Combustion of methane in the free piston pulsed compression reactor

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A novel reactor employing the principle of pulsed gas compression has recently been developed. The reactor consists of a vertically installed double-ended cylinder and a free piston which divides the cylinder into two compression chambers. The piston reciprocates with a very high frequency (up to 400 Hz) compressing in turn a feed gas in the lower and upper chambers. The cylinder has inlet and outlet ports in its wall for the injection of the feed and exhaust of the reaction products respectively. The reciprocation is maintained by the reaction itself or by an actuating gas.

Several reactors of different design and dimension have been studied experimentally without chemical reaction. The experiments have shown that the reactors can easily be started using the developed start up systems and operate smoothly without wear. The use of the free, gas lubricated piston makes it possible to provide very high frequencies of piston oscillation and compression ratios (up to 100). Short duration of the extreme conditions prevents a significant heat exchange between the hot, compressed gas and the cylinder and provides unique combinations of pressures and temperatures - from several hundreds to several thousands of bar and up to several thousands of K - far beyond the maintainable in steady state chemical reactors. The achieved pressures and temperatures are ideal for almost instantaneous completion of many industrially important chemical reactions. High frequency of piston oscillation results in very high space velocities (millions per hour). Huge rates of temperature and pressure change (up to 10^7 K/s, 10^7 bar/s) afford an excellent way of freezing the high temperature products and producing a better yield. Gas compression in the reactor can be adjusted depending on desired conditions and not determined by the length of the piston rod.

The free piston behaves like a pendulum swinging between two gas springs. Only compensation of the inevitable energy losses due to friction and gas leakage is required in order to maintain oscillation. These energy losses are incomparably smaller than the losses in the conventional processes. Since no piston rings and lubricating oil are used cooling of the reactor is not necessary. The reactor comprises the entire or almost entire processing train: gas compression, heating reaction itself, cooling of products and utilization of the released reaction energy occur in the reactor.

Technical feasibility of the new reactor concept has been demonstrated by performing combustion of methane with air.