ABSTRACT

Engines are the major components of any automobile. A user of an automobile wants to get maximum power output from the engine, at the same time, not sacrificing fuel efficiency.

The design of an engine is very important. One of the most important parts of engine design is the design of the combustion chamber. Different types of combustion chamber heads are being used at present.

One type of chamber head is the hemispherical head. The hemispherical head design enables the user to extract more power from the engine. The engines using hemispherical heads are known as HEMI engines.

Modern HEMI engines are using various developments that have come up in the recent past. This has enabled these engines to provide the user with additional advantages apart from serving its major purpose, ie, supplying more power.

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1.0 INTRODUCTION

Engine is the basic component of any automobile. Combustion engines may be divided into two general classes – internal combustion engines and external combustion engines.

In the external combustion engines, a working fluid is utilized to transfer some of the heat of combustion to that portion of the engine wherein this heat is transformed into mechanical energy.

The internal combustion engine inducts air from the atmosphere and the combustion of fuel and air occurs in or near that portion of the engine, which converts heat to mechanical energy.

Internal combustion engines may be further classified into reciprocating engines and non-reciprocating engines. Internal combustion engines may also be divided as spark ignition engines and compression ignition engines.

Spark ignition engines may work in a two-stroke cycle or a four-stroke cycle. The four strokes involved are

1) Intake stroke
2) Compression stroke
3) Power stroke
4) Exhaust stroke

Any two strokes of a four-stroke engine will be coupled in a two-stroke engine.

The HEMI engine is a four stroke, spark ignition, reciprocating type, internal combustion engine.

The design of the combustion chamber for a spark ignition engine has an important influence on the engine performance and its knocking characteristics. The design involves the shape of the combustion chamber, the location of the spark plug, and the location of the inlet and exhaust valves. The important requirements of a spark ignition engine combustion chamber are to provide higher power output with minimum octane requirement, high thermal efficiency and smooth engine operation.

2.0 BASIC DESIGN

The HEMI engine was first developed in 1951 by the Chrysler Corporation. The advantage of HEMI engine over other engines of the time was that it produced more power. The reason for this was the efficiency of the combustion chamber.

2.1 FLATHEAD ENGINE DESIGN

Most cars prior to the 1950's used what was known as a flathead and many lawn-mower engines still use the flathead design today because it is less expensive to manufacture. In a flathead engine, the valves are in the block, rather then in the head and they open in a chamber beside the piston.

The head in a flathead engine (fig. 2.1) is extremely simple- it is a solid metal casting with a hole drilled in to accept the spark plug. The camshaft in the block pushes directly on the valve stems to open the valves, eliminating the need for push rods and rocker arms. Everything is simpler in the flathead engine. The problem with a flathead engine is its thermal efficiency.

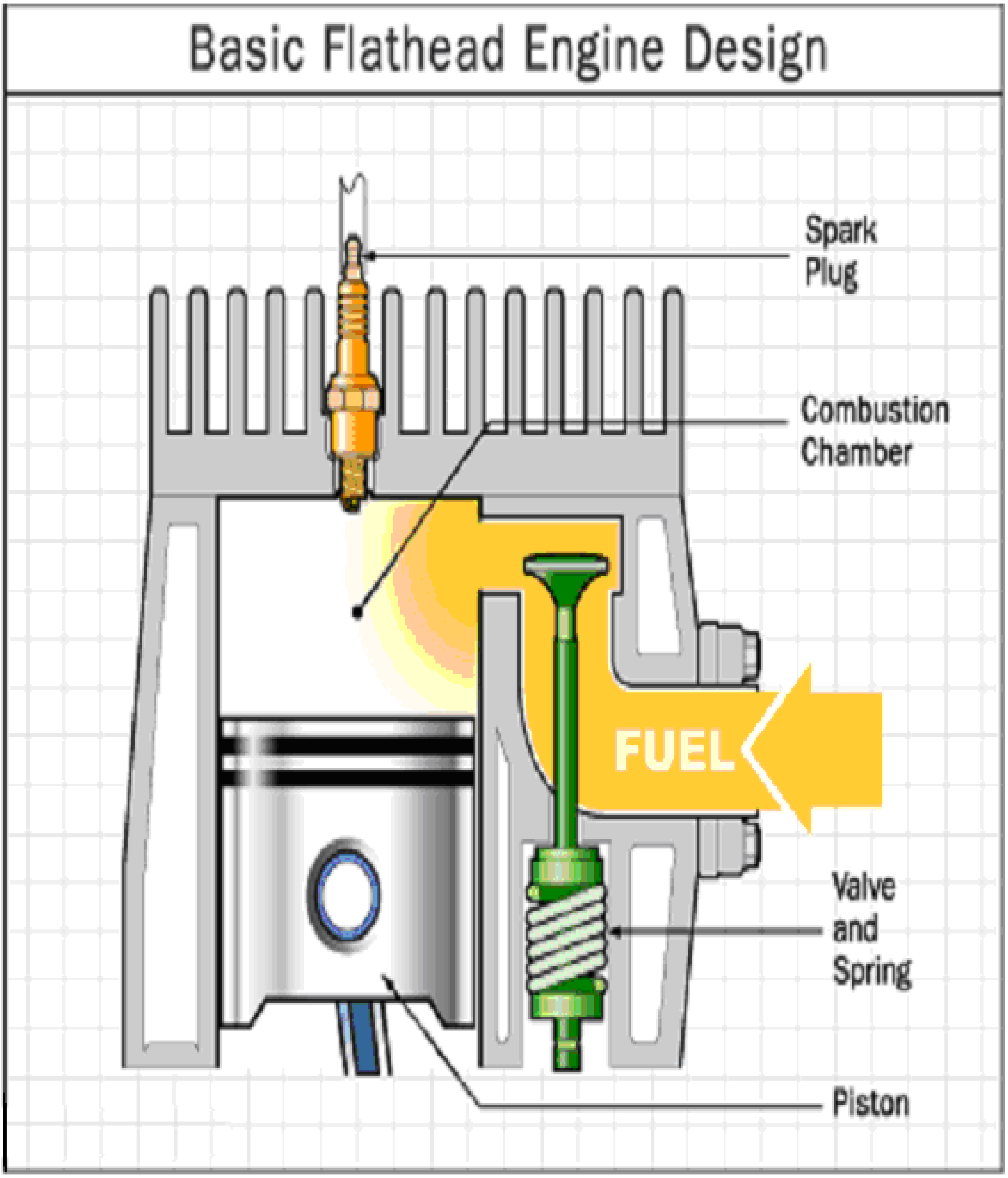
Basic Flathead Engine Design
Spark Plug
Combustion Chamber
FUEL
Valve and Spring
Piston

Fig 2.1

2.2 HEMI ENGINE DESIGN

In a HEMI engine (fig. 2.2), the top of the combustion chamber is hemispherical. The combustion area in the head is shaped like half of a sphere. An engine like this is said to have “hemispherical heads”. In a HEMI head, the spark plug is normally located at the top of the combustion chamber and the valves open on opposite sides of the combustion chamber.

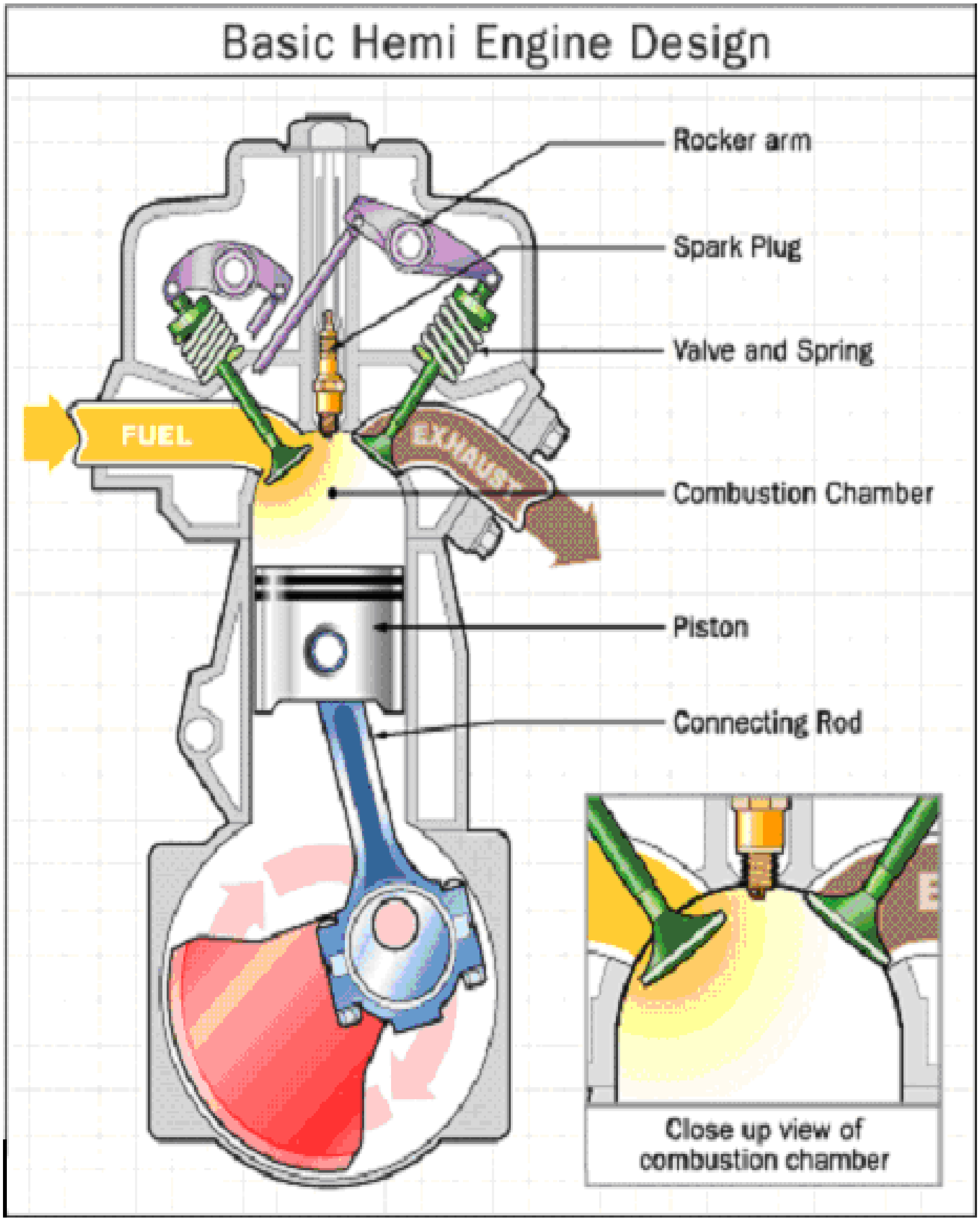
Basic Hemi Engine Design
Rocker arm
Spark Plug
Valve and Spring
FUEL
EXHAUST
Combustion Chamber
Piston
Connecting Rod
Close up view of
combustion chamber

Fig 2.2

3.0 MERITS AND DEMERITS

3.1 MERITS

There are many different parts of an engine's design that control or determine the amount of power you can extract from each combustion stroke.

You want to burn all the gas in the cylinder. If the design leaves any of the gas unburned, that is untapped energy.

You want the maximum cylinder pressure to occur when the crankshaft is at the right angle so that you can extract all of the energy from the pressure.

You want to waste as little as the engine's energy as possible to suck air and fuel into the combustion chamber and pushing exhaust out.

You want to waste as little heat as possible to the head and the cylinder walls. Heat is one of the things creating pressure in the cylinder; so lost heat means lower peak pressures.

All these factors are satisfied in the HEMI engine because of its design. The last item in the list is one of the key advantages of the HEMI head versus the flat head engine. Surface area causes heat loss. Fuel that is near the head walls may be so cool that it does not burn efficiently. With a flat head, the amount of surface area relative to volume of the combustion chamber is large. In a HEMI engine, surface area is much smaller than that in a flat head, and so less heat escapes and peak pressure can be higher.

Another factor with a HEMI head is the size of the valves. Since the valves are on the opposite sides of the head, there is more room for valves. The engine design that preceded the HEMI was a wedge shaped combustion chamber with the valves in line with each other. The in line arrangement limited valve size. In a HEMI engine, the valves can be large so that airflow through the engine is improved.

Thus, the HEMI engine delivers more power owing to its design. The design helps in attaining a high degree of turbulence (by inlet flow configuration or squish), high volumetric efficiency, improved anti-knock characteristics and compactness of combustion chamber.

3.2 DEMERITS

Not all engines are using HEMI heads though they have the advantages mentioned earlier. This is mainly because of two reasons.

One thing that a hemispherical head will never have is four valves per cylinder. The valve angles would be so crazy that the head would be nearly impossible to design. Having two valves per cylinder is not an issue in drag racing or NASCAR because racing engines are limited to two valves per cylinder in these categories. But on the street, four slightly smaller valves let an engine breath easier than two larger valves. Modern engines use a pentroof design (fig. 3.1) to accommodate four valves.

Another reason most high performance engines no longer use a HEMI design is the desire to create a smaller combustion chamber. Small chambers further reduce the heat lost during combustion and also shorten the distance the flame front has to travel during combustion. The compact pentroof design is helpful here as well.

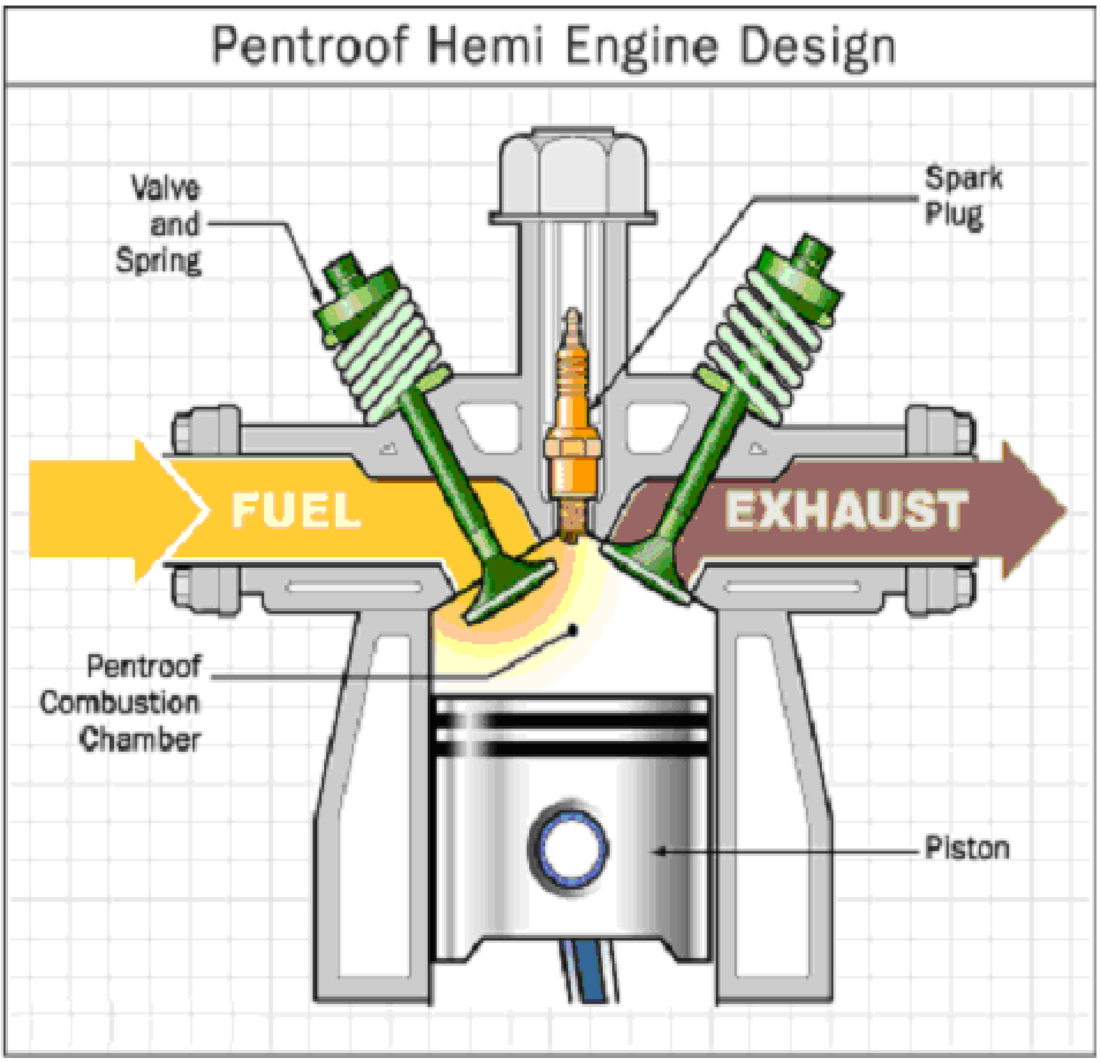

Fig 3.1

4.0 RECENT DEVELOPMENTS

4.1 SUPERCHARGING

Supercharging is a method used to increase the density of air charge before it enters the cylinder. This allows more Oxygen for combustion than conventional methods. This results in better combustion and more power output.

In January 2003, the first supercharged HEMI engine was produced by Chrysler. It produces 430 horsepower and 480 lb-ft of torque, using the 5.7 Hemi engine and a Whipple supercharger.

4.2 CYLINDER DE-ACTIVATION

A new Mopar 5.7 litre 345 HEMI Magnum V-8 engine was developed recently. It is capable of producing a power of 345 hp at 5600 rpm and a torque of 375 lb-ft at 4400 rpm from 5.7 litres. A 6.1 litre version is being developed to be fitted in the Mercedes five-speed automatic to replace the current V-10 to obtain more power.

This engine featured cylinder de-activation using the multi-displacement system (MDS). The MDS turns off the fuel consumption in four cylinders when V-8 power is not needed. The system deactivates the valve lifters. This keeps the valves in four cylinders closed, and there is no combustion. In addition to stopping combustion, energy is not lost by pumping air through these cylinders. This provides a world-class combination of power and fuel economy.

Customers will experience estimated fuel economy gains of up to 20 percent under various driving conditions, and a projected 10 percent aggregate improvement. Improved fuel economy is realized without any change in customer experience—drivers will receive the benefit without changing their driving habits and without compromising style, comfort or convenience.

An LX engineer said that the Hemi was in part inspired by the slant six - in particular, the dual oiling circuit, with oil coming through the pushrods. This could maintain lubrication when cylinders are at rest.

It was found that only four cylinders were used during 17% of the suburban traffic portion of the test, during a full 48% of the freeway test which included "over 70 mph" speeds. Overall, they found that the engine powered down to four cylinders about 40% of the time. Non-enthusiast drivers may experience even more savings.

This engine is the first high volume, modern production vehicles in North America to feature fully functional cylinder de-activation. Owners get the power of HEMI engines and fuel economy of smaller or less powerful engines, when they use this system. This system should triumph where the Cadillac 4-6-8 failed because of the speed of modern electronic controls, the sophistication of the algorithms controlling the systems, and the use of electronic throttle control. The HEMI will be able to transition from eight cylinders to four in 40 milliseconds (0.04 seconds).

Bob Sheaves discussed multiple displacement on smaller engines:
"An Otto cycle engine requires 2 full revolutions of the crankshaft to fire all the cylinders. Therefore: 2 x 360=720 degrees of rotation. Divide that total rotation by the number of cylinders to have an even firing engine (naturally balanced) will give you: 120 degrees, which means that you have a cylinder firing every 120 degrees of rotation. Now, when you take out 3 of the cylinders, you have increased the firing rotation to 240 degrees (720/3), still balanced between each firing of a cylinder. The catch is that you have now increased the harmonic vibrations as the rpms increase. By deactivation of 4 cylinders in a V6, you no longer have a multiple of 6 that will keep the engine in primary balance. This is the reason balance shafts are often used in 90 degree V6s and inline 4 cylinder engines over 2.5L of displacement."

4.2.1 Specific Advantages

The cam was placed high up in the block to keep the pushrods as short as possible. The hollow cam has oversized journals and lobes to minimize side loading on the roller-style lifters. The valve springs are beehive types, more effective than standard springs so they can be lighter, with less lifter collapse. Rockers have much less inertial mass than usual, with the form and size carefully designed for a conservative .500 inches of lift; but the valves flow well enough to make this more than enough.

Generally, the engine appears to have been designed for lighter weight. The new Hemi is precision cast, which allows it to be lighter than a typical 5.7 litre engine, even with a taller deck height than Chevy's; and, partly to counter the inertia of its relatively long stroke, the pistons were made light as well, using cast eutectic alloy. The slipper-style piston has much in common with racing pistons, with a weight of 413 grams. For longevity, the Hemi pistons use a hard anodise on the top ring land, to act as a heat barrier and anti-micro weld mix, and to allow the top ring to be only 3 mm from the top of the piston, cutting emissions while bringing more power. As with the old 426 Hemi, the rings are also relatively thin. Also in common with racing engines is a reservoir groove underneath the top ring, to reduce the pressure between the top and second ring. The cast iron block has a "meaty" deep-skirt design, with a crankshaft supported well by four bolts per main bearing (two vertical, two horizontal). The heads are aluminium, with the usual Chrysler plastic intake manifold.

The skirt is coated to allow for variance in production piston sizes, increase the fit for ring seal, and reduce piston noise. The lightweight wrist pin is also high-set.

The crank has larger inner counterweights than equivalent Chevy engines; but their weight is offset by the lighter pistons and rods. A windage tray sits underneath the crank, while the serpentine belt pulley also acts as a torsional vibration damper. The connecting rods are also designed for strength and low weight, using a powder metallurgy process first used by Porsche, and negating the need for a balance pad. A cap bolt is used instead of a through bolt.

One problem with the Hemi is that a speed density system is used for measuring air into the engine rather than air mass, so that cold air packages and such can throw the system off.

MDS saves about 3 mpg city, 3 mpg highway - that's by comparing original Chrysler 300C fuel mileage estimates with actual EPA figures.

According to Bob Lee, vice president of Powertrain Product Team, Chrysler Group, the MDS was a part of the engine's original design and hence resulted in a cylinder-deactivation system that is elegantly simple and completely integrated into the engine design. The benefits being fewer parts, maximum reliability and lower cost.

4.3 TWIN SPARK PLUGS

Each cylinder has an ignition coil pack over one spark plug, and a regular plug wire connected to the other spark plug. Further, the coil pack also has a plug wire attached to it that extends to the opposite cylinder bank. It appears that each cylinder shares a coil pack with another cylinder.

It appears that a separate coil fires each of the two plugs on a given cylinder. One plug has a coil directly attached, and the other is fired via an ignition wire connected to a coil located on another cylinder on the opposite bank. The benefits would be one-half the number of coils (8 vs. 16) compared to each plug having its own coil, and of course less weight.

There are two possibilities as to how the coils are fired. One is that the coils could contain two sets of windings that are insulated from each other and operate separately (one winding set for the plug directly underneath and another for the plug attached on the other bank). The other approach would be a coil with a single set of windings, and timing such that when the coil is firing a plug on the other bank, the cylinder under the coil would be on the exhaust stroke and that plug would fire also but with no effect.

5.0 CONCLUSION

Today's HEMI is that in name only. Nowadays HEMI pentroof engines, due to the disadvantages mentioned earlier, are replacing the HEMI engines. It is found that the power delivered by these engines is greater than the power output from engines with I-head, H-head, L-head, T-head, etc.

These engines are being used more and more in modern cars. Though Chrysler is the major user of this type of engines, other motor companies are also beginning to use these engines with some variations because of the patent protection that is present for these engines.

HEMI engines also find a major application in cars being used for racing purposes.

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