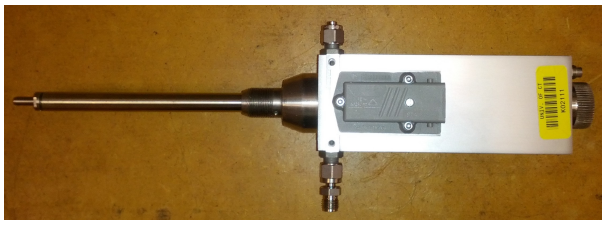


Figure 1: Photo of the GSV prior to installation in the RCM. Samples enter the valve from the left and are removed through the ports in the center of the GSV.

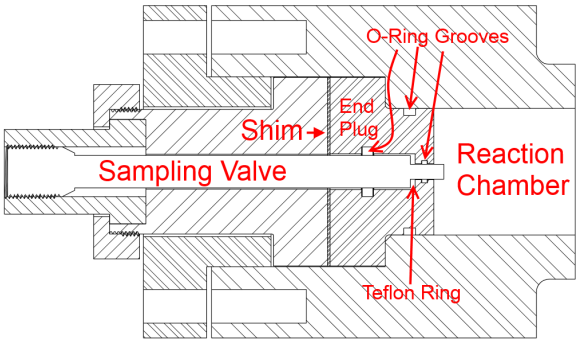


Figure 2: Schematic of the GSV assembled into the reaction chamber showing the position of the sealing o-rings and the protrusion of the poppet face.

The fast sampling system (FSS) used in this work is a commercial system supplied by SME-Tec Gmbh. from Germany. The FSS is composed of two parts, the gas sampling valve (GSV) and the Controller. A photo of the GSV is shown in Fig. 1. Gases are admitted from the reaction chamber into the heated carrying tubes through the poppet-style valve on the left of the GSV. The sampled gases are then conducted through the GSV outlet into a sampling bottle.

A schematic of the GSV assembly is shown in Fig. 2. The GSV is mounted to the RCM by a custom-made end plug. The reaction chamber is sealed by an O-ring on the small- and large-diameter portions of the GSV. The depth that the GSV is inserted into the reaction chamber is adjustable by adding or removing shims in the end plug assembly. The insertion depth is chosen so that the tip of the GSV is outside the boundary layer on the end wall.

The portion of the GSV protruding into the reaction chamber has minimal effect on the homogeneity of the reaction chamber. Moreover, the removal of samples has minimal effect on the measured ignition delay. This has been verified experimentally by measuring the ignition delay with and without the GSV present, and with and without sampling occurring. In both cases, the difference in ignition delay was statistically insignificant for $\alpha = 0.05$.

Tests of the ignition delay with and without the valve, and with and without sampling are shown in Fig. 3. It can be seen that the pressure traces follow each other closely, including through the ignition event, indicating that the presence of the valve and the activation of the valve to remove a

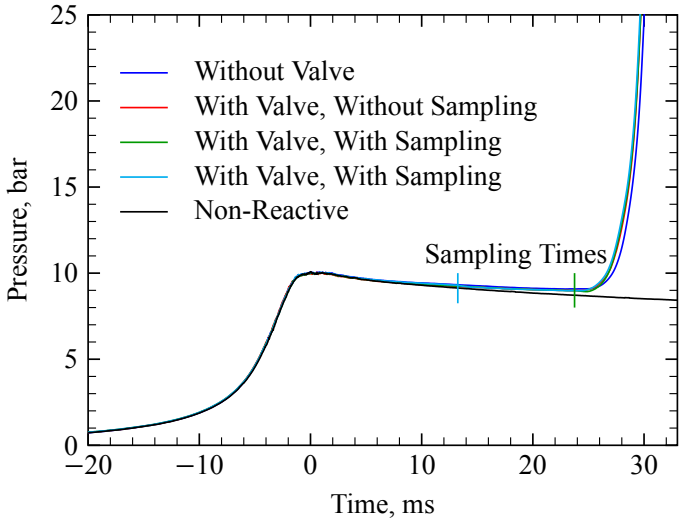


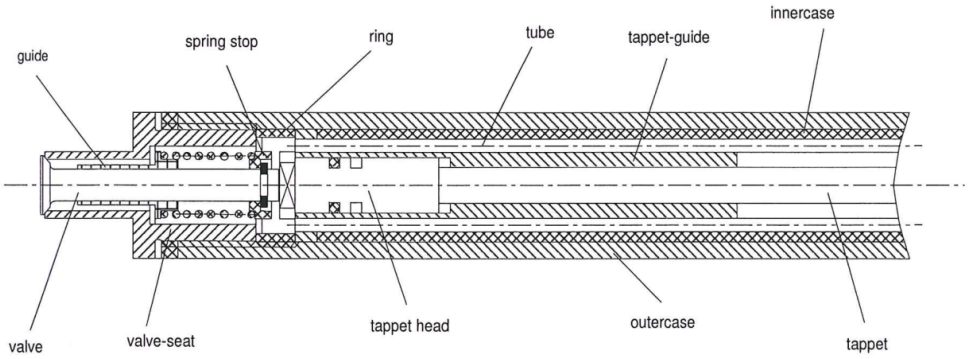
Figure 3: Representative pressure traces from RCM experiments with and without the GSV present, and with and without sampling occurring. Two sampling times are shown. The corresponding non-reactive pressure trace is also shown.

sample do not substantially disturb the ignition process.

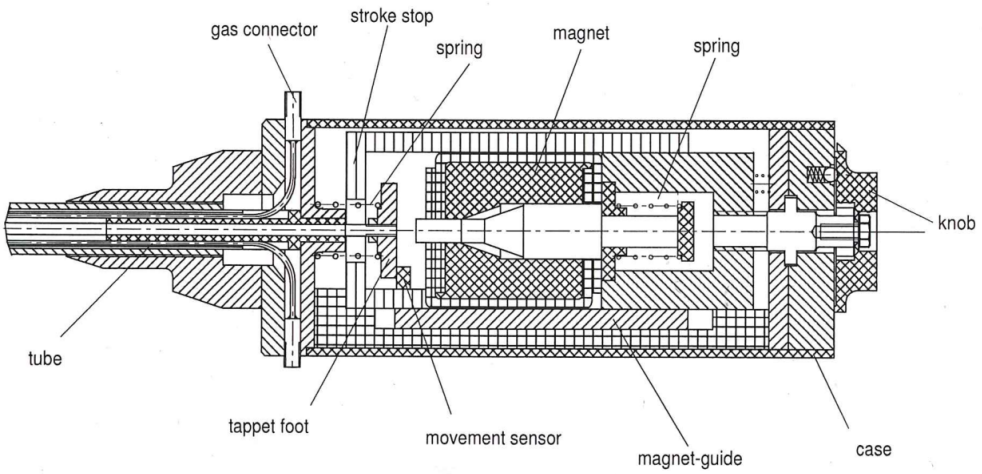
The close-open-close (COC) cycle of the GSV is controlled by a mass-spring system shown in Fig. 4b. The poppet face is connected to a rod running the length of the GSV and connected to the mass at the rear of the valve. To open the poppet, the mass is accelerated forward by passing current through the coil around the mass. The rod is also connected to a spring that is used to restore the poppet to its original position after being extended.

The GSV has an adjustable COC time, by adjusting the distance the plate is allowed to move. Furthermore, the GSV has the ability to measure the displacement of the mass, allowing the direct measurement of the COC time and the absolute time of opening.

The GSV controller is triggered by a 5 V signal from the cDAQ. The timing of the trigger signal is controlled by the LabView VI. The pressure signal from the reaction chamber is read from the cDAQ in 1 ms chunks in a loop. On each loop iteration, the maximum pressure is checked against a desired trigger pressure; when the reaction chamber pressure exceeds the trigger pressure, the cDAQ sends the trigger to the GSV controller. The GSV controller has an adjustable delay (4.5 ms to 70 ms) that is used to control the timing of the opening of the GSV during the induction period. The absolute opening time of the GSV is thus dependent on three parameters:



(a) Front section of the GSV containing the sample transfer tubes and the poppet valve that is inserted into the reaction chamber



(b) Rear section of the GSV containing the driving magnet and sample extraction fittings.

Figure 4: Schematic of the front and rear portions of the GSV. Images courtesy SMETec GMBH.

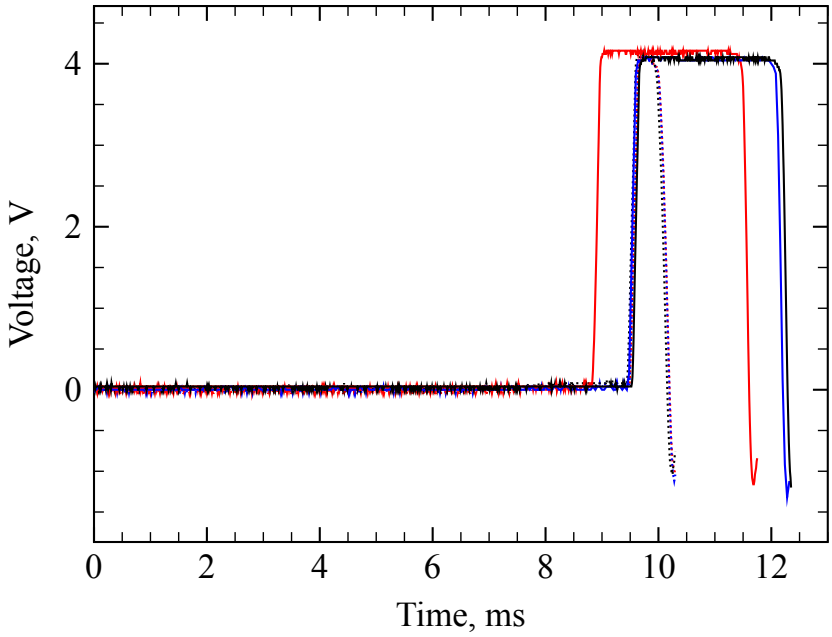


Figure 5: Representative voltage traces from three runs each of two COC times: dotted: 0.8 ms; solid: 2.5 ms.

1. The cable delays from the PC to the cDAQ; from the cDAQ to the GSV controller; and from the GSV controller to the GSV itself
2. The processing time of the LabView VI
3. The delay set in the GSV controller.

The absolute opening time of the GSV is measured by the signal sent from the GSV to the controller (and thence to the cDAQ). This signal is shown in Fig. 5. The time that the cDAQ sent the trigger signal to the GSV controller is set to be the zero time; Fig. 5 thus demonstrates the repeatability of the delay (within 1 ms) in GSV motion relative to the trigger signal.

The COC time is measured as the width of the first peak in the GSV valve signal in Fig. 5. Figure 5 shows the repeatability of the COC time as the width of the first peak for the two sampling times corresponds closely between runs.

Further characterization work is required to determine the temperature drop of the gas as it enters the GSV and to ensure that the GSV tip protrudes beyond the boundary layer. In addition, an experimental procedure must be developed to integrate the GSV with the GC/MS analysis.