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Performance Analysis of Inlet-Outlet Valve Time Parameters Applied to Automobile Industry

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Abstract: *We have reviewed technical ,numerical and experimental papers of different investigators proposed new innovation ideas in the development of valve timing parameters for diesel and petrol engines single or multi cylinder two or four stroke engines in this paper. Development in advanced Variable Valve Actuation technology with Multi Air system and to improve engine performance parameters like specific fuel consumption, brake thermal efficiency and mechanical efficiency etc. in automobile industry, experiments were conducted by adjusting the valve lift and opening period in rocker arms and testing various follower configurations in a commercially-available rocker arm and made comparison was made different levels of valve lift and opening period in the intake and exhaust valves mechanism have reported in their technical papers. The development of a new exhaust rotary valve enabling the control of the opening independently from the control of the closure of the exhaust port based on kinetic and thermodynamic analysis in premixed combustion and heterogeneous compression combustion have been adopted to improve the control of emissions from automobile engines.*

I. Introduction:

Mateos Kassa et al [1] presented in their technical paper the impact of the intake valve timing on knock propensity is investigated on a dual-fuel SI engine leveraging a low octane fuel and a high octane fuel to adjust the fuel mixture's octane rating (RON) based on operating point. Variations in the intake valve timing have a direct impact on residual gases concentration due to valve overlap and changes in the compression pressure and temperature due to variations of the effective compression ratio. In this study, it was shown that the fuel RON requirement for a non-knocking condition at a fixed operating point can vary significantly solely due to variations of the intake valve timing. The fuel RON requirement at 2000 rpm and 6 bar BMEP ranges between 80 to 90 as a function of VVT, and between 98 to 104 at 2000 rpm and 14 bar BMEP. Xianlin Ouyang et al [2] presented in their technical paper effective approaches for improving the gasoline engine fuel economy for both Atkinson and Miller cycles, the engine can be designed with a higher geometric compression ratio for increasing the expansion work and the effective compression ratio was governed by the intake valve close (IVC) timing for the knock control. Duration of the intake event and IVC timing affect not only the pumping loss during the gas exchange, but also have strong influences on the friction torques of the intake cams and the turbulence intensities for the in-cylinder charge motion. The latter governs duration of combustion and EGR tolerance, both of which have impacts on the engine thermal efficiency. Dojoong Kim et al [3] presented in their technical paper the development of an end pivot rocker arm type two-step VVA mechanism, in which single cam drives two valves. The mode conversion of the two-step variable mechanism is done by an electronic switching system instead of a conventional hydraulic system. Luigi Teodosio et al [4] presented in their technical paper a promising technique to cope with the above drawbacks consists in the Variable Compression Ratio (VCR) concept. An optimal Compression Ratio (CR) selection, in fact, allows for further improvements of the thermodynamic efficiency at part load, while at high load, it permits to mitigate knock propensity, resulting in more optimized combustions.

Andrea Piano et al [5] presented in their technical paper a simulation for the impact of Variable Valve Actuation technology on the exhaust temperature of a modern light duty engine attached with a Variable Geometry Turbine.Mirko Baratta et al [6] presented

in their technical paper the development of a small displacement turbocharged engine, which combines the advanced Variable Valve Actuation technology MultiAir system for the air metering with the direct injection of natural gas. The activity focused on the development and fluid-dynamic characterization of the gaseous-fuel injector.

Igor Trevas et al [7] presented in their technical paper a comparison between different way of actuation in combustion analysis of a Variable Valve Actuation system on a spark ignition engine. Guy Babbitt et al [8] presented in their technical paper an overview of the analysis and design of the Digital camless valve train including the architecture and design of the valve and head and the details of the electric valve actuator, and the flow characteristics of the valves and resulting charge motion in a motoring engine. The valve stroke provides the full flow area about 25% of the stroke of the equivalent poppet valve, thus saving electrical actuation with very low power consumption. Dileep Malkhede et al [9] presented in their technical paper a numerical model for the kinematic analysis of a continuous variable valve lift . It consists of eccentric shaft fitted with a series of intermediate rocker arm, which in turn control the degree of valve lift. The main characteristic of this mechanism was that it uses a general curve contact between the elements, which was determined using theory of envelope curve. Shinji Kasatori et al [10] presented in their technical paper the development of an alloy of titanium exhaust valves and heat-resisting titanium alloy with high deformation resistance because of its superior strength at high temperature. José Ramón Serrano et al [11] presented in their technical paper the influence of several design parameters was studied by modeling approach under steady state operating conditions in a Diesel engine. Jorge Martins et al [12] presented in their technical paper the development of a new exhaust rotary valve enabling the control of the opening independently from the control of the closure of the exhaust port. The study was based on kinetic and thermodynamic analysis. Yan Chang et al [13]. presented in their technical paper the negative valve overlap was used as an alternative method of dilution in which early exhaust valve closing causes combustion products to be retained in the cylinder and recompressed near top dead center, before being mixed with fresh charge during the intake stroke. The potential for fuel injection during negative valve overlap to extend the dilution limit of spark ignition combustion was evaluated in this work using experiments conducted on a gasoline direct injection engine with variable intake and exhaust valve timing.

Xiangyu Zhang et al [14] presented in their technical paper experiments were conducted to study the effects of five different valve strategies, including three intake valve closure timing strategies and two rebreathing strategies on the combustion and emission characteristics at various low loads on a heavy-duty diesel engine. In order to control the NO_x emissions within low levels, the externally cooled exhaust gas recirculation was used .

Bernhard Semlitsch et al [15] presented in their technical paper the consequences of the valve and piston motion onto the energy losses and the discharge coefficient. Large Eddy Simulations are performed in a realistic internal combustion geometry using three different modeling strategies that is fixed valve lift and fixed piston, moving piston and fixed valve lift, and moving piston and moving valve, to evaluate the heat losses. The differences in the flow field development with the different modeling approaches was delineated and the dynamic effects onto the primary quantities. Ming Jia et al [16] presented in their technical paper coupling a multi-dimensional computational fluid dynamics code and genetic algorithm , the potential of high-load expansion by using late intake valve closing was explored in a light-duty diesel engine. Can Cinar et al [17] presented in their technical paper an alternative combustion mode HCCI seems as one of the most effective choice to increase the thermal efficiency and reduce the soot and NO_x emissions among the other conventional combustion modes. HCCI combustion has common properties which gasoline and diesel engines . In order to obtain HCCI combustion, using variable valve mechanism was found to be the most effective and practical method in spark ignition engines. In this study, four different valve mechanisms were used in order to extend HCCI operating range in a four stroke, single cylinder gasoline engine. The experiments were performed between 800 and 1900 rpm engine speeds.

J.P. Zammit et al [18] presented in their technical paper the influence of early inlet valve closure on emissions, fuel economy and exhaust gas temperature of a turbocharged, multi cylinder common rail direct injection diesel engine and compared with the influence of deactivating two cylinders. inlet valve closing timings were set at up to 60^0 crank angle degrees earlier than the production setting of 37^0 after bottom dead centre for the engine. At the earliest timing, effective compression ratio was reduced from 15.2:1 to 13.7:1. The effects on emissions were significant only for EIVC settings at least 40 CA degrees earlier than the production setting, and were sensitive to engine load. At 2 bar brake mean effective pressure and fixed levels of NOx, soot emissions were reduced but carbon monoxide and hydrocarbon increased unless fuel rail pressure was reduced. With increasing load, soot reduction diminished .

Kenta Goto et al [19] presented in their technical paper to improve engine torque and specific fuel consumption in a vehicle and experimentally adjusted the valve lift and opening period in rocker arms for testing various follower configurations . Using the follower configuration in a commercially-available rocker arm, we compared four different levels of valve lift and opening period in the intake, and four different levels in the exhaust, making sixteen combinations. utilizing five kinds of modified follower configurations of the rocker arms in the intake, and three in the exhaust and compared twenty four combinations at the speed of 2400rpm.

Nobuyuki Tanaka and Akihiko Kawata [20] presented in their technical paper thermal effects control using sodium filled hollow valves in preference to solid valves in order to decrease the exhaust valve temperature. The most common method for detecting the valve temperature was to find the temperature by measuring hardness on valve surface . The hardness test was applicable to the condition up to 800°C. Therefore, this paper presents new techniques for measuring the temperature for sodium-filled valve using infrared thermography and thermocouple as an alternative hardness test. The authors also examined the valve temperatures at a variety of engine speeds and cooling of the sodium-filled valve during engine operation.

Habib Aghaali and Hans-Erik Angstrom [21] presented in their technical paper the divided exhaust period technology was coupled with the turbocompound engine. In the divided exhaust period concept the exhaust flow was divided between two different exhaust manifolds, blowdown and scavenging, with different valve timings. This leads to lower exhaust back pressure and improves engine performance like the fuel consumption reduction and there was a compromise between the turbine energy recovery and the pumping work in the engine optimization.

V. De Bellis et al [22] presented in their technical paper the potentialities offered by an advanced valve lift design are numerically analyzed. In particular, the study was carried out by a one dimensional approach and regards the characterization of a VVA strategy named "pre-lift" applied to a downsized turbocharged four-cylinder engine to increase the valves overlapping..

Bozza Fabio et al [23] presented in their technical paper a numerical methodology for the engine calibration and the intake valve lift profile that simultaneously minimize the brake specific fuel consumption and the noise at part load. The engine was coupled with turbocharged Spark-Ignition Direct Injection (SIDI) ICE equipped by a lost motion valve actuation system for the intake valves. GT-Power software was used with user routines for the description of the combustion process and the handing of variable valve lift profiles.

Federico Millo et al [24] presented in their technical paper a new intake port configuration has been designed, analyzed by means of 3D CFD simulation and experimentally tested on a turbocharged Spark Ignition (SI) engine, with the aim of addressing the issue of the poor in-cylinder turbulence levels which are typical of the Early-Intake-Valve-Closing (EIVC) strategies adopted in Variable Valve Actuation (VVA) systems at part load to reduce pumping losses. The proposed intake port layout promotes turbulence by increasing the tumble motion at low valve lifts in order to achieve a proper flame propagation speed at part load. The new layout was proved to have a significant and positive effect in improving the EGR tolerance and in shortening the combustion process, especially at the lower loads, which are the more critical for VVA systems using an EIVC strategy.

Cheolwoong Park et al [25] presented in their technical paper the strategy of varying the valve overlap was employed to reduce methane emissions. Although a torque valve cannot meet engine emission specifications, the hydrocarbon and methane emissions were reduced by approximately 41% by decreasing the valve overlap duration while using HCNG fuel. Jongtai Lee, Kwangju Lee, Jonggoo Lee and Byunghoh Anh [26] presented in their technical paper the potential of simultaneously achieving high output, similar to the output of a gasoline engine, without backfire, by using a complex valve timing variation and lean boosting. The study achieved almost zero NOx emission and high efficiency in a single cylinder engine built for research purposes with a valve timing variation system. Experimental results revealed that retarding the intake valve opening timing could control the backfire generated when increasing the output of the hydrogen engine, and the method above is also effective with lean boosting. Stable combustion in the lean region of $\Phi = 0.2$, which can reduce temperature below the NOx generation temperature, was possible due to the large ultra-lean limit of hydrogen. In addition, the exhaust was almost NOx free due to the low temperature combustion, by supercharging the ultra-lean mixture under high power operation similar to that of gasoline. Rohit T. Londhe and J.M. Kshirsagar [27] presented in their technical paper material as per various parameters like Temperature, Mach inability, weld ability, Cost, availability for valve & valve seat in gas fuel engine.

Mohammed Moore Ojapah et al [28] presented in their technical paper the load can also be controlled by changing the intake valve closing timing - either early or late intake valve closing. Both strategies reduce the pumping loses and hence increase the efficiency. However the early intake valve closure (EIVC) can be used as mode transition from SI to CAI combustion.

Mickael Cormerais et al [29] presented in their technical paper a new technology for engine cooling systems that was able to control the coolant flow and temperature in relation to the engine conditions such as load and rotational speed. With a no flow in crankcase cooling strategy and a high engine temperature regulation, the Active Cooling Thermomanagement Valve succeeds in decreasing the fuel consumption without deteriorating engine's performance. Ming Jia, Yaopeng Li et al [30] presented in their technical paper the effect of late intake valve closing on combustion and emission characteristics in a diesel premixed charge compression ignition engine in a wide speed and load range.

The results indicate that the in-cylinder swirl ratio and turbulence kinetic energy are significantly enhanced with increased engine speed, while only swirl ratio was slightly affected by the variation in intake valve closing timing .

Alasdair Cairns, Hua Zhao, Alan Todd, Pavlos Aleiferis [31] presented in their technical paper the effects of gasoline–ethanol and gasoline–butanol blends on the combustion, fuel economy and engine-out emissions of a single cylinder research engine equipped with a mechanical variable valve train on the inlet and variable valve timing on the exhaust. Gasoline or iso-octane were splash blended with varying amounts of ethanol or 1-butanol and studied under a range of part-load engine conditions. During warm idle operation, high ethanol content fuels allowed significant improvement in tolerance to internally recycled burned gases, primarily associated with increased burning velocities of such blends when near to stoichiometric fuelling levels. In turn this allowed higher valve lifts to be used, with reduced throttling locally at the inlet valves, further small fuel savings and reductions in engine-out emissions of NOx.

Osama H. M. Ghazal1 et al [32] presented in their technical paper the calculations of engine performance were carried out using the simulation and analysis engineering software lotus and engine emissions using zinox program. Sensitivity analysis shows that the reduction of 10% of exhaust valve opening angle gave a reduction of around 2.5% in power and volumetric efficiency, also a slight increase in nitrogen oxide and carbon monoxide , while a 10% decrease in exhaust valve closing around 1% improvement in Power. Peter Forsberg et al [33] presented in their technical paper the regulations demand reduced amounts of soot and particles, sulfur compounds act as beneficial for the seating surfaces. The reductions are expected to increase the metal-to-metal contact. Hirokazu Suzuki etal [34] presented in their technical paper one or two injectors in an in-line four-cylinder gasoline engine, and two or three injectors in an in-line six-cylinder gasoline engine, and then investigated the resulting fuel consumption and variation rates of engine speed. We calculated fuel consumption by measuring fuel injection time and engine speed. Results indicate that, in an in-line four-cylinder gasoline engine, deactivating every other fuel injector, in cylinder firing order, making two deactivated injectors, reduced fuel consumption, compared to the usual condition with all fuel injectors activated, under idling, no-load and lighter load conditions.Ming Jia et al [35] presented in their technical paper a full-cycle computational fluid dynamics simulation coupled with detailed chemical kinetics mechanism has been used to know the effect of start of injection timing and intake valve close timing on performance and emissions of diesel premixed charge compression ignition engine. By sweeping SOI timing from −35 to −5 °CA ATDC and IVC timing from −140 to −80 °CA ATDC with fixed 50% exhaust gas recirculation (EGR) and 1.8 bar intake pressure, the contour plots for ignition timing, nitric oxides , soot, hydrocarbon , carbon monoxide , indicated specific fuel consumption , and ringing intensity have been developed. The IVC timing should be optimized with consideration of ignition timing and combustion efficiency at different SOI timing in order to improve fuel economy. For purpose of avoiding engine knock, the SOI timing around −20 °CA ATDC and early IVC timing are pursued.

II. Conclusions:

1.A continuous variable valve lift mechanism for a diesel engine consists of a driving plunger, a driven plunger, a hydraulic cylinder, and a hydraulic oil tank. Simulation was studied between maximum valve lift and rotation angle of driving plunger and the results indicate that the maximum valve lift decreases with increasing rotation angle. Rotating the driving plunger was an effective method to regulate valve lift.

2. In a diesel engine consists of combustion chamber, also having an after treatment device to treat emissions , an intake valve for passing air into the combustion chamber, and an exhaust valve for passing exhaust out of the combustion chamber, a method of operating the engine, wherein the method includes performing at least one combustion in the combustion chamber at a first exhaust valve timing and a first intake valve closure timing; determining a temperature of the exhaust gas that enters the after treatment device; and if the temperature of the exhaust gas is equal to or below a preselected temperature threshold, then performing at least one combustion in the combustion chamber at a second, earlier exhaust valve closure timing and a second later intake valve opening timing to thereby increase the internal exhaust gas recirculation and the temperature of exhaust emitted by the diesel engine.

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