# Process, Hydraulic and Control Devices in *Odysseo*, an Object-Oriented Framework for Process Dynamic Simulation

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**Abstract :**

This paper deals with an object-oriented framework for the dynamic simulation of chemical processes, *Odysseo*. As an extensible and reusable development framework, it allows to build general or dedicated efficient dynamic simulation software which can be used for process engineering or operator training purposes. *Odysseo* uses *ATOM*(1) (Applied Thermodynamics Objected-oriented Model) for material systems modelling, and *DISCo*(2) (Do Integrate by a Software Component) as its DAE (Differential-Algebraic Equations) solving kernel. In the continuity of past work(3), *Odysseo* is based on the object-oriented decomposition of units down to material systems(1). A flowsheet object is a set of device objects connected to each other by port objects, inside which material, energy or information flows. There are basically two types of device objects: elementary devices and composite devices. A composite device is a recursive assembly of interconnected devices, either elementary or not. Ports are initially created and managed by elementary devices. For dynamic simulation, hydraulics and control must be taken into account. This paper focuses on the modelling of hydraulic and control networks and hydrodynamics inside devices.

Devices developed within *Odysseo* are classified into three categories. Material and/or energy transformations (like reactions, separations, heating/cooling, etc.) take place inside process devices. The hydraulic devices (like pumps, pipes, valves, etc.) provide junctions between process devices. They have the ability to set flows from the upstream devices which they are connected to. They also allow to cope with reversing of material flows depending on pressure conditions. For this purpose, kinetic and potential energy must be taken into account in energy balances. Thus, *Odysseo*

generalises the definition of ports based on the concept of «potential », whether it is a thermal, electrical or hydraulic potential. Material ports feature a hydraulic potential which is actually the pressure inside their owning device. Hydraulic devices access the upstream and downstream pressures through material ports. These ports include also an elevation and a section that represents respectively the absolute height and the area of the real nozzles. Moreover, material ports are characterised by a « hydraulic energy » variable that represents the kinetic and the potential energy of the flow. Finally, the control devices are designed using the same concepts of object decomposition. Control devices do not transport material, but deals only with information ports. Among these devices, captors, transmitters, controllers and actuators represent typical elements of the full control chain. Hydraulic and control devices are particularly important in the context of dynamic simulation.

Most of models equations are automatically generated depending on the process topology. At the flowsheet level, the equation-oriented models are aggregated and can be solved either globally or separately by isolating the process, the hydraulic and the control networks: the process network imposes the state of the material (temperature, pressure and composition) with respect to given material flows; the hydraulic network imposes material flows depending on port pressures; finally, the control network interconnects the hydraulic and process networks. This approach is particularly suited to cycle-based simulation typically found in operator training simulators, and has been successfully used in the *OPERA*[4] (Operators Training Distributed Real-time Simulations) European Esprit project. *Odysseo* is the basis of the *Hybrid Modelling Framework* designed for this project.

In this paper, the importance of taking into account the process, hydraulic and control facets for the dynamic simulation of a chemical process is underlined. The object-oriented framework, Odysseo, follows an openness principle compatible with the CAPE-OPEN standard[5] and has demonstrated its efficiency in the OPERA project. Some applications will be presented.

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