Spark ignition and compression ignition internal combustion engines are the major source of propulsion of motor vehicles and non-road machinery. Scientists and engineers continuously improve existing engines to meet expectations concerning performance, fuel efficiency and exhaust emissions. Unfortunately, emission targets are always beyond capability of conventional engines. Thus, application of exhaust aftertreatment systems is necessary. Especially, removing of nitrogen oxides and particular matters from exhaust gases pose a challenge. Low temperature combustion in homogeneous charge compression ignition (HCCI) engine is initiated by spontaneous auto-ignition in multiple sites within the combustion chamber. Such a course of combustion is distinguished by lack of flame propagation, typical of both spark ignition and diesel engines. Consequently, uniform and significantly reduced in in-cylinder temperature is achieved. Due to these features, HCCI combustion exhibits a substantial reduction of cylinder-out NOX emissions (even 99% lower) compared to remaining combustion systems. Volumetric combustion controlled by reaction rates provides fast heat release which, in turn, results in isochoric process, thus increasing thermal efficiency. Additionally, the engine is not throttled, as load is controlled via air-fuel mixture strength which further contributes towards high efficiency, especially under low load regime of operation.

Besides extraordinary properties of the new combustion system, it is still under development. This is because there is still insufficient comprehension of fundamental processes of mixture formation and combustion. In-cylinder processes of 150 years old spark ignition and diesel engines are well identified. The paths of development are defined as well. However, gas exchange and combustion in HCCI engines differ from ones in traditional engines. Thus, there is a necessity to continue investigations into fundamental understanding of the effects of different in-cylinder parameters. Results achieved within the planned project will provide new valuable knowledge on in-cylinder processes in HCCI engines.

The general aim of the project is comprehensive analysis of factors determining low temperature combustion in a piston engine under elevated load regime. On the basis of preliminary results it was observed that that under elevated load deterioration in terms of engine emissions appear, which obstacles automotive applications of HCCI engines. These barriers result from increase in in-cylinder temperature and high rate of heat release at high energy density inside the cylinder. It should be noted that problems of controlling HCCI engines under high loads are not the same as in traditional engines. These issues are not sufficiently recognized. There is a number of papers on high load operation; however, still the knowledge is incomplete, not enough for general understanding of in-cylinder processes.

High range of laboratory experiments in parallel with computer simulations are planned within a project framework. Experimental research will be conducted on unique research engine installed on a modern, fully equipped dynamometer test stand. The project contractors have an access to all measurement equipment required for accomplishment of planned experiments; research engine controller, measurement system of in-cylinder pressure and optical emission etc. High quality of the planned research will enable gathering data of a high scientific value. Computer simulations will provide additional data on thermal stratification which widen our understanding of the analyzed processes.

Detailed analyses of processes which take place in the combustion chamber under such conditions are necessary to understand fundamental thermodynamic and chemical effects of mixture properties on low temperature combustion. Realization of the project will make feasible to quantify the relationships between intrinsic combustible mixture related parameters and combustion process. Realization of the project can move scientific community towards elaboration of methods of efficient control of in-cylinder processes in HCCI engines. Lack of this possibility is now a barrier of practical implementation of HCCI engines. Application of this engines would be groundbraking event in domain of combustion engines. Thus, it is worth to realize such innovative research in Poland. It should be noted that scientific level of our accomplished research is high, recognized by world engine scientific community.