Electrically Actuated Valves for Flow Chemistry with Excellent Chemical Compatibility

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This project focuses on modifying commercially available valves from Diba-Omnifit (Arcmed) for electrical actuation. It was initiated to meet the need for automated valves with excellent chemical compatibility, particularly for small-scale laboratory applications.

The commercially available valves used in this project are made from PTFE and PCTFE, materials known for their high chemical resistance, making them suitable for use with highly corrosive media such as 90% nitric acid. The high-pressure valve variant can withstand pressures exceeding 30 bar, making it versatile for a wide range of flow chemistry applications. The low-pressure valve variant is ideal for use on the suction side of pumps in flow chemistry research, where it facilitates automated priming and selection of different liquids for delivery.

List of parts:

Name	Catalogue number	Vendor
4-way, PTFE/PCTFE “L”-valve (max 3 bar)	no. 001112	Diba Omnifit, Arcmed
4-way, PTFE/PCTFE diagonal (“double C”) High-Pressure Rotaty Valve (max 33 bar)	no. 001122	Diba Omnifit, Arcmed
High-torque servo-mechanism; declared torque: 25 kg·cm and 270° degree rotation	DS3225MG-270	DSSERVO, Dongguan City Dsservo Technology Co.Ltd
Lower-torque servo-mechanism; declared torque: 9 kg·cm and 300° degree rotation	HDKJ-D3009	Non-branded, available through various online marketplaces such as Amazon and eBay.

Description of the modification

A high-torque servo mechanism was used for the 33 bar valve variant; however, a lower-torque servo like the popular MG996 may also suffice. A custom valve holder and axle coupler were designed and 3D-printed for described modification. Both valve types have a similar knob mounting method, requiring the knob to be removed to apply the modification. To do this, the valve axle needs a slight re-shaping, which can be done using a mini-drill with a cutting disc or even a hand file.

Before removing the knob, record the valve's current state according to the shaft position. To disassemble the knob, first pry off the front part of the knob (which shows the connection direction) using a small flathead screwdriver. Then, loosen the screw that secures the knob to the PCTFE valve axle with a Phillips screwdriver. Once the knob is removed, cut a notch on the axle using a mini-drill with a cutting disc. Refer to the attached figures for detailed reference. Figure 2 illustrates the dimensions of the notch, which must be cut identically on both low-pressure and high-pressure valves. It’s recommended to have the 3D-printed coupler (“knob holder”) ready to check the fit as you gradually cut or grind the notch.

For both valve types, once all parts are prepared, the alignment of the valve and servo shaft must be done. First, position the servo in one of its extreme positions to ensure full range of motion for the valve shaft. To do this, connect the servo to a 6 V DC power supply (refer to the servo's documentation for maximum voltage ratings) and send the appropriate signal, for instance, from a microcontroller. The pulse length may need to be adjusted experimentally, as different servos can require different pulse lengths. In this project, a pulse of approximately 500 µs (0.5 ms) positioned the servo in one of its extreme positions.

Next, check fitting of the 3D-printed coupler on the servo motor's axle using the plastic round coupler plate that comes with the servo. The holes in the servo's coupler plate needs to be slightly enlarged to fit M3 screws. Use at least two, preferably three or four screws, to evenly distribute the load on the 3D-printed element. Before installing the 3D-printed element with the servo's plastic coupling plate, insert the small screw that secures the plastic servo's coupler to the servo axle between the 3D-printed part and the servo's coupling plate. Tighten the 3D-pritned element to the servo's coupler plate. After fastening these components together with the screws, secure the entire assembly to the servo shaft using a Phillips screwdriver through the bore in the 3D-printed coupler (using a screw placed there before). Finally, assemble the whole device with the valve placed int its holder. In the case of high-pressure valve, fasten it using M3 screws from below. For the low-pressure valve, it should fit securely in the 3D-printed holder without requiring additional tightening mechanisms. If required, additional tighteners for the low-pressure valve can be 3D printed using one of files included in the repository.

A holding adapter for mounting the assembled actuated valve is also available in the repository. Described holding adapter can be used for attaching the valve assembly to a 15 mm rod (ex. laboratory stand). For details, see figures 7 and 8 and the 3D files in "holding_adapter_15mm" folder in the repository.

See figures 1 – 8 for additional details and aid during the assembly process.

3D design drawings

Files containing the 3D-designed pressure sensor holders are available in adequate folders in the repository, for the low-pressure and high-pressure valve variants, as well as the holding adapter. These files include *f3d/f3z* and *3mf* files with the complete design and *STEP* files for individual components. The file names are self-explanatory, reflecting the corresponding parts.

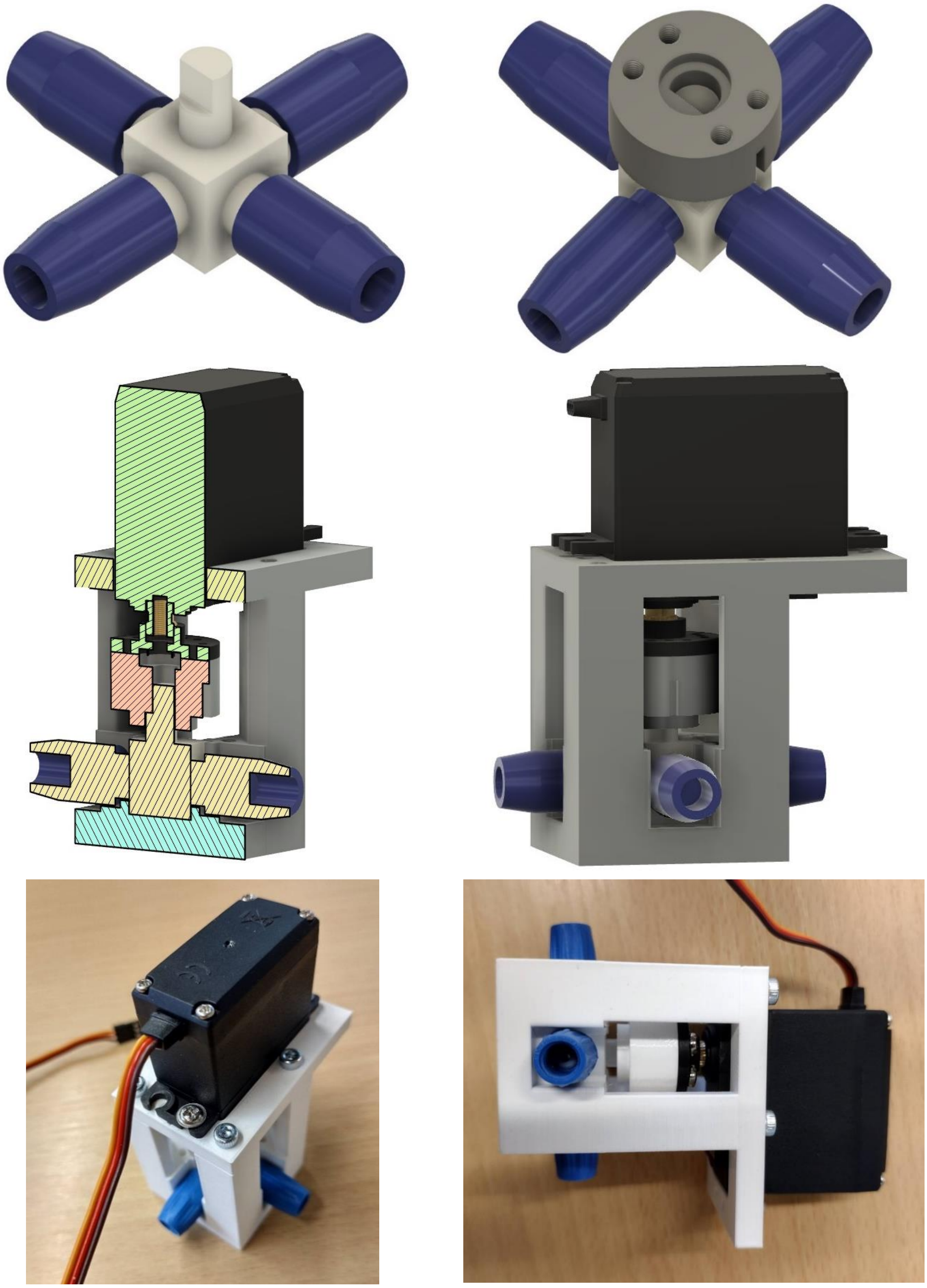

Figure 1. Top left: A created 3D model of the low-pressure valve, used afterwards as a template for designing the holder. The valve axle is shown with the notch that needs to be cut into the real valve's axle (see figure 2). Top right: The designed axle coupler fitted onto the valve's model. Middle left: Cross-section view of the design, showing the connection between the servo-mechanism's shaft (via its plastic coupler plate) and the custom-designed coupler for the valve's axle. Bottom left and right: Photographs of the fully assembled electrically actuated valve (the 3 bar variant).

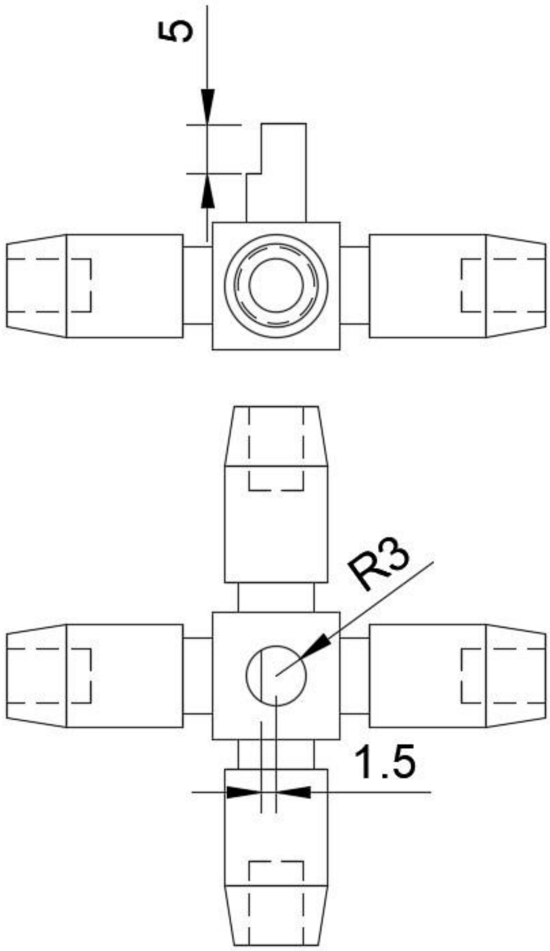

Figure 2. Dimensions of the notch that must be cut into the valve's PCTFE axle. This modification applies to both the low-pressure and high-pressure valves after their knobs have been removed. Be sure to record the valve's position before removing the knob to avoid difficulties when reassembling it later.

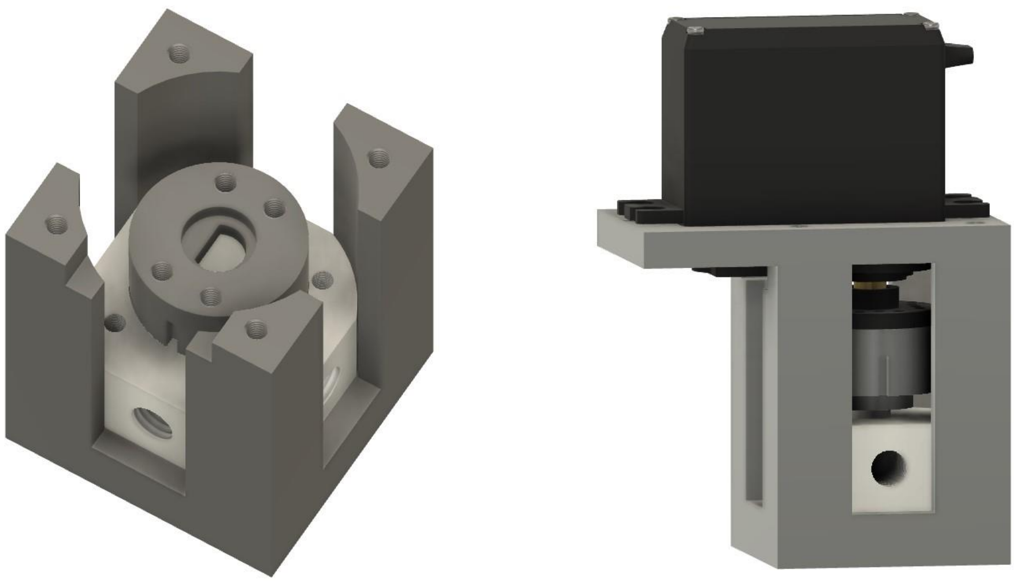

Figure 3. Left: 3D model of the designed high-pressure valve holder with the axle coupler. Right: 3D overview of the high-pressure valve in the holder along with the couple and servo-mechanism in its holding frame.

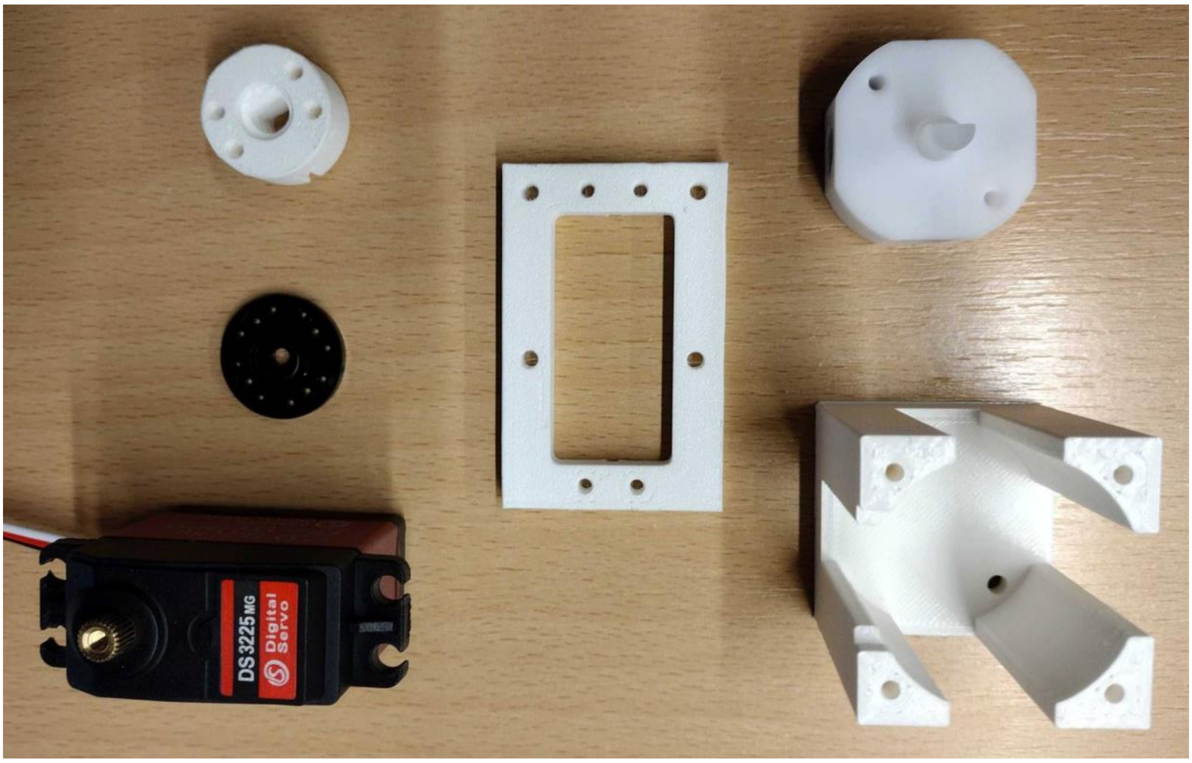

Figure 4. Elements before assembly. The high-pressure valve needs to be screwed in place using M3 bolts – threaded bores visible in the valve body and adequate bores with counterbores are present in the valve holder (element on the bottom right of the photo). The "plastic servo's axle coupler plate" described in the text is the black round element visible above the servo.

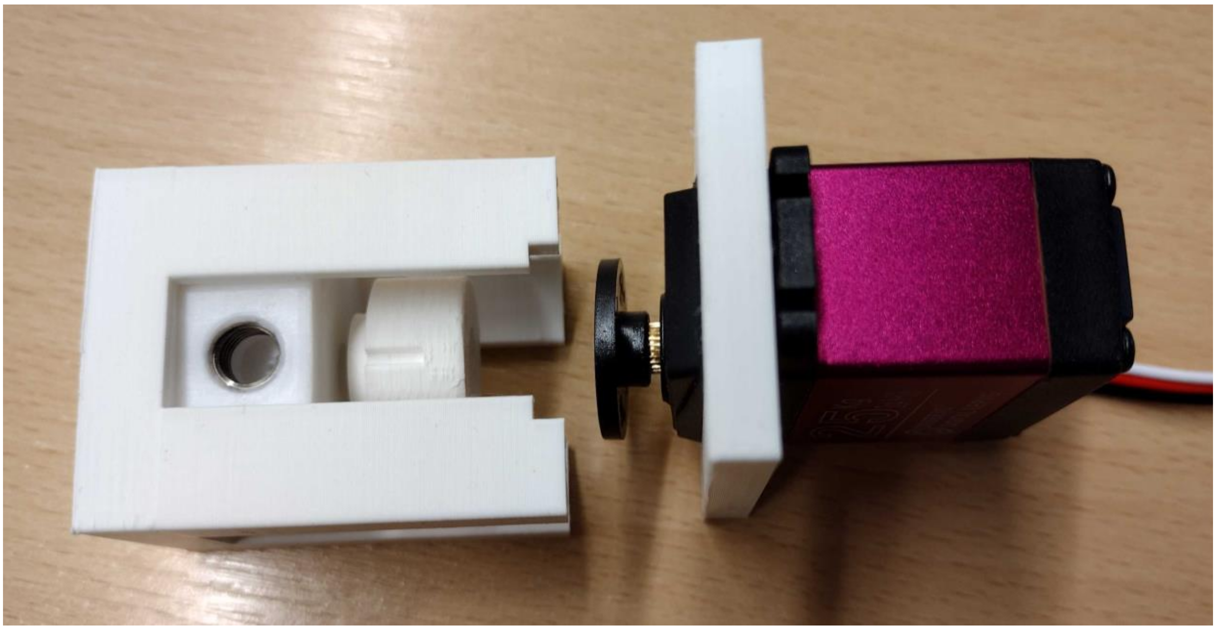

Figure 5. Fitting the parts before assembly.

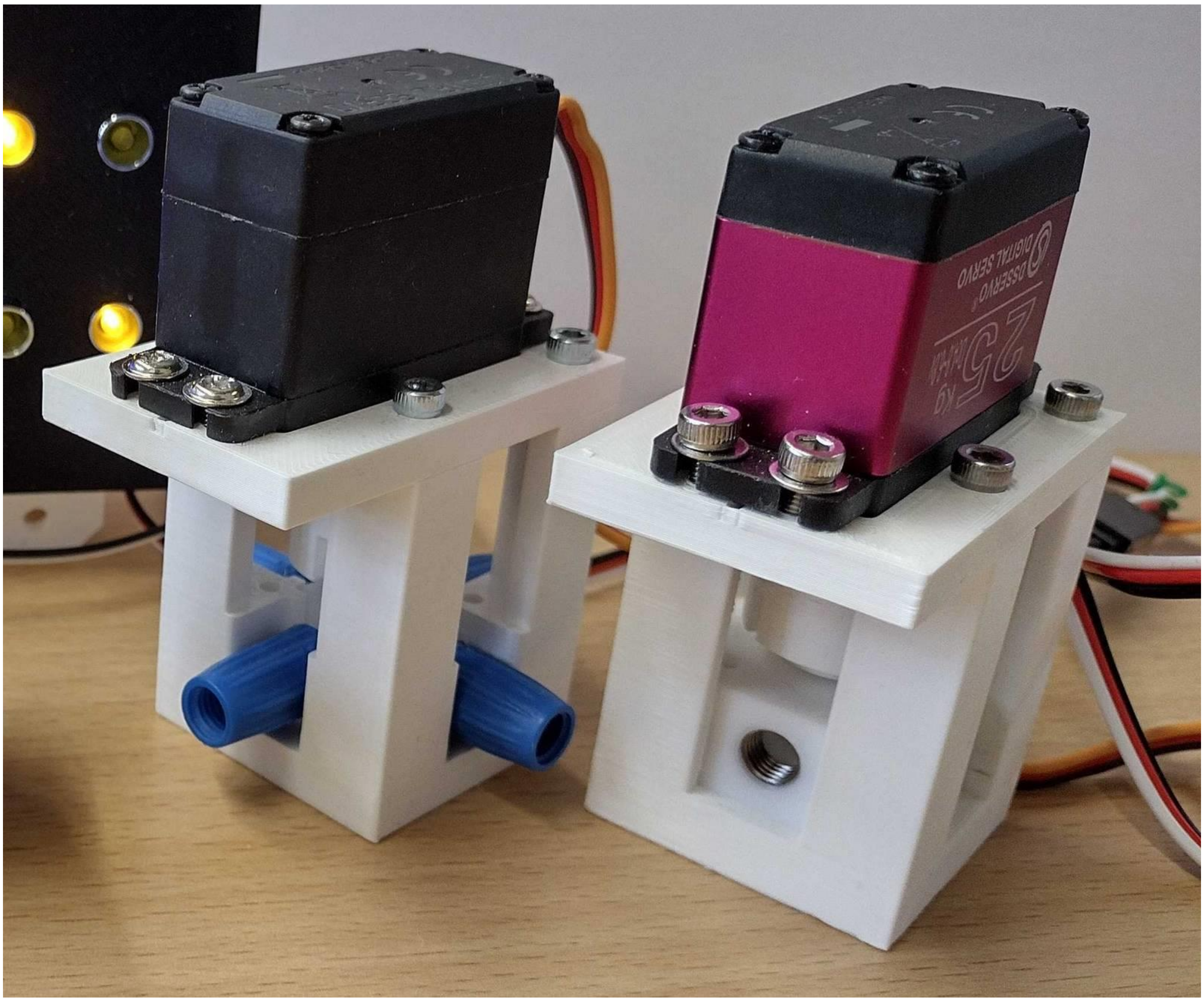

Figure 6. Low-pressure and high-pressure PTFE/PCTFE valves modified for electrical actuation.

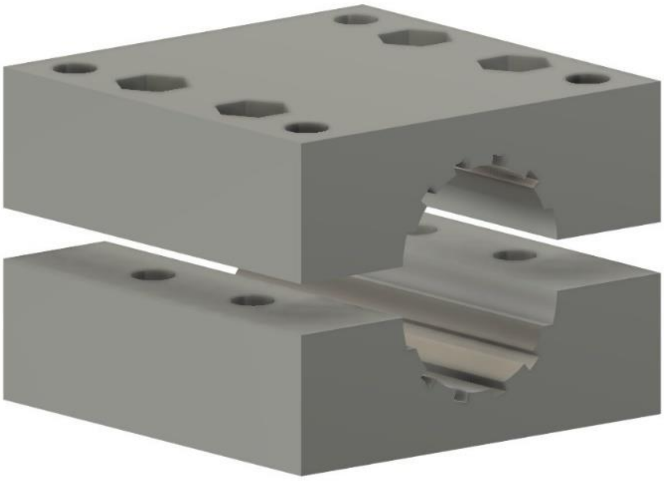

Figure 7. 3D-designed holder allowing attaching the automated valve to 15 mm diameter rod, for example a laboratory stand. Upper part needs to be equipped with hex-nuts and tightened to the automated valve body using M3 bolts. Then the bottom part can be tightened to the upper part using bolts screwed into nuts placed before in appropriate (hex-shaped) cavities.

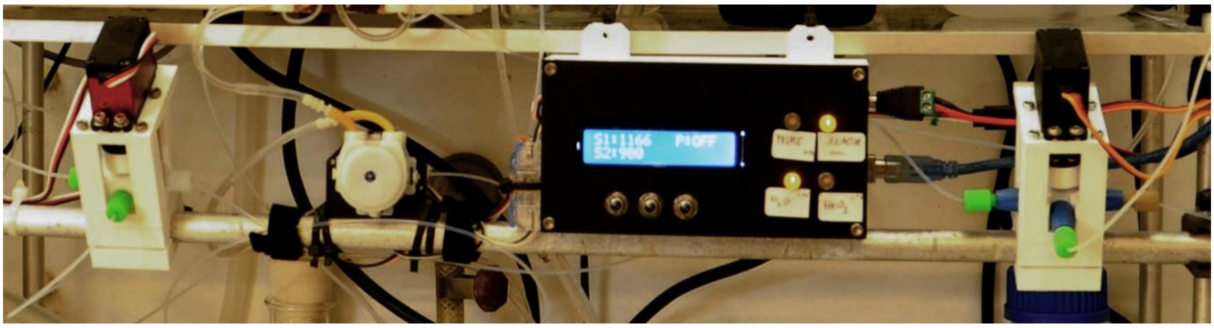

Figure 8. Example of valves installed in a system during research in the filed of flow chemistry at CiTOS. An Arduino Uno based valve controller visible in the middle of the photograph.

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