The process of liquid spray injection into gaseous ambience is widely used in technology and industry. The most common way is liquid injection with parameters under its saturating conditions. However, successive higher requirements for different application demand enhanced atomization and evaporation. The promising way to improve both is liquid injection under the supercritical conditions to obtain so called flash-boiling phenomenon. When liquid is injected into environment pressure below its vapour pressure, then rapid boiling and evaporation occur. Inside the liquid droplets vapour bubbles are generated. Due to rapid vapour expansion, the droplets are burst into smaller ones. As the result the stronger atomization and faster atomization are performed, what allows to shorten evaporation time and length and hence the mixing length. Efficient mixing has a positive influence on the physical processes such as combustion or catalytic reduction what in fact leads to lower emission of harmful substances.

Despite many advantages of such sprays, there are two research area which were not studied enough. The first is recondensation area. During flash-boiling spray formation in certain conditions (ambient pressure and liquid phase temperature) vapour recondensation may occur due to high vapour and non-evaporated liquid concentration. Re-emergence of the liquid has a significant impact on evaporation length and mixing, and may have undesirable effects. This phenomenon is well known. However, the impact scale and penetration of recondensated phase is still not studied enough. The second aspect which should be investigated is flash-boiling spray behaviour is cross-flow conditions depending on gas temeprature and pressure. This research will allow to estimate better the advantages of these spray formation-associated phenomena to be taken into an account during the design of injection systems on fluid-flow machines (for example car exhaust systems) where the liquid is injected in cross-flow conditions. So far research is focused on spray parameters under stationary conditions.

During conducted experimental studies modern optical diagnostic techniques such as high speed recording camera (up to 10000 frames per second) and laser techniques including LIF/Mie Scattering, Shadowgraphy and SLIPI imaging will be used. During investigation the regimes of recondensation phenomenon will be determined as well as penetration length and liquid spray characteristics for injection into constant volume chamber (stationary gas continuum) and injection into gas cross flow.

Knowing the characteristics of superheated liquid spray and its recondensation numerical models calibration will be conducted to achieve proper projection of occurring phenomena including vapour recondensation. Numerical simulations will be carried out using AVL FIRE^{TM} CFD (Computational Fluid Dynamics) software.

The studies will widen the knowledge of the process under hot gas cross-flow regime and allow to formulate accurate numerical models of flash-boiling spray. During the project the knowledge of liquid phase recondensation in superheated spray will be extended.

Moreover, obtained results may be of practical importance by providing fundamental knowledge useful for industry applications. The knowledge will help to design new and more efficient injection strategies in process industry, spray coating, in IC engine design and mixing systems in selective catalytic reduction systems and further development of this prospective method for NOx reduction. Transportation sector is responsible for about half of NO_x emissions in Europe. Every way of improvement in emissions reduction method will have positive impact on Polish and European society.