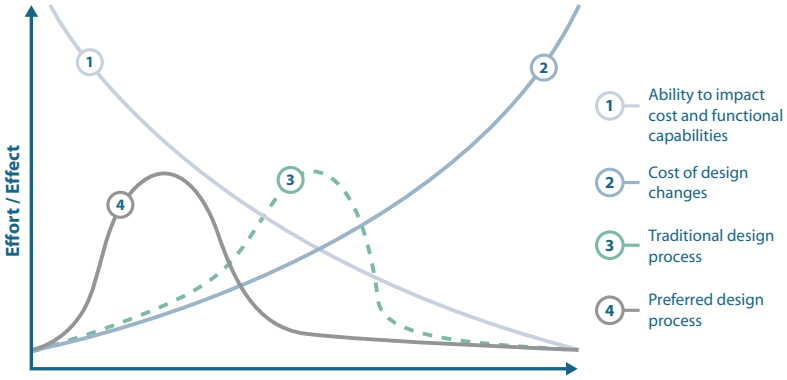
IMPROVED PROCESS DESIGN EVALUATION THROUGH ENHANCED COST ANALYSIS INTEGRATION

ARTICLE BY RAFAEL CORONEL (Engineering Effectiveness Business Manager - Honeywell Process Solutions)
AND STEFAN BAKKER (Sales Engineer - Cost Engineering Consultancy)

CHALLENGES

During these challenging times the oil and gas production, gas processing, petroleum refining and chemical industries need to be able to identify economically viable projects as early in the design process as possible. Every man-hour spent on non-profitable process designs results in opportunity costs that could have made more value for the organization when assigned to efficient and profitable process designs. In order to remain competitive and maximize business performance, optimum designs must therefore be identified quickly with minimum risk of rework, as design changes further in the project development cycle come at the expense of higher cost and more effort (figure 1). To accomplish this, process and cost engineers should work hand-in-hand during the economic analysis of the different solutions.



▲ Figure 1: Impact and cost of design changes during the project progress

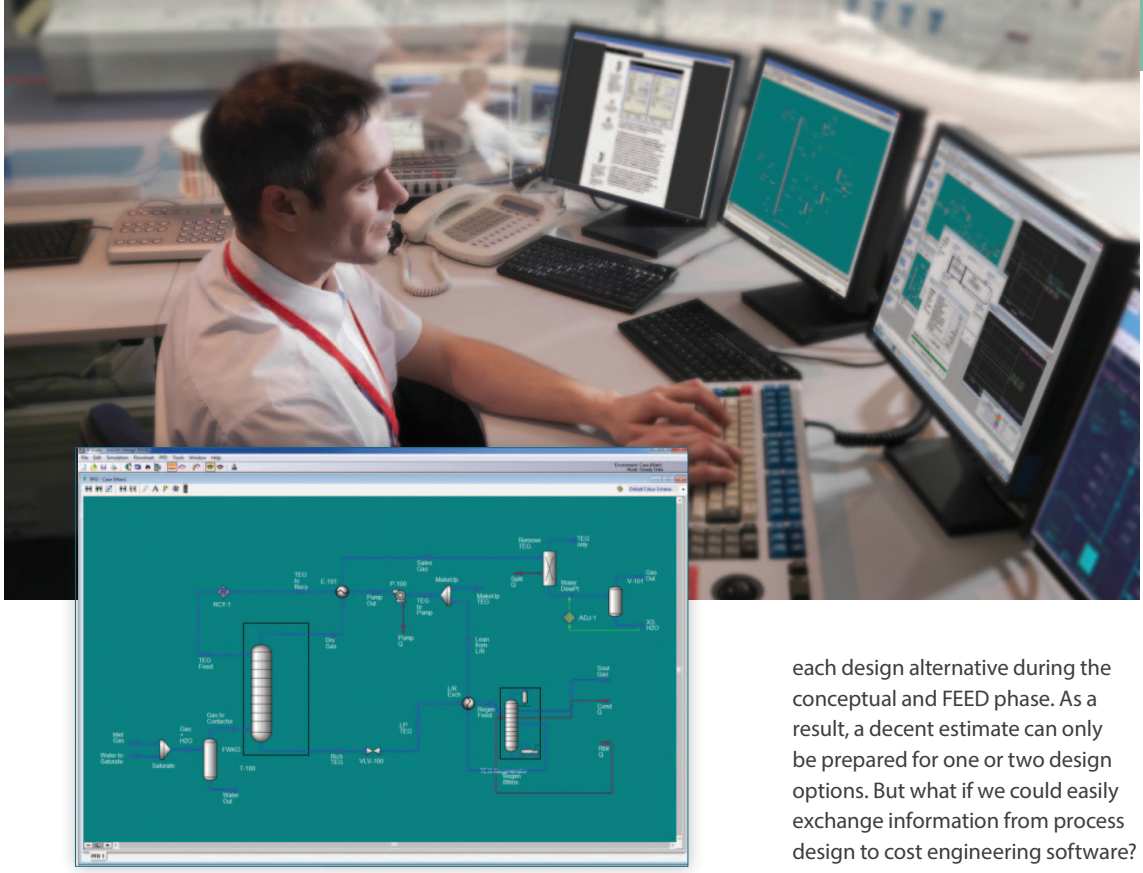
During Conceptual and Front-End Engineering and Design (FEED) project stages, process engineers should aim to accomplish the following objectives:

- **Informed Decision Making**
  Analyze and evaluate the different process alternatives early in the project lifecycle in order to make a substantiated decision to 'do the right project'.
- **Engineering Time & Cost Savings**
  By allowing engineers to quickly and easily determine the cost implications of their process design choices, it will reduce the number of man-hours spent on evaluating expensive process configurations and validating data to support decision trade-offs.
- **Re-use of (Cost-)Engineering Knowledge**
  When process engineers are more involved in the cost aspects of projects it will become much easier to re-use information about cost objects when preparing the process design, resulting in more cost effective solutions.

To achieve this, the process engineer and cost engineer need to intensify their cooperation during the conceptual phase. Not only traditional communication, but also software tools are essential to accomplish this. This article explores today's software solutions, capable of integrating the process design with cost information, allowing for informed decision making during the conceptual design and FEED phases.

PROCESS, MECHANICAL, PIPING AND COST ENGINEERING

In many companies, the process-, mechanical-, piping- and cost engineering disciplines are segregated. The exchange of information follows



▲ Figure 2: UniSim® Design – Process Flow Diagram

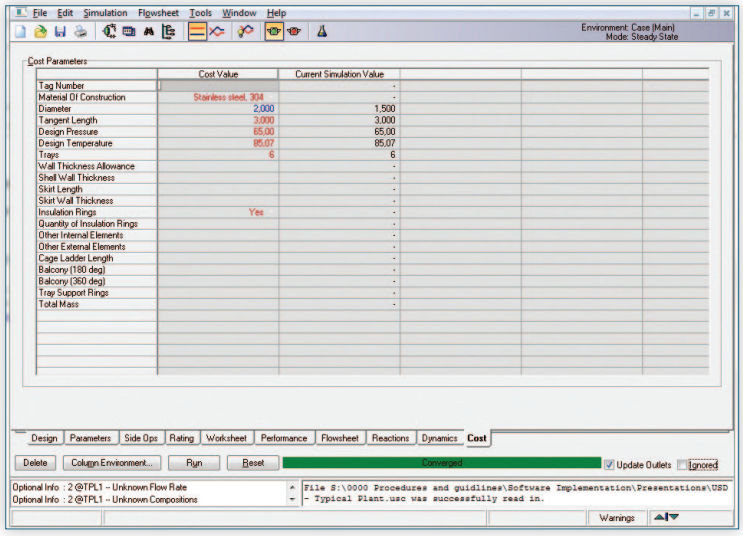
an 'over-the-wall' principle, where people from different disciplines are not fully aware of each other's concerns and priorities. It is important though to have a good and open communication platform between these disciplines, as they are closely related to each other. For example, the placement of the equipment items determines to a large extent the costs of the main pipelines. The complex task to come to an optimal plot plan requires interaction between the different disciplines.

A traditional process design requires input from different engineering departments, such as civil-, piping- and mechanical engineering. In order to evaluate the cost implications and economic viability of a project, the cost engineer should assess the different design alternatives. This requires an optimal flow of information between process engineers and cost engineers.

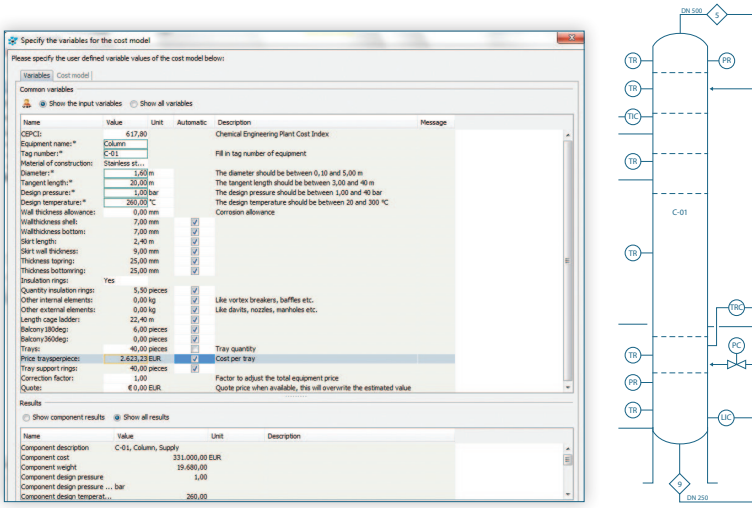
The automation and digitalization of most activities makes it possible to have easier access to useful information in early phases of project development. Still, both process engineers and cost engineers have their own separate software tools to respectively design and estimate the project. It is good to have these dedicated tools, as they are specifically designed for process design and cost estimating purposes. Though, in case the information cannot easily be exchanged between the different tools, it could become a complex and especially time-consuming task to evaluate the cost implications of each design alternative during the conceptual and FEED phase. As a result, a decent estimate can only be prepared for one or two design options. But what if we could easily exchange information from process design to cost engineering software?

INTEGRATING PROCESS AND COST ENGINEERING SOFTWARE

To illustrate the advantages of integrating process design software and cost engineering software, we will look at two global software solutions that have joined forces to integrate the information flow: Honeywell's UniSim® Design (process simulation; figure 2) and Cost Engineering's Cleopatra Enterprise® (cost engineering). Before looking at the interface between these two systems, it is important to understand the cost estimating methodology that is commonly applied during the conceptual and FEED phases of a project. In the end, this determines the required information that should be transferred from process design software to cost engineering software.



▲ Figure 3: UniSim Design - Process Data to export to Cleopatra Enterprise

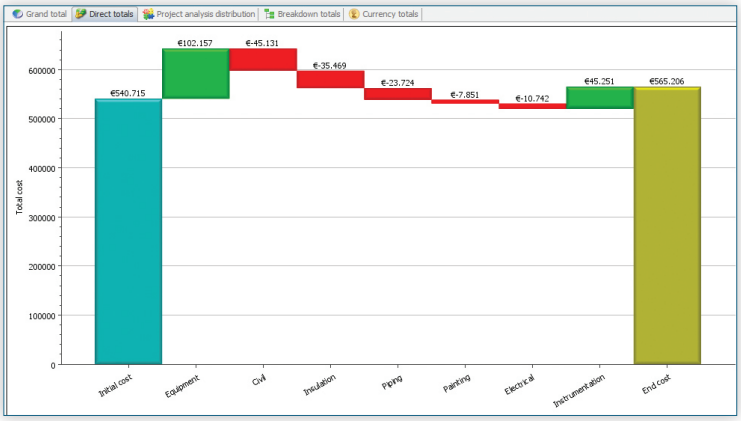


▲ Figure 4: Imported equipment parameters into Cleopatra Enterprise parametric cost model

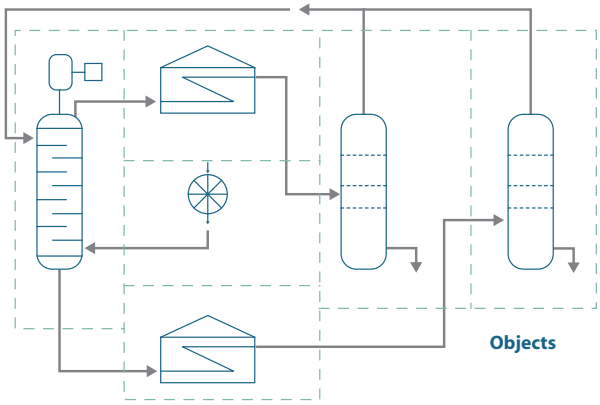
Traditionally, equipment factored methodologies, or simply "factor estimating", is applied during the conceptual and FEED phases of a project. This method uses the correlation between the total equipment costs and the costs of related disciplines (piping, civil, E&I, etc.) to estimate the Total Installed Cost (TIC). For each type of process equipment, different factors are used to reflect the differences in costs of piping, foundations, cables, instrumentation, etc. Although this is a commonly accepted estimating methodology during early phases of project development, the accuracy of the TIC estimate strongly depends on getting the right cost values of your equipment. This in turn requires precise and correct information about equipment parameters like sizing, metallurgy and capacity. Cleopatra Enterprise for example, will use these equipment parameters as an input to its parametric equipment models (based on cost estimating relationships) to come up with an accurate estimate of the equipment.

To be able to quickly screen and compare different project designs on costs and economic viability, a cost engineer needs to get the equipment parameters as an input from the process engineer to make a factor estimate. This is where the integration between UniSim Design and Cleopatra Enterprise comes in. Because of the direct link between the two systems, it has become possible to feed the process data directly from UniSim Design into Cleopatra Enterprise (figure 3). Once the process data has been imported into Cleopatra Enterprise, the UniSim Design process data will be automatically mapped with Cleopatra Enterprise's cost models to produce a cost estimation for the simulated project scope (figure 4).

Because of the automation of the information exchange, process designs can be estimated in less time, allowing for the estimation and consistent comparison of multiple design alternatives (figure 5). This will provide insight into the cost implications for each option. As a result, only the (most) profitable designs will be developed further, reducing the amount of (re-)engineering effort.



▲ Figure 5: Cost comparison between process design alternatives in Cleopatra



▲ Figure 6: Cost objects consist of the equipment item and its associated disciplines. Together the cost objects form the complete project (ISBL).

NEW APPROACH: OBJECT ORIENTED ESTIMATING

Next to the above mentioned factor estimating methodology, Cleopatra Enterprise supports the cost engineer throughout the complete project life cycle, allowing for a new and more advanced estimating methodology: object oriented estimating.

Because Cleopatra Enterprise is a central hub for all project data, it is possible to identify characteristic values from executed projects.

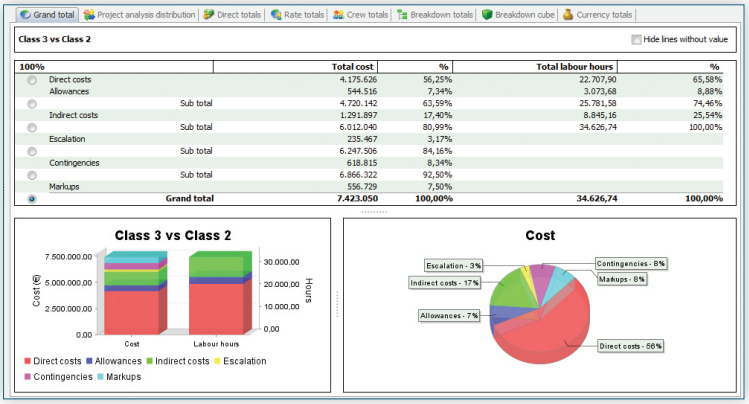
Characteristic values are metrics used for object oriented estimating in order to determine the expected project quantities, without having to involve a full design team to determine these quantities. Some examples of characteristic values are:

- An average of 150 m pipe per equipment
- An average size of 4.5" pipe
- An average of 0.9 - 1.2 control valve per equipment
- An average of 5.5 field instruments per equipment

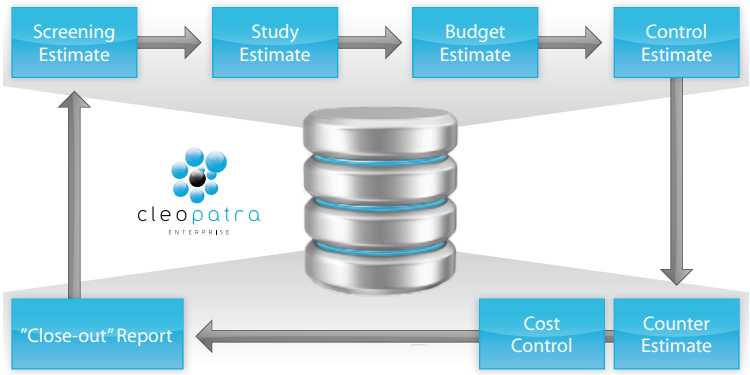
These characteristic values can be used to create 'cost objects', combinations of characteristic values for each discipline, representing the associated scope (figure 6). A cost object can be for example a pump with associated foundation, piping, instrumentation and electrical work. The cost objects are driven by the quantities of the characteristic values. These quantities (the generic equivalent of MTO quantities) can be priced using Cleopatra Enterprise's cost databases for estimating, to derive the total project cost (figure 7).

One of the main advantages of focusing on quantities rather than costs is that quantities are better understood by the engineers and designers and thus improve communication. (See page 71 for more information about object oriented estimating.)

Coming back to the UniSim Design and Cleopatra Enterprise integration, object oriented estimating can be applied in Cleopatra knowing the equipment type and its main parameters (size, metallurgy, etc.). For example, if Cleopatra Enterprise gets the equipment parameters of a 40m3 tank from UniSim Design it can be matched to the associated cost object in Cleopatra's cost database which contains not only the high level equipment cost, but also a detailed built-up of the costs and quantities associated with this equipment. No longer are the costs for piping represented by a single number based on factors, but due to the characteristic values a hierarchical structure of the quantities and costs will be given for the different disciplines.



▲ Figure 7: Total project cost overview in Cleopatra Enterprise



▲ Figure 8: Typical Estimating life-cycle: closing the loop between execution and conceptual phase

Because of the added information to the estimate and the open and flexible structure of Cleopatra Enterprise, it remains possible for the cost engineer to fine-tune the cost objects if necessary. This will again enhance the evaluation process of the different design alternatives. This can be done for example with the project analysis tool within Cleopatra Enterprise, where the cost engineer can have a detailed look at the cost variations for the different scenarios.

Given the ability of Cleopatra Enterprise to support also the construction phase of projects, cost engineers will be able to 'close the loop' between executed projects and early type estimates during conceptual design, creating a continuous improvement cycle (figure 8).

MOVING TO A MULTIDISCIPLINARY APPROACH

Getting a good insight in the cost implications of process designs is not the only advantage of the link between process and cost engineering tools. Because process engineers can almost directly see the cost impact of changes in the process design, their cost awareness will improve. From a technical perspective it could be a perfect solution to double the size of a heat exchanger, but perhaps it will be more cost effective to have two separate items to achieve the same result. Eventually, the process engineer will be able to recognize the optimum cost-effective designs before actually putting in the effort and time to develop less effective designs.

The other way around, also the cost engineer will get a better understanding of the process engineer's thoughts. This will improve the communication between the two disciplines. Keep in mind that it is not recommended to make the process engineer responsible for the cost estimate or vice versa. But in the end, by combining each other's knowledge, the synergy effect will result in an optimal technical and economical solution for the project.

FINDINGS

Businesses want to make better decisions earlier in the project

development stage. To do this, it is needed to have already a good insight in the technical as well as the economic viability of a project during the conceptual and FEED phases. Recent software developments allow for a tight integration between process design and cost engineering software, making it possible to compare design alternatives and choose the most profitable solution.

The link between UniSim Design and Cleopatra Enterprise highlighted in this article shows an integrated solution. This solution supports not only the traditional factor estimating methodology during conceptual design and FEED, but also object oriented estimating, a more advanced estimating method based on characteristic values and quantities. Throughout the development stages of the project, Cleopatra Enterprise supports also detail estimating and can even close the loop by identifying new characteristic values or improve existing ones. In short the integration of process design and cost engineering software will result in:

- **Informed decision making**
  By having a clear understanding of the cost implications of process design alternatives, better informed decisions can be made. Already during the conceptual phase one can choose the 'right' project, based on not only technical but also economic factors.
- **Engineering cost & time savings**
  The "UniSim Design – Cleopatra Enterprise" interface will significantly reduce the estimating time for the different process alternatives, while at the same time the number of re-engineering hours will be reduced, because unprofitable process designs are identified early on in the project development stage.
- **Enhanced flexibility**
  Process engineers will have the possibility to quickly explore the cost impacts of design changes, giving them more flexibility to explore 'out-of-the-box' solutions that normally would not be considered.
- **Object Oriented Estimating**
  The object oriented estimating methodology supported by Cleopatra Enterprise allows for an easier advancement into a detail estimate as opposed to traditional factor estimating methodologies.
- **Transparency**
  Because Cleopatra Enterprise is capable of object oriented estimating based on the input of high level process equipment information, the cost estimate has a hierarchical structure, from detailed information up to the object level. This provides a transparent view on the build-up of the cost estimate.
- **Communication**
  The integration of otherwise isolated process engineering and cost engineering tools will remove the communication barriers between the two disciplines.

Due to the integration of tools like UniSim Design and Cleopatra Enterprise, significant value can be added during the conceptual phase, resulting in informed decision making which is highly desired by today's businesses.

REFERENCES

- *G3415–1 Een kwantiteitenbegroting aan de hand van de apparatenlijst, DACE Cost Engineering manual - Cost Engineers april 1989 (A quantitative estimate based on the equipment list)*
- *Syllabus DACE Introduction Cost Engineering – Quantitative estimating methods, 2005, DACE*
- *Syllabus Factor Estimating, Cost Engineering Intensive , 2008, A.M. Jansen-Romijn*
- *Fundamentals of Factored Estimating for the process industry, 2 day workshop by L. Dysert*
- *CCC/CCE certification paper: Define and Apply Projects' Characteristic Values and Improve Estimate Accuracy, 2011, By A.M. Jansen-Romijn*
- *Recommended Practice 18R-97, "Cost Estimate classification system – As applied in Engineering, Procurement, and Construction for the process industries", AACE*
- *Design of Simple and Robust Process Plants, 2000, J.L.A. Koolen*
- *Product Data Management (PDM), 2000, John Stark*

For more information please contact:

Cleopatra Enterprise
sales@cleopatraenterprise.com

Honeywell
Rafael Coronel
rafael.coronel@honeywell.com