxide pellet filter reduces the emission of CO and CO_2 by 71.24 and 67.59 percent.
- The combination of magnesium oxide and cobalt oxide pellet filter reduces the emission of CO and CO_2 by 60.10 and 59.71 percent.
- The combination of ferric oxide and cobalt oxide pellet filter reduces the emission of HC by 58.35 percent.
- The combination of magnesium and ferric oxide pellet filter reduces the emission of NO_x by 49.23 percent.
- The combination of magnesium oxide, cobalt oxide and ferric oxide pellet filter reduces the following emissions:
  - HC by 47.97percent
  - CO by 48.88 percent
  - CO_2 by 59.71 percent
  - NO_x by 37.42 percent

It is found that for simultaneous reduction of the pollutant emission from engine, combination of MgO, FeO and CoO were the best catalysts to control the emission. It may yield better results if excess air (or) preheated air (or) combinations of these were used.

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