Despite a significant progress in the use of renewable energy sources, the fossil fuels will serve as the main source of energy in domestic, transport and industrial applications for many years. However, the desirable decrease of green-house gases emissions requires a deep understanding the physical and chemical mechanisms that have an impact on a combustion process. In a majority of technical applications the combustion appears in a turbulent flow. Turbulence itself is a complex phenomenon that requires further theoretical and experimental investigations. The most important challenge for both experiments and numerical simulations in turbulent flows is a multiscale character of turbulence. This means that in turbulent flows a wide range of scales is present including large-scale structures controlled by the flow geometry, and very small-scale structures which dissipate a flow energy into heat via viscous forces. A simulation of such a phenomenon requires a numerical mesh that covers the whole flow domain, but dense enough to represent also the smallest flow structures. In effect, the required meshes involve billions of the grid points that exceeds abilities of the most powerful computers nowadays. The computational cost grows significantly when the turbulent flow involves a chemical reaction, e.g. combustion. First, in the case of chemical reactions additional equations describing the species transport have to be solved. Moreover, characteristic length and time for chemical reactions are most often smaller than the smallest scales of the turbulent flow. Hence the modelling of combustion requires even finer meshes. A problem of mathematical description of turbulent flows leading to a system of equations that can be solved with limited computer power has been in the focus of investigations of many research centres for the last 50 years. This research domain is called the closure problem or turbulence modelling. An interesting feature of turbulence is that kinetic energy of large scale structures, according to the Kolmogorov hypotheses, is transported through a cascade of smaller structures or eddies down to the smallest dissipative eddies. Hence, a direct interaction of eddies with very different scales is quite limited, and “a memory” of an anisotropic character of the largest eddies is, in this cascade of the energy transfer, gradually lost. As a result, the smallest structures are isotropic and their size is determined by the energy dissipation rate and fluid viscosity. Since the smallest eddies are isotropic and independent of the flow geometry the task to formulate their mathematical model is much simpler than for the large scale motion. A method that uses this feature of turbulence, that has been under intense development for the recent years is the so-called LES-Large Eddy Simulation. The LES approach relies on a separation of large and small scales. From the mathematical point of view extracting of large scales is realized via low-pass filtration of the equations. Information on the large scales dynamics is obtained from the direct solution of the filtered equations. A mesh required for this solution does not need to be very fine as it refers to relatively large structures. An impact of the small scales, characterized by length scales smaller than the mesh size, must be introduced into the set of equations in the form of a certain mathematical model. This approach is also applied in modelling of turbulent reactive flows. However, application of the LES method to the transport equations of chemical species is especially challenging. The chemical reactions rate depends on temperature and molar concentrations of the chemical species. This dependence is a complicated non-linear function. As a result, substituting into this function the temperature and species concentrations representing large scales leads to results very much different from a value that would be obtained by the filtration of the source term expressing the reaction rate. A new approach has recently been proposed for the turbulent reactive flows. This method relies on an approximate inverse filtration of large scales that allows estimating a flow field including scales smaller than the mesh size. Such a deconvoluted flow field is used for the filtration of the source terms. In the research performed so far this approach was applied with low-order numerical approximations. However, in the modelling of turbulent reactive flows high-order numerical schemes are profitable since a more precise solution can be obtained with relatively low computational cost. Further development of this method within the project will include new inverse filters related to high-order numerical schemes. Another innovative element in the project will take into account non-linear interactions of large scale eddies and their impact on the small scales generation. The new model will be applied to study turbulent premixed and non-premixed lifted flames and flames with local extinctions that are particularly difficult for mathematical modelling. It is expected that the new model will be much more efficient than previous models in terms of the computational time.