DECISION ANALYSIS AS A PROJECT MANAGEMENT TOOL FOR PRODUCT AND PROCESS DESIGN

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Abstract

Industrial design or R&D project can be understood as series of decisions. A method for project administration, based on a detailed decision analysis, is presented. In addition to conventional project management, the approach helps to take into account unique features of a project and to improve the methodological performance.

Keywords

Process design, design project, project management, decision analysis.

Introduction

Industrial projects for the development and design of new products and processes always have many simultaneous goals. Usually one ends up with a compromise between subgoals originating from technical and economical requirements, as well as from the schedule. In addition, projects usually have specific goals connected e.g. with safety aspects or mechanical problems typical for the project in question. Simultaneous consideration of all these goals sets very high requirements on project administration.

Some qualitative goals arise also from the requirements to carry out the project in a right way. Because of the changes in chemical industry, both product and process development usually appear in the projects. The traditional routines of R&D and design projects are not necessary adequate then. Secondly, concurrent process design is a widely accepted goal, but still poorly achieved in practice. And in R&D stage one has to decide on optimal strategy, i.e. to select the experiments, the experimental equipment and conditions, theories utilized in the models, simplifying assumptions and many other items. Actually the whole strategy of R&D consists of extremely large number of choices.

How well the project goals will be reached and how the different requirements will be fulfilled depend on the decisions made during the project. The whole process lifecycle, starting from R&D and continuing by design, construction, start-up and operation, can be interpreted as a chain of decisions. There are three types of them: quantitative decisions resulting in exact numerical values, selective decisions representing a choice between several alternatives and go / no go – decisions which determine if the project should be continued or terminated. The project management approach described in this paper is based on detailed decision analysis because the decisions are crucial in reaching the objectives of the project.

The method originates from experience with real industrial process R&D projects. Development of melamine production process (Turunen and Oinas, 1998; Turunen, Ilme, Sundquist, Määttä, 1999) is used as an example case.

Project objectives

The objectives of a project can be classified into three groups: main goals, project specific goals and methodological goals.

The main goals determine the project budget, technical content and quality as well as the schedule of the project. These goals are usually well defined and can be expressed by numbers or exact statements.

The second group, project specific goals, is needed to take into account any unique features of a project. In our case project, melamine, a specific goal was to call attention to mechanical problems typical in the operation of the process. Similarly, certain processes may require special attention e.g. to safety or environmental problems. Also strategic goals of the company might be included in this group.

The methodological goals concern the project performance. Integration of product and process design, process intensification and increasing the concurrency of different design and R&D activities are examples of these. In the example case, melamine project, energy integration was taken as a methodological goal because of large heat content of the process flows.

Decision analysis

The number of decisions in a typical design or R&D project is very large. Only the decisions with have a substantial influence on the project goals will be selected for analysis. These include decisions from each group: selective, quantitative and go/no-decisions. Fortunately the most important decisions are made at an early project stage when one has to decide e.g. about process type, select the solvent or define the product specification.

Each of the selected decisions will be analyzed carefully beforehand. Special form is used to represent the results of the analysis in the method. The analysis includes at least the following aspects:

- contents of the decision
- initial data for the decision
- criteria of the decision
- influence of the decision
- relative importance of the decision

The decision criteria can be roughly classified into three groups, as presented in Table 1. However, the table gives only a checklist because in real decision analysis it is necessary to go at more specific and more detailed level.

Table 1. General criteria of decisions

1. Economical aspects
   Costs
   - investment costs
   - production costs
   Returns
   - return on investment
2. HSE (Health, safety and environment)
   Safety and health
   - fire and explosion risk
   - toxicological risk
   - noise risk
   Environmental
   - emissions
   - waste
   - plant location
   - energy efficiency
3. Technological aspects
   Technological novelty
   Operability
   - controllability
   - flexibility
   Availability performance
   - reliability
   - maintainability
   - Technical performance

The relative importance of the decisions can be evaluated separately on the basis of different criteria, e.g. costs, HSE-criteria or technological aspects.

Analysis of the main decisions in the example project is given in Table 2. The list of decisions is classified according to the stage of process lifecycle and the analysis of the relative importance of the decisions is included.

Table 2. Identification and evaluation of the main decisions during the melamine process lifecycle (Q:quantitative, S:selective, G:go/no go-decicons).

Life cycle	No	Name and type of decision	Importance based on Cost	HSE	Tech
Idea stage	1	Product spec. (S)	2	1	3
	2	Capacity (Q)	3	2	2
	3	Technology strategy (S)	5	2	5
R&D	4	Process concept (S)	5	4	5
	5	R&D strategy (S)	4	3	3
	6	Location (S)	3	4	2
Conceptual design	7	Go/No go (G)	5	5	5
	8	Reactor type and sizing (Q,S)	3	2	4
	9.	Crystallizer type and sizing (Q,S)	2	1	3
	10.	Mass integr. (Q,S)	3	1	3
	11.	Heat integr. (Q,S)	4	1	3
Detailed design	12.	Reactor design (Q)	2	2	4
	13.	Crystallizer design (Q)	1	1	3
	14.	Tracing system (Q,S)	2	2	4
	15.	Go / No go (G)	5	5	5
	16.	Final lay-out (S)	4	3	3
Construction and erection	17.	Selection of contractor (S)	3	1	2
Start-up and test runs	18.	Start-up plan (S)	2	3	3
Operation	19.	Production plan (S)	3	2	2
Retrofitting	20.	Process impr. (S,Q)	2	2	3
Closure	21.	Close / Not close (G)	4	5	2

Project planning

The next step is to construct a decision map on the basis of decision analysis. This is a graphical representation where the decisions are shown as points along the time axis. In addition to chronological order of decisions, also the logical order can be indicated in the map. Then the knowledge of the initial data for each decision, as well as its influence on the later ones, is included. The vertical axis can be used to describe the relative importance of the decisions.

The decision map is actually the first stage of project plan. It can be used for different purposes. The most evident way is to use the decision map for normal project administration, such us scheduling and project resource and cost estimation.

Different decision maps can be made to emphasize certain important goals or problems which are characteristic to the process being studied or designed. In the example process, melamine, mechanical problems, such as leakage, plugging in pipelines and failures of sealing and instruments are to be predicted. Decision map including the decisions connected with such matters would be very useful tool to deal with these problems.

Finally, decision maps can be used to improve the project performance in a methodological sense. Concurrent design and selection of proper R&D strategy are examples of valuable goals which can be more easily reached by systematic decision analysis with the maps.

A summary of a detailed R&D plan for melamine project, generated by decision map analysis, is shown in Table 3.

Table 3. Project plan for melamine process R&D.

PERIOD	ACTIVITIES
Start-up period. 3 months. Goals: Smooth operation, mechanical problems solved.	- Start-up - Observation and solving mechanical problems. - Observation of process reliability.
Quality optimization period. 3 months. Goals: Acceptable quality reached and product samples available to customers.	- Experiments with key variables in predetermined range.
Process R&D period. 2 months. Goals: Validated process models available for scale-up and energy optimization.	- Steady-state experiments. - Dynamic experiments. - Estimation of model parameters. - Model validation. -- Aspen -- Detailed models.
Studies of exceptional conditions. 4 months. Goals: Knowledge of alternative operating conditions, start-up procedures etc.	- Several specific process tests.

Conclusions

Administration of industrial R&D and design projects is not easy because of their multiple goals and specific features. In addition, changes in chemical industry require also modernization in the methods of design and research. The whole R&D and design project can be understood as a chain of decisions. Detailed analysis of these decisions offers an efficient tool not only for conventional project administration but also to deal with specific goals of the projects and to improve the methodology of project performance.

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