K.L.N. College of Engineering

Pottapalayam – 630612.(11 km From Madurai City)
Tamil Nadu, India.

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DEPARTMENT OF MECHANICAL ENGINEERING

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VISION

To become a Centre of excellence for Education and Research in Mechanical Engineering.

MISSION

- Attaining academic excellence through effective teaching learning process and state of the art infrastructure.
- Providing research culture through academic and applied research.
- Inculcating social consciousness and ethical values through co-curricular and extra-curricular activities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO I	Graduates will have successful career in Mechanical Engineering and service industries.
PEO II	Graduates will contribute towards technological development through academic research and industrial practices.
PEO III	Graduates will practice their profession with good communication, leadership, ethics and social responsibility.
PEO IV	Graduates will adapt to evolving technologies through lifelong learning.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Mechanical Engineering Graduates will be able to:

PSO 1	Derive technical knowledge and skills in the design, develop, analyze and manufacture of mechanical systems with sustainable energy, by the use of modern tools and techniques and applying research based knowledge.
PSO 2	Acquire technical competency to face continuous technological changes in the field of mechanical engineering and provide creative, innovative and sustainable solutions to complex engineering problems.
PSO 3	Attain academic and professional skills for successful career and to serve the society needs in local and global environment.

MECASO

MECHANICAL ENGINEERING NEWSLETTER

Principal Message

I feel extremely delighted to observe that technical magazine MECASO from department of Mechanical Engineering is to coming out this year, thanks to the dedicated and committed efforts of the faculty and the students of the department. The magazine is truly the reflection of the interest of the students, involved in technical endeavours. Ever since the inception of Mechanical Engineering department , we have been striving for excellence in different areas of Mechanical Engineering and Technology, and at the same time marching forward with the mission of professional as well as intellectual development of the students, i feel gratified that we are doing our best in carrying on the mission of grooming our students as such professionals who are not only competent enough to combat the challenges in their life but also become good human beings with moral excellence and social sensitivity. I congratulate the efforts of the members of the editorial board that they have brought out the third volume of the magazine in such an informative form. It is because of their selfless and untiring efforts that we see the magazine enriched with variety of articles. As a parting message to students of Mechanical Engineering, I wish them a pleasant and prosperous future and advise them to delve deep in their career and come out with the pearl of name and fame, both for themselves and their future.

Principal

Dr.A.V. RAMPRASAD

Message from the Head of the Department

On behalf of all the staff and students of the Mechanical Engineering Department, a very warm and affectionate welcome to the third volume of MECASO. I congratulate all the students and faculty members in bringing out the departmental technical magazine in spite of having a busy academic schedule. We are proud to have a reasonably good placement record even though most of them are in the software industry. This year the department has organized various certification courses

On this occasion I would like to bring to the attention of all Mechanical Engineering students about the importance of Graduate Aptitude Test in Engineering (GATE) examination for securing a placement in core companies. GATE is an all India examination which examines the comprehensive understanding of various undergraduate subjects in engineering and science. The candidate can choose from any of the 22 disciplines including Mechanical Engineering. Admissions to the various PG courses in engineering at most of the prominent institutions across the country including IIT's and IISc are on the basis of GATE score. GATE has been gaining more recognition during the last couple of years and even some of the foreign universities have been admitting students on the basis of GATE score. For example the National University of Singapore is admitting students for MS and Ph.D programs based on GATE score. Apart from higher education, GATE scores are being increasingly used for recruitment of engineering graduates in many Public Sector Units (PSU's). Mechanical Engineering graduates who secure a good score in GATE examination are welcomed by top PSU's in the country with well paying jobs. Top PSU's who are recruiting Mechanical Engineers through GATE 2015 includes ONGC, BPCL, Indian Oil, HPCL and NTPC. Preparation for GATE should ideally start from the second year of graduation since most of the topics included in the GATE examination are studied during the second and third year.

In the GATE examination the ability of the candidate to apply engineering principles to solve practical problems is being tested. Therefore, students attempting the GATE examination should possess a thorough understanding of the basic engineering principles of their respective discipline. Mock tests and sample papers are an integral part of the GATE preparation. . I advise all the students who dream for a job in core companies to prepare well and appear for the GATE examination. I am hopeful that in the coming years more number of students from the department will secure good score in GATE and will get placed in top PSU's in the country

HOD/MECH

Dr. P. Udayakumar

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Digital Twin Spark Ignition (DTSI)

By R.Nirmal Kumar (131001) IV Year A Section

Introduction:

A conventional 4 Stroke engine has a Single Spark Plug located at one end of the combustion chamber and hence the combustion is inefficient leading to sub optimal mileage and sub optimal performance & can even have problems with oil flow. Hence forth there was a requirement to change engines' design, fueling, ignition, production and quality to achieve the following objectives. Uniform power delivery in all operating conditions; A high degree of drivability; First rate standards of reliability; Long service life. With a view to overcome the above limitations a new patent was introduced that is known as DTS-I technology & its use is increasing day by days. DIGITAL TWIN SPARK ignition engine has two Spark plugs located at opposite ends of the combustion chamber and hence fast and efficient combustion is obtained. The benefits of this efficient combustion process can be felt in terms of better fuel efficiency and lower emissions. The, ignition system on the Twin spark is a digital system with static spark advance and no moving parts subject to wear. It is mapped by the integrated digital electronic control box which also handles fuel injection and valve timing. It features two plugs per cylinder. This innovative solution, also entailing a special configuration of the hemispherical combustion chambers and piston heads, ensures a fast, wide flame front when the air-fuel mixture is ignited, and therefore less ignition advance, enabling, moreover, relatively lean mixtures to be used. This technology provides a combination of the light weight and twice the power offered by two-stroke engines with a significant power boost, i.e. a considerable "power-to-weight ratio" compared to quite a few four-stroke engines. Fig.1. show the actual picture of Bajaj Pulsar Bike.

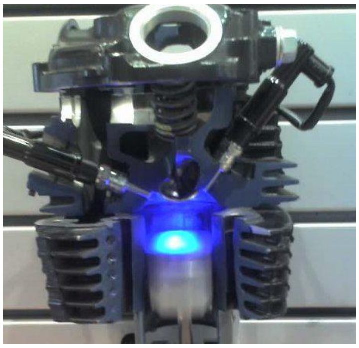


Fig.1. DTSI Engine (Courtesy: Bajaj Pulsar Bike)

Moreover, such a system can adjust idling speed & even cuts off fuel feed when the accelerator pedal is released, and meters the enrichment of the air-fuel mixture for cold starting and accelerating purposes; if necessary, it also prevents the upper rev limit from being exceeded. At low revs, the over boost is mostly used when overtaking, and this is why it cuts out automatically. At higher revving speeds the over boost will enhance full power delivery and will stay on as long as the driver exercises maximum pressure on the accelerator.

Main characteristics

- Digital electronic ignition with two plugs per cylinder and two ignition distributors;
- Twin overhead cams with camshaft timing variation.
- Injection fuel feed with integrated electronic twin spark ignition.
- a high specific power
- compact design
- superior balance

Its main characteristics are:

- Digital electronic ignition with two plugs per cylinder and two ignition distributors;
- Twin overhead cams with camshaft timing variation;
- Injection fuel feed with integrated electronic twin spark ignition...

Cylinder capacity amounts to 1,962 cc thanks to an 84 mm bore and 88.5 mm stroke with the Compression ratio 10: 1. Maximum power output at 5,800 rpm is a remarkable 148 BHP DIN, while maximum torque, of 19 mkg DIN, is reached at 4,000 rpm. The shape of the torque curve has been perfected to make available fully 16 mkg when revving speed reaches 2,000 rpm and 18 mkg as early as 3,000 rpm, thus making the engine's performance much more responsive

Valve drive

The twin overhead cams, driven by a double chain, act directly on the valves set in a tight Vee configuration (46^{o}). The timing of the valve train is not fixed as in most present day engines, but can be adjusted by a patented device conceived and produced by Alfa Romeo, the timing variator. This is an electro-hydraulic actuator keyed onto the gear that drives the camshaft acting on the intake valves. This actuator enables the camshaft to be shifted into two different angular positions and to modify the intake valve opening durations. Its operation is controlled by the electronic control box of the integrated ignition and fuel injection system. Valve timing actuator logic is predetermined so that overlap - i.e. that fraction of the engine's operating cycle when both the exhaust and the intake valves are open simultaneously – is shorter at low revs and with lighter loads, and longer at higher engine speeds when extra power is required. At high and medium-high engine speeds or whenever additional power has to be provided (normal timing) cylinder filling is opti- mal, maximizing power output and torque. At low and medium-low revs and lighter loads (delayed timing), fluctuation-free operation is ensured combined with a reduction in specific consumption. At all engine speeds, noxious emissions are minimized.

Advantages of using Twin Spark systems thus includes better starting of engine even in Winter season & cold climatic conditions or at very low temperatures because of increased Compression ratio. Since both the spark plugs spark continuously, the rate of increase of temperature of engine thus increases that helps make Engine warmer. However in case of summer when the surrounding temperatures is quite more the Engine gets overheated which results in Knocking. Overheating of Engine results in Pre-Ignition of fuels i.e. burning of fuels before their specified timings because of coming in contact with the end of spark plugs & the walls of the cylinder head i.e. combustion chamber that are at a temperature greater than the ignition temperature of the fuel. Hence if two spark plugs spark alternatively, each will get a fraction of time to cool itself that would help its efficient working by maintaining its temperature & thereby conductivity. This would particularly help increase the Thermal Efficiency of the Engine & even bear high loads on it. Because of twin Sparks the diameter of the flame increases rapidly that would result in instantaneous burning of fuels. Thus force exerted on the piston would increase leading to better work output. In case the Engine is kept unused for a long time soiling of spark plugs occur. Twin Spark system helps to reduce this problem.

Working of DTSI

Digital Twin Spark ignition engine has two Spark plugs located at the opposite ends of the combustion chamber and hence fast and efficient combustion is obtained. The benefits of this efficient combustion process can be felt in terms of better fuel efficiency and lower emissions. The ignition system on the Twin spark is a digital system with static spark advance and no moving parts subject to wear. It is mapped by the integrated digital electronic control box which also handles fuel injection and valve timing. It features two plugs per cylinder.

Conclusion:

From this paper I have concluded that perfect Combustion in Internal Combustion engine is not possible. So for the instantaneous burning of fuels in I.C. engine twin spark system can be used which producing twin sparks at regular interval can help to complete the combustion.

Micromachining

By P.C.Shesathiri (141118) III Year C Section

Abstract

Miniaturization is the order of the day. Until recently a decade ago traditionally watch parts were considered to be the micro components one can think off. Recent changes in society's demand have forced us to manufacture variety of micro components used in different fields starting from entertainment electronics to be bio medical implants. Present day manufacturing processes used for miniaturization are the micro electronic fabrication techniques used for Micro Electro Mechanical Systems (MEMS). The limitation of all these processes is that they are applicable for producing 2D patterns and thickness of parts are very low; say a few microns and they are employed on materials such as Silicon and crystalline materials and not metals. Miniaturized parts may have overall sizes of a few millimeters but may have many features that fall in micron range. Also we need many such miniaturized parts may be with 3D profiles, that too made up of metals in many fields like aerospace to bio-medical applications. A new candidate requiring micro products is the field of biotechnology. In the medical field, diagnosis and surgery without pain are achieved through miniaturization of medical tools. Micromachining is one of the key technologies that can enable the realization of all the above requirements for microproducts and fields with such requirements are rapidly expanding. If complementary machining processes are developed to overcome the above shortcomings, metallic miniature devices will be economically feasible reality.

Micromachining

Literally Micro in micro machining implies that parts are made to the size of 1 to 999 µm. However Micro also means very small in the fields of machining, manufacture of small parts are not easy. Therefore micro components should also indicate too small components to be machined Prof. Taniguchi defines Micro Engineering as the fields where components sizes are a few millimeters. When the part size is between 100µm to 100mm, a term MESO manufacturing is also used to address such parts. In fact, the range of micro varies according to era, person, machining method, type of product or material.

Micromachining conditions

The machining processes for micro/meso manufacturing can be derived from traditional machining processes such as turning milling, drilling, grinding, EDM, laser machining, etc., by judicious modification of these machines. Unit metal removal and improving equipment precision are the key factors for adapting the traditional machining processes to micro machining. When these two guidelines are set, the approach is almost correctly directed toward micromachining.

Unit removal

The concept of unit removal was introduced as processing unit by N Taniguchi to explain the difference in removal phenomena between micromachining and conventional machining. Unit removal (UR) is defined as the part of work piece (length, area or volume) removed in one cycle of metal removal operation. Since UR gives the achievable tolerance on the part it should be much smaller than the size of the part it should be much smaller than the size of the component. The smallest UR is the size o0f the atom. UR of sub-micrometer order is also required when the object size is very small or when high precision of the product is required. It is difficult to achieve ideal UR and machine accuracy in the lower range of sizes, say 1 to 10 microns

Equipment precision

When maniaturised part is required the component is scaled down. Then, it is necessary that the dimensional error of the product be likewise reduced. Therefore, higher precision of the micromachining equipment is desired although it is often impossible to reduce the dimensional error in proportion to the size of product. If the above two equipments small UR and high equipment precision were satisfied micro-machining would be possible independent of the type of machining process. Since the theoretical minimum UR possible in most process are the nanometer order. Micro-machining is theoretically possible in most existing machining progresses on the other hand the theoretical smallest UR is largest than the size of the atom. This suggest that in micromachining in the lower range of dimensions for example. 1 to 10 μm it make more difficult to achieve the ideal UR and equipment precision because of the influence of this absolute limit.

Classification according to machining phenomena

- Removal by Mechanical Force
- Removal by ablation
- Removal by dissolution
- Plastic Deformation

The following Table shows the major methods grounded by the machining mechanism and the work material amenable for those process.

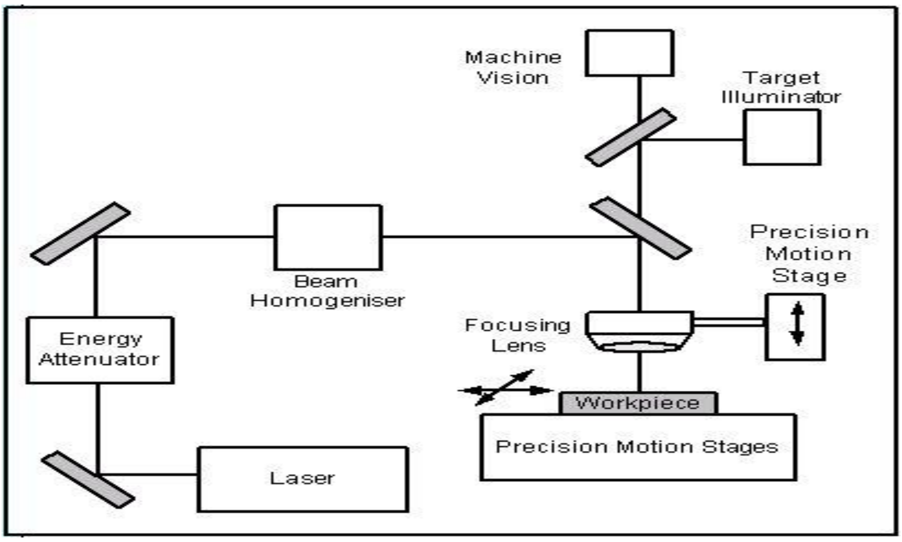
Table: Micromachining Processes

Machining phenomena	Micromachining Process	Materials
Force	Micromilling , micro grinding	Ceramics, metals,si
Ablation	Excimer Laser, Femto Second Laser	Ceramics, Polymers
Dissolution	Etching, ECM Reactive ion etching (R:E)	Galss, Quartz Si Ceramics, Polymers
Plastic Deformation.	Punching , Press	Plastic Deformation

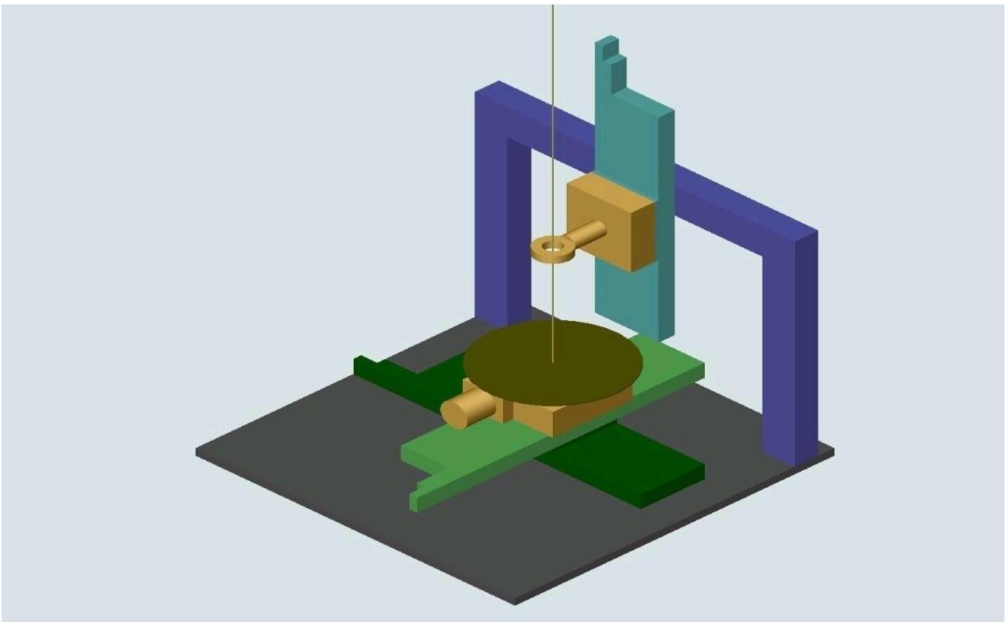
Laser Micromachining

unlike the CO_2 or Nd: YAG lasers, Examier and Femto Second lasers, on the contrary, offer high-precision machining without the formation of re-solidified layer and heart –affected zone. There are two types of methods that are based on material removal by ablation. One uses a power source that emits a beam with very high quantum energy. If the energy exceeds the binding energy among atoms of the workpiece each molecule can be decomposed directly into atoms and removed from the workpiece. The other method uses an energy beam of which incident power density on the workpiece is extremely high such a high power enables the removal of the workpiece by vaporization, skipping the phase of melting in some cases, molecules are also decomposed in both types, microshapes can be generated by projecting mask patterns, whose size is reduced by using optics. Excimer laser and femto second lasers (hereafter referred to as FS lasers) are respectively typical examples of power sources for the above two types. The Excimer laser is an ultraviolet laser which can be used to micromachine a number of materials without heating them, unlike many other lasers which remove materials without heating them without heating them, unlike many other lasers which remove material by burning or vaporising it. Higher accuracy can e achieved when a shorter wavelength, for example, 193nm of an ArF laser is applied. Since the applied photon energy is similar to the energy level of molecular bonds in plastics, the ideal targets for excimer laser machining are plastics, and similar materials and not metals. When a very high power is applied, the removal phenomenon involves a combination of heating and photon attack. FS lasers have short (femto second) pulse duration and high (tera watt) power and overcomes the above limitation. The remarkable feature of these methods is that little heat affected layer remains on the machined surface. This leads to the possibility of machining microshapes with high dimensional accuracy and less defects in the surface layer. The main drawbacks are low efficiency in material removal and consequently, low machining speed another drawback is the high cost of equipment due to their short history.

Setup



Conceptual Solid Model of Laser Micromachining Setup



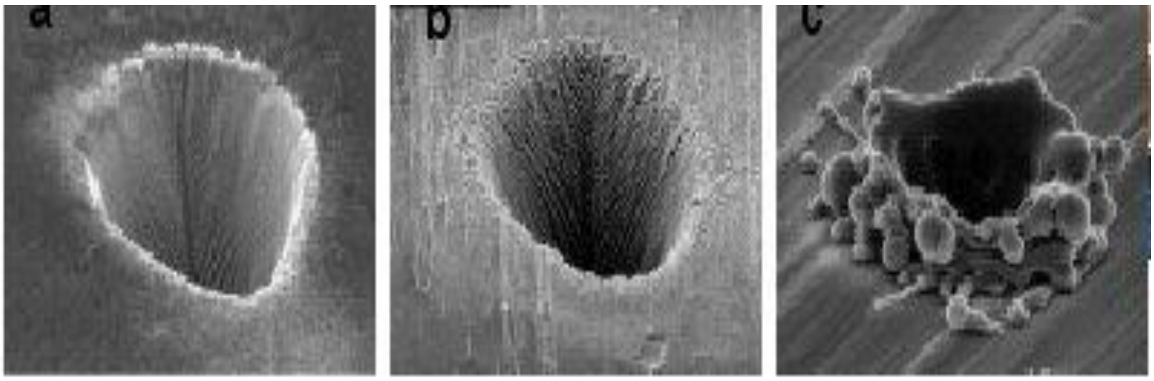
Working

Laser is emitted from the source is passed through the energy attenuator. After it is passed through the beam homogenizer to homogenize the beam. The target illuminator and machine vision controls the beam to the focusing lens. The lens is moved by precision motion stages. The beam is then falls on the work piece and the machining is takes place.

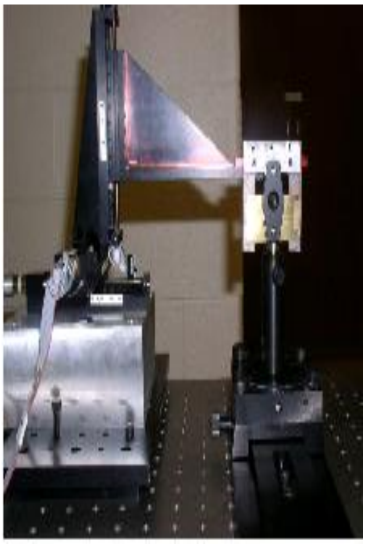
Characteristics of Femtosecond Laser Micromachining

- Very high peak powers in the range 1013W/cm2 provide for minimal thermal damage to surroundings
- Very clean cuts with high aspect ratios
- Sub-micron feature resolution
- Minimal redeposition
- Possible to machine transparent materials like glass, sapphire etc

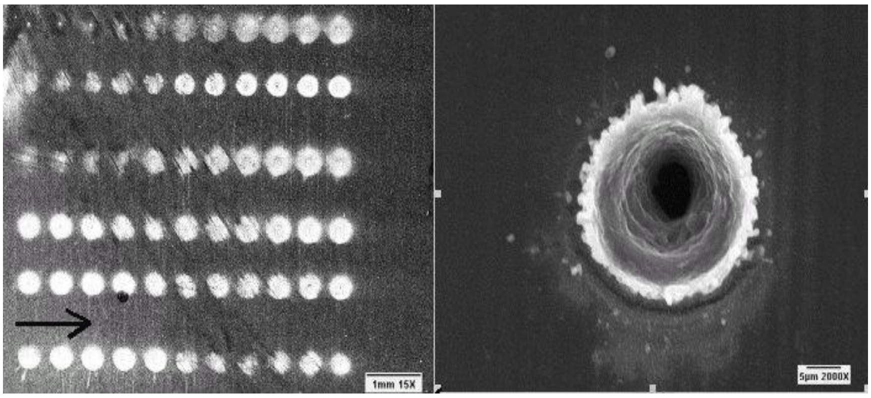
Ultra short Pulses vs. Long Pulse Micromachining



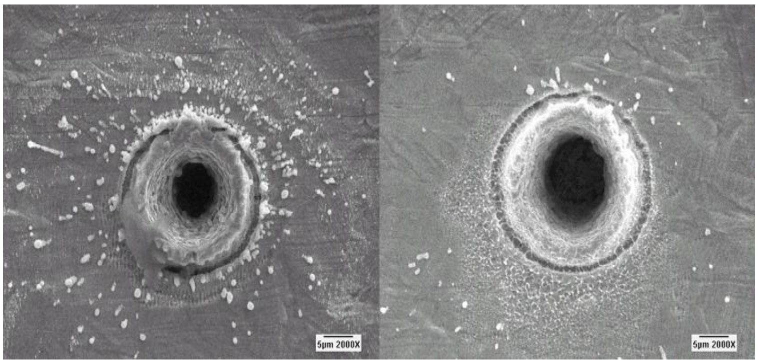
Femtosecond Laser Micromachining



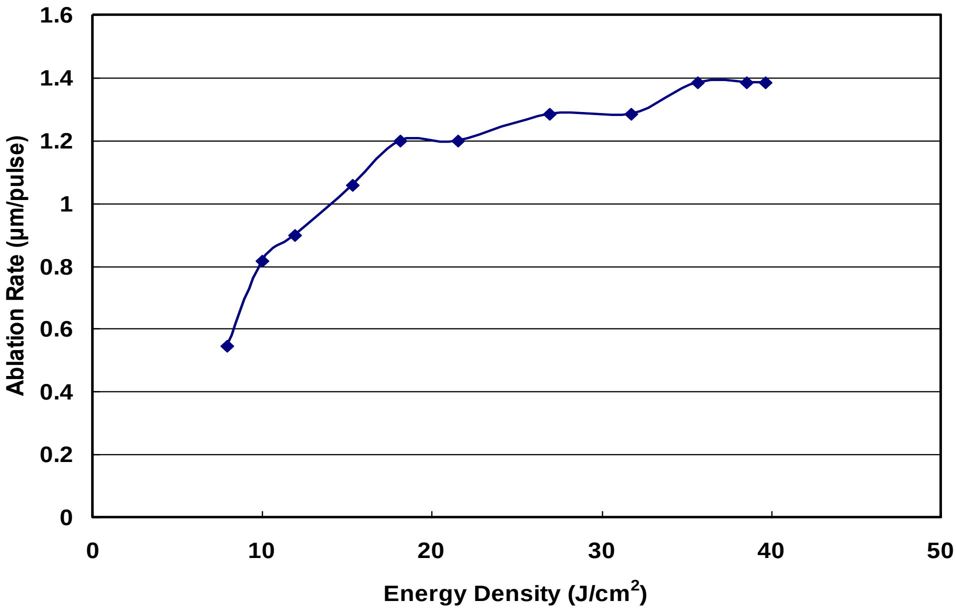
Micromachining in 18µm Thick Aluminum Foil



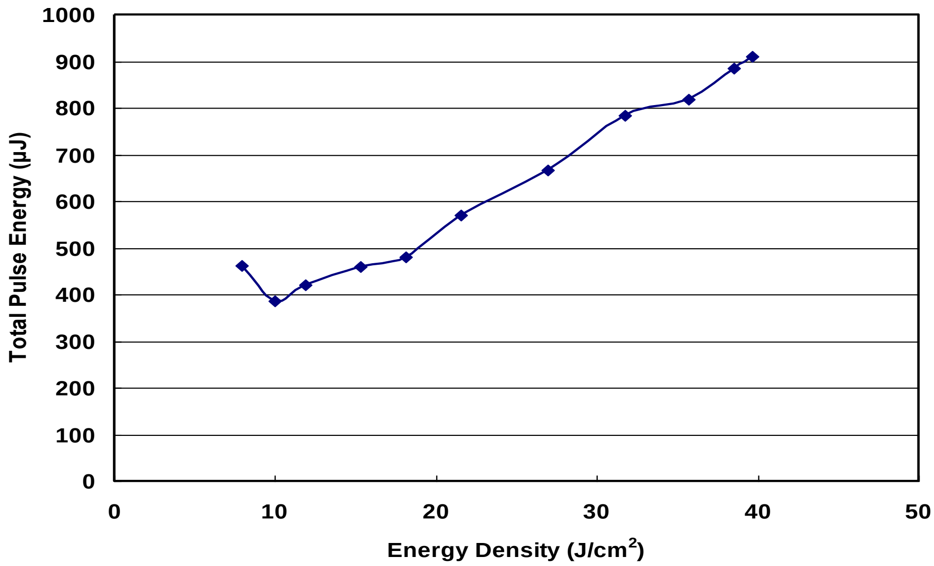
Holes drilled in 25µm thick brass foil



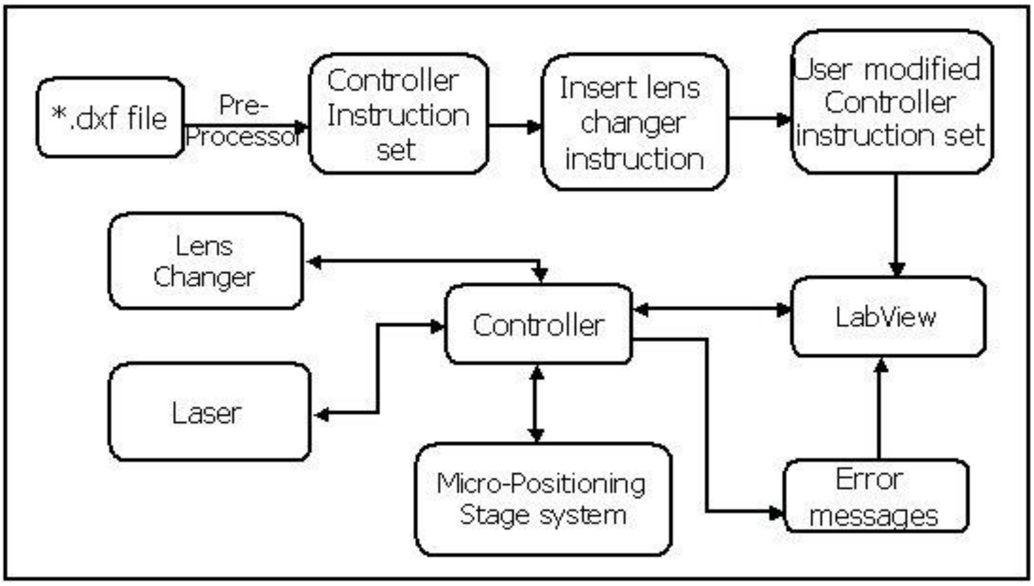
Ablation Rate vs. Energy Density in 18µm Thick Aluminum Foil



Optimization of Pulse Energy Required to Drill Holes



Automation of Laser Micromachining Process



Application of micromachining

- Micro milling
- Micro grinding
- Chemical etching
- Micro punching
- Manufacturing of injection nozzles, Micro surgical tools, VLSI circuits

Micromilling & MicroGrinding

Among the conventional machine processes based on material removal from a workpiece, the most popular case those in which the useless part of the workpiece is removed by mechanical force through plastic or brittle breakage. In the process of this type, the first requirement of micromachining ,small Ur. Is satisfied when a high stress that causes breakage of material is applied to a very small areaor volume of the workpiece. Although cutting is the most conventional machining process, the availability of ultra precision cutting machines with highest level of positioning accuracy, has enabled us to apply this process in micromachining.. Turning, milling and griding are example of processes of this type. For realising this a tool that was its edge sharpe

Micromilling & Microdrilling is capable of the fabricating holes several tens of micrometers in size for practical applications other types of products such as grooves, cavities and 3D convex shapes may be fabricated when micro end mill is used instead of a micromill. In such cases, the machining force exerts a larger influence on accuracy because the main direction of the force is perpendicular to the tool axis.

Microgrinding can be applied to the fabrication of micropins and microgrooves, where a grinding wheel with large diameter can be used for such application. The only requirement is to reduce the thickness of the grinding wheel to the required resolution of the product, for example, the width of the grove. The thickness of tens of micrometer order is available so far and correspondingly narrow grooves are reasonable targets of this method. Submicron –order grains of diamond, tungsten carbide or CBN are desirable for realizing good product geometry. The UR of grinding is small because cutting is realized by means of micrograins. However, in the field of micromaching, it is not always a superior method. One of the technological problems is the fact that the tool must be made up of an abrasive and a matrix .when the tool size is very small, the grain size cannot be ignored; this leads to certain difficulties in forming the precise shape of the grinding wheel.

Chemical etching

Chemical or electrochemical dissolution in liquid is also utilized in micromachining. In this type of process, the removal mechanism is based on ionic reaction on the workpiece surface. This leads to very small UR in the direction perpendicular to the surface. The other two dimensions are usually specified by patterned mask. The advantages in etching besides a small UR are as follows:

- The machining force is almost zero
- The surface after machining is free from any damage, residual stress or heat effects
- The mechanical properties of the workpiece do not influence the removal mechanism
- In most cases the dissolution phenomenon renders the workpiece surface smooth.

Chemical etching is the process of removing layers of silicon in the atomic dimensional level through chemical reaction between a chemical etchant solution and the exposed silicon surfaces. The bonds between the atoms on the surface and the ones immediately underneath are broken in the process and the surface atoms come out loose. If the etching proceeds predominantly in one direction while the etching does not proceed in the perpendicular direction, then it is called as anisotropic etching. In contrast, if is called isotropic etching. The following are the two types of etching predominantly used.

Punching (plastic Deformation)

As there is neither removal nor addition of material in these processes , UR is meaningless. In order to introduce this method into micromachining, we must be able to manufacture the micropounch and die can be produced by applying appropriate micromachining technologies explained above. Therefore, the realisation of micropouncing depends on the development of a system that ensure easy setting of microtools.

The most remarkable advantage is the production speed in many cases, the machining time is of millisecond order in principle. This indicates the suitability of these processes for mass production . the main issue ----- loss of accuracy is the spring back phenomenon or the partial recovery from deformation after processing. Another issue is the flowability limit of the workpiece material. The flowability is sometimes insufficient to follow the sharp corners of the die/mold . the basic restriction of these processes is that only workpieces softer than the die/mold can be processed.

Conclusion

Technology and ‘request to technology’ influence each other. As a result, the front of technology advances as the front of request to technology moves to a higher level. As regards micromachining the dimensions of the product is one of the good indicator of the levels of technology and request. How ever, he level of request from the industry varies widely. The development of technology owes much to the high end of the request. Consequently, the average level of the request is always behind the front of technology.

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Exhaust Gas Recirculation

By R.G.Gowthamraj (151011) II Year C Section

1. Introduction

All internal combustion engines generate power by creating explosions using fuel and air. These explosions occur inside the engine's cylinders and push the pistons down, which turns the crankshaft. Some of the power thus produced is used to prepare the cylinders for the next explosion by forcing the exhaust gases out of the cylinder, drawing in air (or fuel-air mixture in non-diesel engines), and compressing the air or fuel-air mixture before the fuel is ignited.

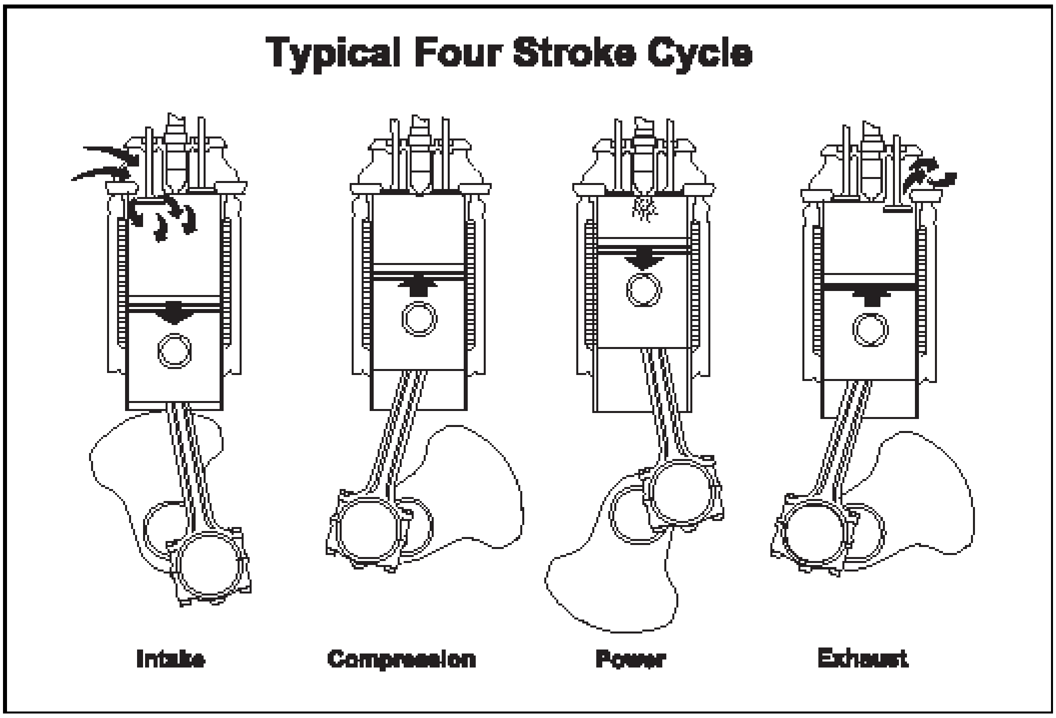

Fig 1. Working of four stroke engine.

There are several differences between diesel engines and non-diesel engines. Non-diesel engines combine a fuel mist with air before the mixture is taken into the cylinder, while diesel engines inject fuel into the cylinder after the air is taken in and compressed. Non-diesel engines use a spark plug to ignite the fuel-air mixture, while diesel engines use the heat created by compressing the air in the cylinder to ignite the fuel, which is injected into the hot air after compression. In order to create the high temperatures needed to ignite diesel fuel, diesel engines have much higher compression ratios than gasoline engines. Because diesel fuel is made of larger molecules than gasoline, burning diesel fuel produces more energy than burning the same volume of gasoline. The higher compression ratio in a diesel engine and the higher energy content of diesel fuel allow diesel engines to be more efficient than gasoline engines.

1.1 Formation of Nitrogen Oxides (NOx)

The same factors that cause diesel engines to run more efficiently than gasoline engines also cause them to run at a higher temperature. This leads to a pollution problem, the creation of nitrogen oxides (NOx). You see, fuel in any engine is burned with extra air, which helps eliminate unburned fuel from the exhaust. This air is approximately 79% nitrogen and 21% oxygen.

When air is compressed inside the cylinder of the diesel engine, the temperature of the air is increased enough to ignite diesel fuel after it is ignited in the cylinder. When the diesel fuel ignites, the temperature of the air increases to more than 1500°F and the air expands pushing the piston down and rotating the crankshaft.

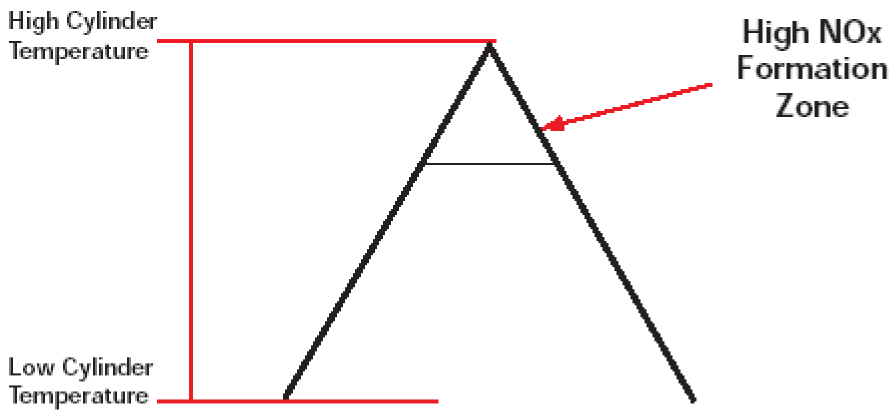

Fig 2. NOx formation zone.

Generally the higher the temperature, the more efficient is the engine

1. Good Performance
2. Good Economy

Some of the oxygen is used to burn the fuel, but the extra is supposed to just pass through the engine unreacted. The nitrogen, since it does not participate in the combustion reaction, also passes unchanged through the engine. When the peak temperatures are high enough for long periods of time, the nitrogen and oxygen in the air combines to form new compounds, primarily NO and NO2. These are normally collectively referred to as "NOx".

1.2. Problems of NOx

Nitrogen oxides are one of the main pollutants emitted by vehicle engines. Once they enter into the atmosphere, they are spread over a large area by the wind. When it rains, water then combines with the nitrogen oxides to form acid rain. This has been known to damage buildings and have an adverse effect on ecological systems.

Too much NOx in the atmosphere also contributes to the production of SMOG. When the sunrays hit these pollutants SMOG is formed. NOx also causes breathing illness to the human lungs.

1.3. EPA Emission Standards

Since 1977, NOx emissions from diesel engines have been regulated by the EPA (Environmental Protection Agency). In October 2002, new NOx standards required the diesel engine industry to introduce additional technology to meet the new standards

The EPA has regulated heavy duty diesel engines since the 1970s. The following chart shows the trend to ever-lower emissions. Understanding the details of the chart is not of interest to most truckers. Even though the emissions standards become increasingly more difficult to meet, the diesel engine industry has always been able to continue to improve engine durability, reliability, performance, and fuel economy. A quick look at the bottom right hand side of the chart also shows that emissions from diesel engines built in 2007 and beyond will approach zero.

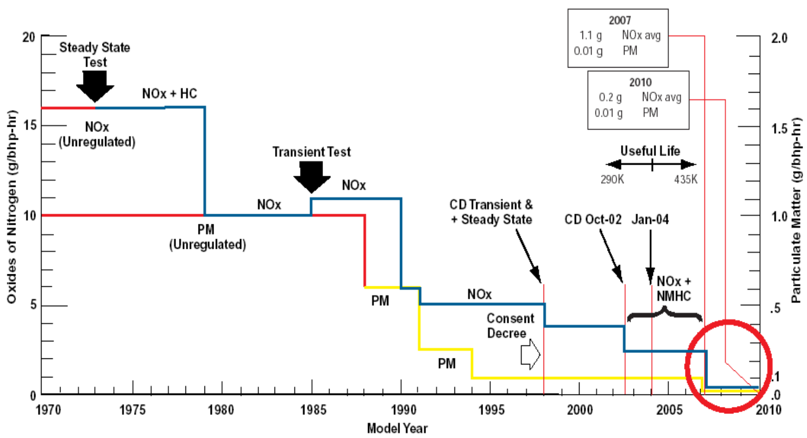

Fig 3. EPA Heavy Duty Engine Emission Standards

1.4. How can NOx be reduced?

Since higher cylinder temperatures cause NOx, NOx can be reduced by lowering cylinder temperatures. Charge air coolers are already commonly used for this reason.

Reduced cylinder temperatures can be achieved in three ways.

- Enriching the air fuel (A/F) mixture.
- Lowering the compression ratio and retarding ignition timing.
- Reducing the amount of Oxygen in the cylinder

Enriching the air fuel (A/F) mixture to reduce combustion temperatures. However, this increases HC and carbon monoxide (CO) emissions. Also Lowering the compression ratio and Retarded Ignition Timing make the combustion process start at a less than the optimum point and reduces the efficiency of combustion.

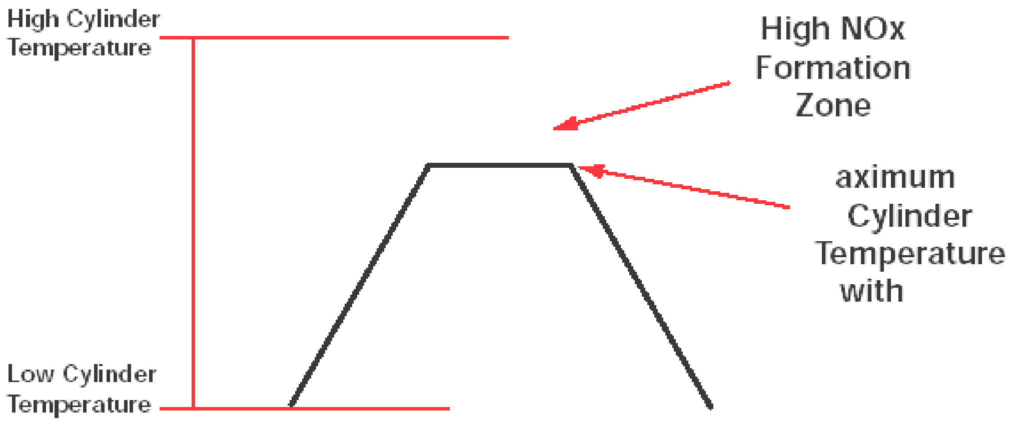

Fig 4. NOx reduction by lowering the temperature

These techniques lowers the cylinder temperature, reducing NOx, but it also reduces fuel economy and performance, and creates excess soot, which results in more frequent oil changes. So, the best way is to limit the amount of Oxygen in the cylinder. Reduced oxygen results in lower cylinder temperatures. This is done by circulating some exhaust gas and mixing it into the engine inlet air. This process is known as Exhaust Gas Recirculation.

2. Exhaust gas Recirculation

Exhaust Gas Recirculation is an efficient method to reduce NOx emissions from the engine. It works by recirculating a quantity of exhaust gas back to the engine cylinders. Intermixing the recirculated gas with incoming air reduces the amount of available O2 to the combustion and lowers the peak temperature of combustion. Recirculation is usually achieved by piping a route from the exhaust manifold to the intake manifold. A control valve within the circuit regulates and times the gas flow.

2.1. Uses of Exhaust Gas Recirculation

First, exhaust gas recirculation reduces the concentration of oxygen in the fuel-air mixture. By replacing some of the oxygen-rich inlet air with relatively oxygen-poor exhaust gas, there is less oxygen available for the combustion reaction to proceed. Since the rate of a reaction is always dependent to some degree on the concentration of its reactants in the pre-reaction mix, the NOx-producing reactions proceed more slowly, which means that less NOx is formed.

In addition, since there is less oxygen available, the engine must be adjusted to inject less fuel before each power stroke. Since we are now burning less fuel, there is less heat available to heat the fluids taking place in the reaction. The combustion reaction therefore occurs at lower temperature. Since the temperature is lower, and since the rate of the NOx-forming reaction is lower at lower temperatures, less NOx is formed.

2.2. Basic Parts of EGR

There are 3 basic parts of EGR

1. EGR Valve
2. EGR Cooler
3. EGR Transfer Pipe

Typical Four Stroke Diesel Engine with Basic Parts of EGR

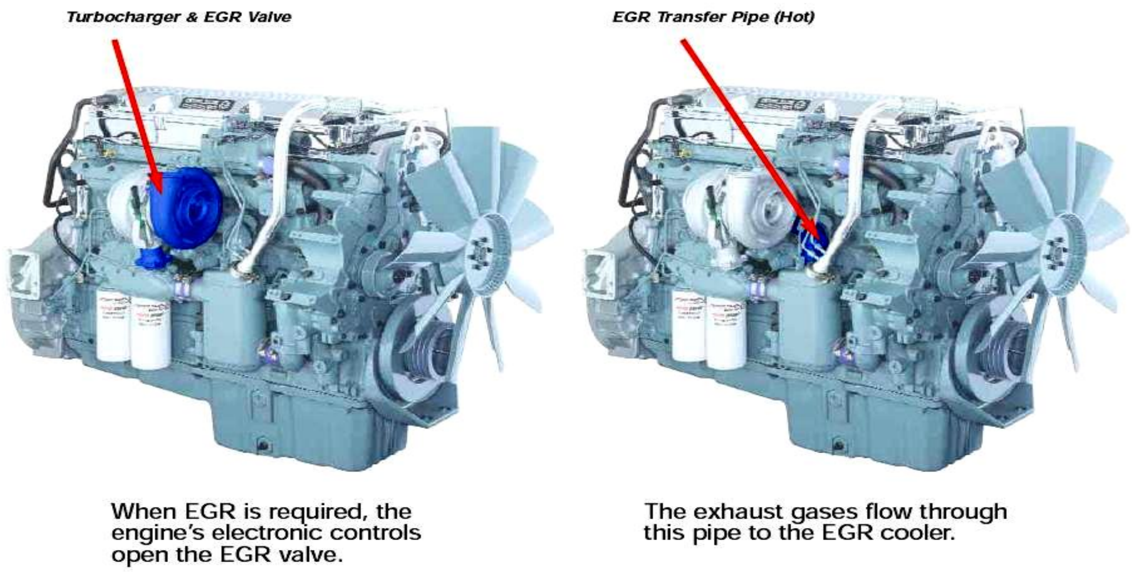

Figure 5

When EGR is required engine electronic controls open the EGR valve. The exhaust gas then flows through the pipe to the cooler. The exhaust gases are cooled by water from the truck cooling system. The cooled exhaust gas then flow through the EGR transfer pipe to the intake manifold.

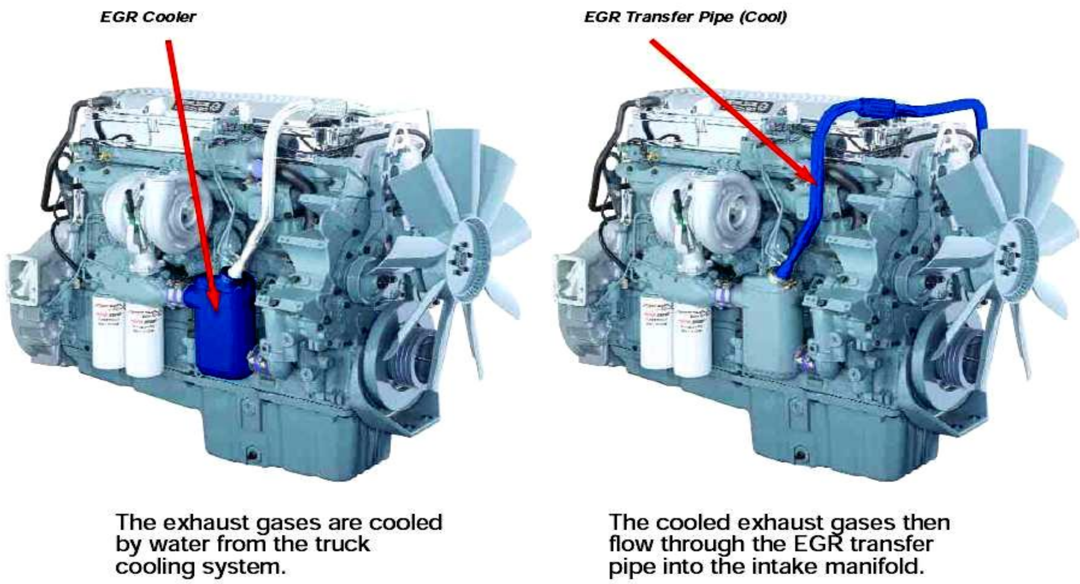

Figure 6

2.3. EGR Operating Conditions

There are three operating conditions. The EGR flow should match the conditions

1. High EGR flow is necessary during cruising and midrange acceleration
2. Low EGR flow is needed during low speed and light load.
3. No EGR flow should occur during conditions when EGR flow could adversely affect the engine operating efficiency or vehicle drivability. ie, during engine warm up, idle, wide open throttle, etc.

2.4. EGR Impact on ECS

The ECM (Electronic Control Machine) considers the EGR system as an integral part of the entire ECS. Therefore the ECM is capable of neutralizing the negative aspects of EGR by programming additional spark advance and decreased fuel injection duration during periods of high EGR flow. By integrating the fuel and spark control with the EGR metering system, engine performance and the fuel economy can actually be enhanced when the EGR system is functioning as designed.

2.5. EGR Theory of Operation

The purpose of the EGR system is to precisely regulate the flow under different operating conditions. The precise amount of exhaust gas must be metered into the intake manifold and it varies significantly as the engine load changes. By integrating the fuel and spark control with the EGR metering system, engine performance and the fuel economy can be enhanced. For this an ECM (Electronic Control Machine) is used to regulate the EGR flow. When EGR is required ECM opens the EGR valve.The ECM is capable of neutralizing the negative aspects of EGR by programming additional spark advance and decreased fuel injection duration during periods EGR flowThe exhaust gas then flows through the pipe to the cooler. The exhaust gases are cooled by water from the vehicle's cooling system. The cooled exhaust gas then flow through the EGR transfer pipe to the intake manifold.

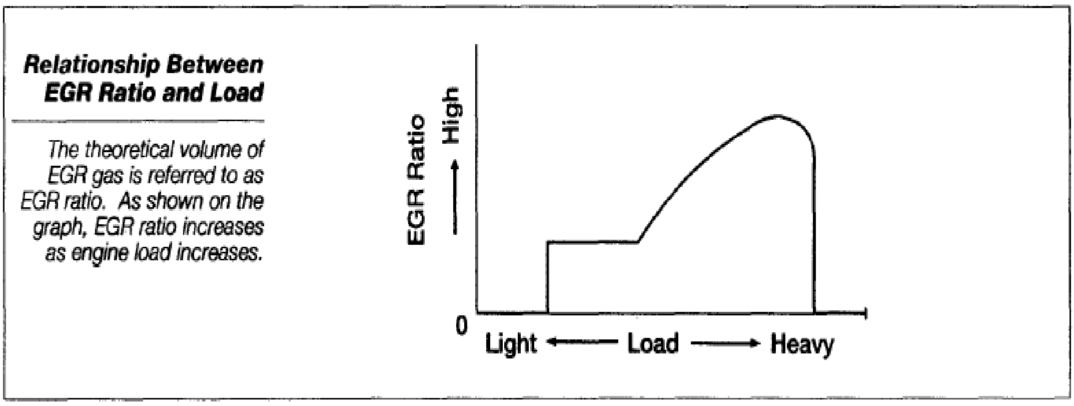

Fig 7. Relationship between EGR Ratio and Load

4. EGR Limits

This is based on an experiment conducted. The research objective is to develop fundamental information about the relationship between EGR parameters and diesel combustion instability and particulate formulation so that options can be explored for maximizing the practical EGR limit, thereby further reducing nitrogen oxide emissions while minimizing particulate formation. A wide range of instrumentation was used to acquire time-averaged emissions and particulate data as well as time-resolved combustion, emissions, and particulate data. The results of this investigation give insight into the effect of EGR level on the development of gaseous emissions as well as mechanisms responsible for increased particle density and size in the exhaust. A sharp increase in hydrocarbon emissions and particle size and density was observed at higher EGR conditions while only slight changes were observed in conventional combustion parameters such as heat release and work. Analysis of the time-resolved data is ongoing.

The objective of this work is to characterize the effect of EGR on the development of combustion instability and particulate formation so that options can be explored for maximizing the practical EGR limit. We are specifically interested in the dynamic details of the combustion transition with EGR and how the transition might be altered by appropriate high-speed adjustments to the engine. In the long run, we conjecture that it may be possible to alter the effective EGR limit (and thus NOx performance) by using advanced engine control strategies.

Experiments were performed on a 1.9 liter, four-cylinder Volkswagen turbo-charged direct injection engine under steady state, low load conditions. Engine speed was maintained constant at 1200 rpm using an absorbing dynamometer and fuel flow was set to obtain 30% full load at the 0% EGR condition. A system was devised to vary EGR by manually deflecting the EGR diverter valve. The precise EGR level was monitored by comparing NOx concentrations in the exhaust and intake. NOx concentrations were used because of the high accuracy of the analyzers at low concentrations found in the intake over a wide range of EGR levels.

4.1. Combustion Characterization with HC and NOx Emissions

Steady state measurements were made of CO, CO2, HC, NOx, and O2 concentrations in the raw engine-out exhaust using Rosemount and California Analytical analyzers. Crank angle resolved measurements were also made of HC concentration in the exhaust using a Fast Flame Ionization Detector. The HC sampling probe was located in the exhaust manifold and the data were recorded.

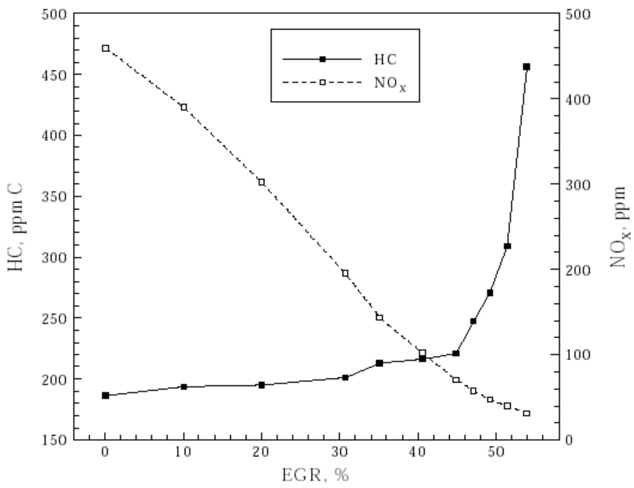

Fig 8. Trade-off between HC and NOx concentration as a function of EGR Level

Time-averaged HC and NOx concentrations in the raw engine-out exhaust are shown in the Figure versus EGR level. This figure shows NOx concentration decreasing and HC increasing with increasing EGR as would be expected. Note the sudden increase in HC and leveling-off in NOx at approximately 45% EGR, where there appears to be a significant shift in combustion chemistry. This major transition is in sharp contrast to the slight changes observed in the integrated pressure parameters, HR and IMEP. Because of the suddenness of the emissions change at 45% EGR, it is clear that dynamic engine behavior at or above this operating point will be highly nonlinear. Thus it is imperative that any control strategies being considered should be able accommodate such behavior.

4.2. Combustion Characterization with PM

Our measurements have identified significant changes in PM emissions with EGR level as was expected. Similar to the gaseous emissions (e.g., HC and NOx), there was a sharp increase in PM at a critical EGR level. This critical level corresponding to a sharp increase in PM was observed in mass concentration, particle size, and particle density.

Mass Concentration

A Tapered Element Oscillating Microbalance (TEOM) was used to measure particulate mass concentration and total mass accumulation as a function of time. A sample of diluted exhaust is pulled through a 12 mm filter to the end of a tapered quartz element. The frequency of the element changes with mass accumulation. The instrument has approximately 3 sec resolution on mass concentration.

Particle mass concentration and total mass accumulation were measured on dilute exhaust using the TEOM. Mass accumulation rates were calculated based on over 100 mass data points and are shown in the figure as a function of EGR level. Mass accumulation rates begin to increase significantly at 30% EGR and continue to increase rapidly until the maximum EGR level. The intersection of the particulate mass and NOx curves represents a region where the engine out particulate mass and NOx concentration are minimized for this engine condition.

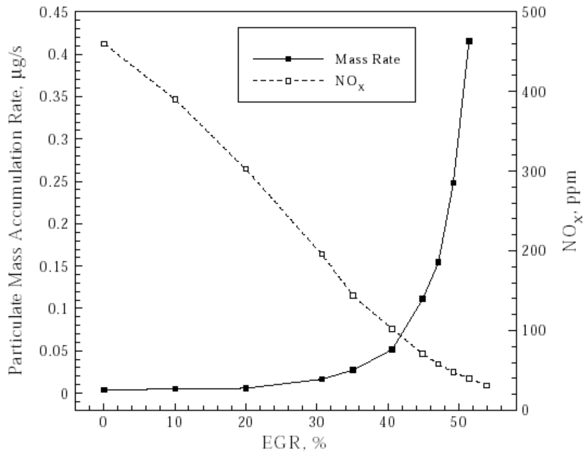

Fig 9. Relation of PM Accumulation Rate and NOx emission with EGR.

Particle Size

A Scanning Mobility Particle Sizer (SMPS) was used to measure the steady state size distribution of the particulates in the exhaust stream. The particles are neutralized and then sorted based on their electrical mobility diameter. The range of the SMPS was set at 11 nm – 505 nm.

Particle sizing was performed on dilute exhaust using the SMPS. Number concentration vs. particle diameter is shown in the figure for several EGR levels. Two aspects of the data stand out. The first is the increasing number concentration with level of EGR. The second is the increasing particle size. Note that the particle size at the peak concentration increases by a factor of approximately two between 30% and 53% EGR.

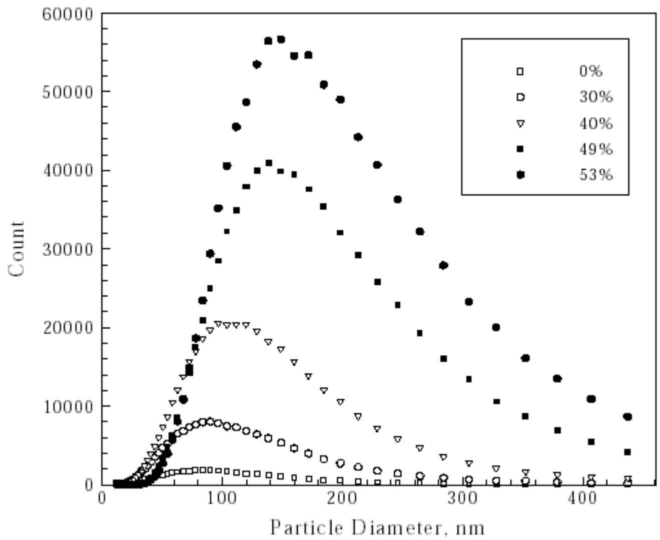

Fig 10. Time-averaged size distributions as measured by the SMPS.

The likely mechanism for particle growth is the reintroduction of particle nuclei into the cylinder during EGR. The recirculating exhaust particles serve as sites for further condensation and accumulation leading to larger particles. A significant fraction of the measured size distribution appears larger than the 500 nm upper bound of the SMPS for the highest EGR rates. This is significant because these particles contain much of the exhaust particulate mass.

The frequency plot in the figure illustrates the disappearance of small particles and the growth of much larger particles. The divergence between the curves for particles > 100 nm and particles 60-100 nm increases significantly at 30% EGR and continues to increase. The figure does appear to show that the smallest particles are contributing to the growth of the largest ones. The increase in larger particles is less steep than the increase in particle mass in the figure.

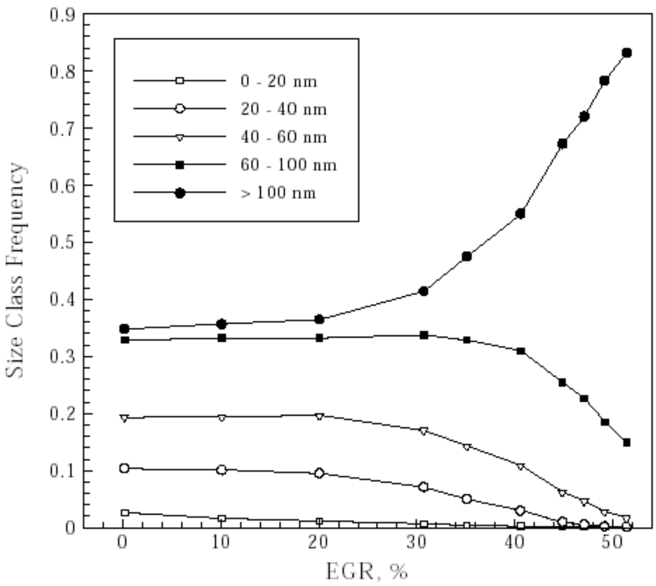

Fig 11. Frequency of occurrence of particle size classes as a function of EGR.

4.3. NOx reduction effect of EGR

Fig. 12 shows the typical NOx reduction effect of EGR at the mid-speed range of the test engine.Under all load conditions, the amount of NOx decreases as the EGR rate increases. The graph also shows that the NOx reduction curves with the 0 % EGR point as the origin slope downward at different angles according to the load; the higher the load, the steeper the angle. In other words, the NOx reduction effect at the same EGR rate increases as the engine load becomes higher.

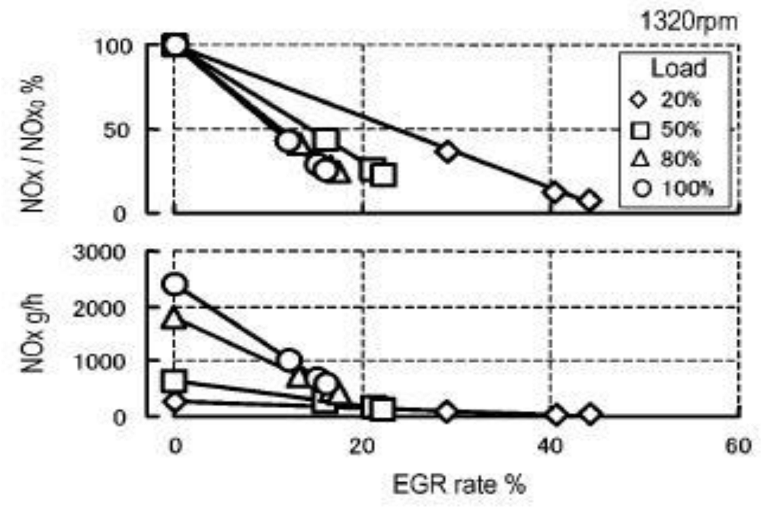

Fig.12. Relationship between EGR rate and NOx

It is generally known that there are two reasons to reduce NOx by EGR. The first of them is the reduction of combustion temperature. The addition of exhaust gases to the intake air increases the amount of combustion- accompanying gases (mainly CO2), which in turn increases the heat capacity and lowers the combustion temperature. The second effect is the reduction of oxygen concentration in the intake air, which restrains the generation of NOx. **Fig. 13** shows the NOx emission test results as a function of the concentration of oxygen in the intake air/EGR gas mixture. This graph shows that the NOx reduction rate depends mostly on oxygen concentration, and not on the engine load or EGR rate.

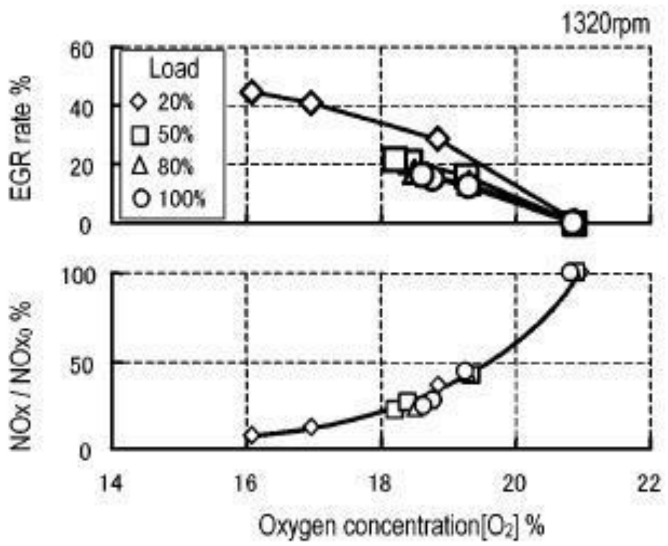

Fig 2 Relationship between oxygen concentration and NOx reduction

Fig.13 shows the results of NOx emission tests conducted while varying both the engine operating conditions and EGR rate, in which the test results shown in **Fig. 13** are merged. As in **Fig.13**, almost all the data are on or in a single curve, indicating that there is a strong correlation between the oxygen concentration and NOx reduction rate. The reason for this is thought to be as follows: In **Fig.12**, the NOx reduction rate under a certainload is different from that under another load even when the EGR rate remains the same because the difference in load causes a difference in the amount of combustion-accompanying gases and oxygen concentration in EGR gas, which in turn changes the oxygen concentration in the intake gas (mixture of intake air and EGR gas).

5. Internal EGR

When a fraction of the combustion products is still present in the cylinder at the moment that the exhaust valves close, the mixture at the beginning of the next engine cycle will consist of air and fuel, as well as combustion products. These products are called internal EGR (in contrast to external EGR, which means that exhaust gases are recycled to the intake system, after which they mix with the air and fuel.) The fraction of internal EGR that is present in the cylinder at the beginning of the compression stroke is mainly dependent on the timing of the intake and exhaust valves.

The **valve timing** of traditional engines, such as the Diesel and Otto engines, is such that the fraction of exhaust gases (or residuals) at the start of the cycle is as small as possible. Traditional engines have Residual Gas Fractions (RGF) in the range 5-15 mass%.

6. Technical Issues

6.1. Combustion Contamination

Exhaust gas from any combustion process may have certain contaminants, including acid forming compounds, unburned and partially burned hydrocarbons, air pollutants, and liquid water. These contaminants can be successfully reintroduced into the combustion chamber but may lead, over time, to serious combustion degradation and instability, and shorter component life. Such effects need to be fully understood and documented, and appropriate improvements made to the combustion process to protect the customer’s investment and maintain true long-term emissions compliance. This activity would be a key element of any major engine manufacturer’s development process.

6.2. Control System Stability

Control systems for modern engines have been developed over two decades and involve integrated strategies to adjust air/fuel ratio, ignition timing, and air flow rates to maintain emissions control at varying loads, speeds, and fuel conditions. These systems are at the heart of successful engine operation today and are vital to satisfactory long term operation. Adding EGR into the combustion process introduces further complexity that must be carefully integrated into the entire engine control system approach for successful operation over a wide range of conditions. For instance, if fuel quality changes over time, the air/fuel ratio, ignition timing, air system rates, and the EGR rate must be adjusted accordingly to keep the combustion system stable and emissions in compliance. On the other hand, if the engine's load changes rapidly from part load to full load and back to part load, the EGR system dynamics must be included in the overall control strategy response to make sure the engine operates smoothly during this transition.

6.3. Materials and Durability

EGR systems may decrease long-term life of the components affected, including the EGR coolers and control valves, the pistons and cylinder heads, exhaust manifolds and sensors, as well as the post engine catalyst. Operating a few hundred hours per year may not lead to any significant materials degradation in the overall lifespan of an engine. However, continuous duty applications at 8500 hours per year may cause near term emissions noncompliance and longer term materials breakdown, shorter component life, and even unexpected, catastrophic engine failures. To minimize or eliminate the potentially negative impacts of EGR on engine components, compatible components and designs must be used that often require thousands of hours of lab and field test operation for validation. Although both expensive and time consuming, such efforts are a necessary part of proving any new combustion design including EGR systems. Therefore, major engine manufacturers worldwide need to plan for and execute these tests in order to develop the materials needed for successful EGR applications.

6.4. Liquid Dropout

During exhaust gas recirculation, the gasses must be cooled with an external cooler before being reintroduced into the cool inlet manifold of an engine. The cooling process for the EGR may result in liquids being formed in the return lines, depending on temperatures and local humidity, much as liquids are formed in the tailpipe of an automobile at certain conditions. This liquid dropout could be a continuous stream that needs to be carefully understood and managed with the needs of the local environment in mind. While there may be ways to reintroduce this liquid into the combustion process, doing so may create further problems with combustion and lead to other emissions complications and instability. As such, managing liquid dropout needs careful study and development in an integrated development program.

7. Conclusion

Thus, as seen that using Exhaust Gas Recirculation Technique in engines, the emissions are vary much controlled due to lesser amounts of NOx entering the atmosphere. Thus the emission levels to be maintained are attained by the engines. As seen, Exhaust Gas Recirculation is a very simple method. It has proven to be very useful and it is being modified further to attain better standards. This method is very reliable in terms of fuel consumption and highly reliable. Thus EGR is the most effective method for reducing the nitrous oxide emissions from the engine exhaust. Many of the four wheeler manufacturers used this technique like Ford Company, Benz Motors etc to improve the engine performance and reduce the amount of pollutants in the exhaust of the engine.

PROGRAM OUTCOMES (POs)

Mechanical Engineering Graduates will be able to

1.	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to solution of complex engineering problems.
2.	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3.	Design / development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4.	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5.	Modern tool usage: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6.	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7.	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8.	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9.	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10.	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11.	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects in multidisciplinary environments.
12.	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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MISSION

To Develop and Make Students Competent Professional in the Dynamic Environment in the field of Engineering, Technology and Management by emphasizing Research, Social Concern and Ethical Values through Quality Education System.

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