

# Automation d'une Installation Polyvalente

Adolfo Semadeni\* and Guy-Bernard Meyer\*

## Automation of a Multipurpose Facility

**Abstract:** The characteristics of a multipurpose production unit are its capacity to carry out chemical processes for highly complex molecules with several synthesis steps and its high flexibility to ensure fast adaptation to different manufacturing procedures, thereby greatly reducing campaign change-over times. As for the technical aspects, the unit is designed in standard and independent modules, linked to each other by distribution stations and collector groups. To meet these flexibility and rapid change-over requirements and to reduce operating costs, the production unit is automated.

The solutions chosen depend on the context of the projects. One of the main aspects of the industrial site of Monthey is the high level of automation of its equipment and the standardisation of its concepts and systems. For more than 20 years, a single type of process control system (FOCLAN) has been used on the site. Thus, coherent automation concepts are designed and passed on from project to project, encouraged by an uninterrupted development of the control system.

The automation of a multipurpose facility differs in many points from that of a standard unit. To meet project requirements in terms of safety, flexibility and multivalence, automation design has evolved towards better use of the possibilities of the automation system, a larger modularity of the 'application' programmes and a strict separation between the description of the unit (mechanical) and that of the process (recipe).

**Keywords:** Automation · Flexibility · Modular programming · Modularity · Multipurpose plants · Recipe management



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## 1. Introduction

Dans le domaine de la protection des plantes, à la fin des années 80, la tendance est de développer des produits biologiquement très actifs. L'utilisation des produits sur les cultures passe d'une quantité de 1–5 kg par hectare à des dosages beaucoup plus faibles, entre 20 et 100 g par hectare.

Les nouvelles molécules, développées pour atteindre une sélectivité et une activité biologique plus élevées, sont complexes et requièrent plusieurs étapes dans leur synthèse. Les volumes de production annuelle de ces produits très actifs deviennent relativement réduits. Pour limiter les stocks, avec la conséquente immobilisation de capital, la production doit être conduite par campagnes adaptées à la demande. Afin de répondre à ces critères, il s'agit de concevoir et de dimensionner des unités de production polyvalentes et de haute flexibilité.

## 2. Conception de l'Installation

### 2.1. Concept Général

Comme mentionné, une unité de production chimique polyvalente doit pouvoir répondre très rapidement aux sollicitations de la planification. Pour l'établissement du concept de base pour la conduite de l'installation, nous avons auparavant défini les formes de polyvalence à atteindre:

- production simultanée de plusieurs produits dans les divers modules, avec des configurations ou regroupements d'appareillage changeants.
- productions successives de plusieurs produits ayant des chemins de synthèse similaires dans une ligne de production prédéfinie, constituée par un regroupement d'appareillages.

Atteindre la flexibilité signifie concilier la polyvalence, réalisée au niveau de l'installation mécanique, avec la souplesse requise pour l'adaptation des recettes

aux paramètres donnés par la complexité des synthèses. La rapidité d'exécution et la qualité des travaux de nettoyage et d'adaptation mécanique lors des changements de campagne deviennent aussi des éléments essentiels, pour garantir une qualité rigoureuse et l'absence de toute contamination croisée dans ces produits à haute activité.

L'idée de base du concept adopté est de configurer et découper l'installation en modules standards, autonomes et indépendants comprenant l'appareil principal et ses périphériques fixes, par exemple le réacteur avec ses systèmes de remplissage, de vidange, de brassage, de chauffage/refroidissement et de distillation. La sécurité de fonctionnement mécanique et le déroulement du procédé doivent être garantis pour chaque module.

Ainsi chaque module standardisé doit pouvoir exécuter une ou plusieurs opérations unitaires telles que préparation, réaction, extraction, séchage, distillation tout en remplissant les conditions d'hygiène, de sécurité et de protection de l'environnement.

Il en résulte que, pour réaliser ces critères de flexibilité et de changements rapides, un système de commande automatisé s'impose pour piloter les modules de base, pour coordonner les liaisons entre les modules standardisés et pour gérer les recettes des divers procédés. De plus, l'automatisation des installations permet de réduire fortement les coûts d'exploitation de l'unité de production.

## 2.2. Réalisation Technique

Pour la réalisation pratique d'une unité polyvalente de chimie fine, la flexibilité constitue le critère le plus important. Le pragmatisme influence le choix technologique final, afin de concilier les tendances divergentes entre le niveau d'automatisation, critère majeur pour la réduction des coûts d'exploitation, la modularité dans la réalisation mécanique, qui donne la flexibilité d'utilisation, et la limitation des coûts d'investissement et d'exploitation.

Pour l'unité polyvalente, le choix se porte sur la technologie des réacteurs par charge (batch). Ces réacteurs présentent une grande flexibilité et sont bien adaptés à la production de quantités réduites de produits à haute valeur ajoutée. Lors du montage, le module de base, appareil principal, est installé et est complété avec ses périphériques fixes uniquement en fonction des exigences des procédés, afin de contenir les investissements tout en prévoyant des extensions futures possibles (Fig. 1).

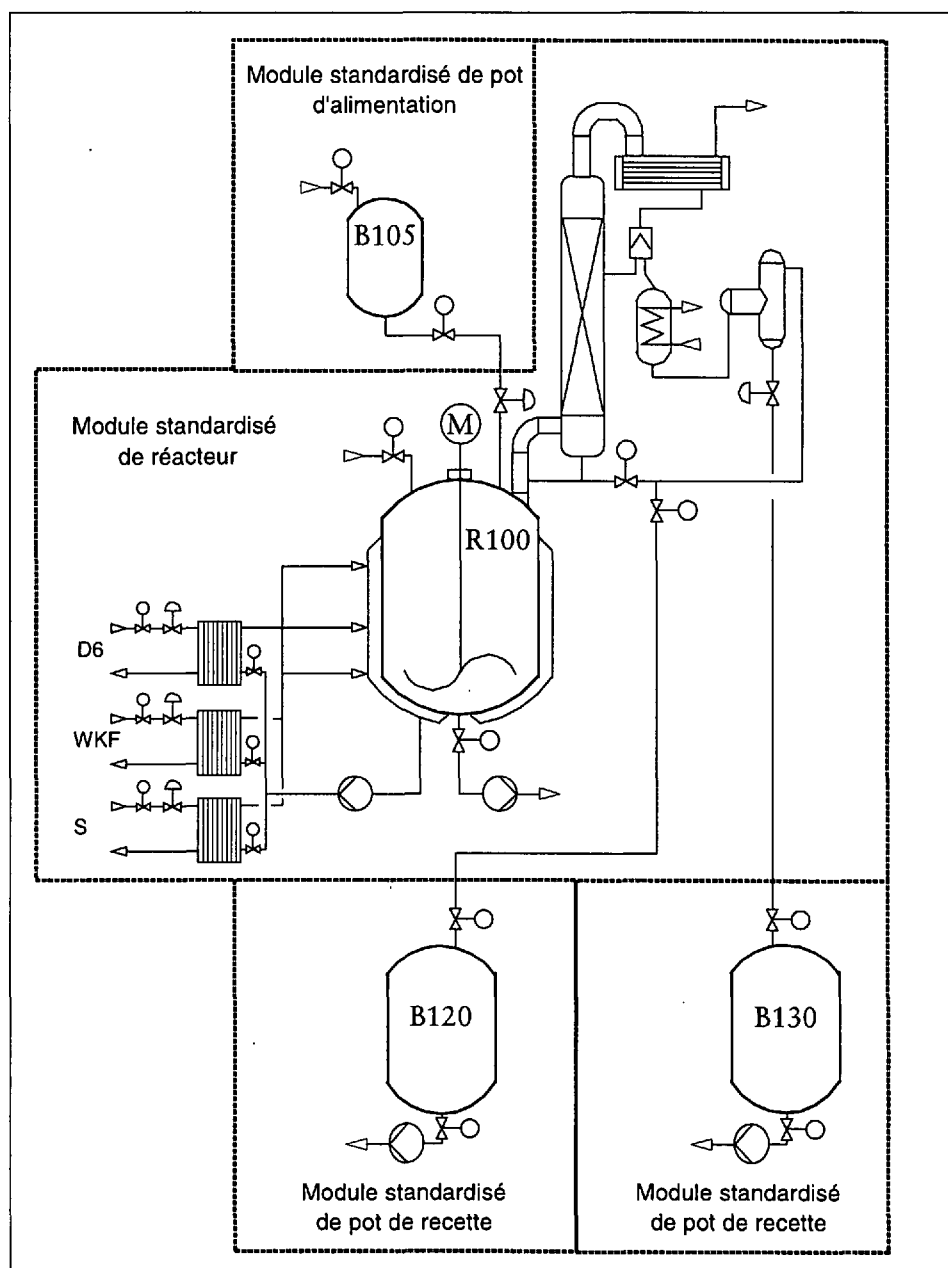


Fig. 1. Conception modulaire standardisée des installations

La distribution des liquides entre les différents modules est réalisée au moyen de nappes de collecteurs de distribution et de gares de liaison entre les mêmes modules (Fig. 2).

Les échappements gazeux de chaque module sont aussi reliés aux unités de traitement spécifiques pour la protection de l'environnement, au moyen de distributeurs et de collecteurs (Fig. 3).

L'installation d'un système d'introduction de solides pulvérulents est également nécessaire pour certains modules.

Le système de commande est centralisé et conduit par ordinateur. L'automatisation de l'installation polyvalente doit donc être conçue pour satisfaire aux contraintes de flexibilité et de modularité définies par l'exploitant.

## 3. La Stratégie d'Automatisation du Site de Monthey

Le choix de la solution technique dépend du contexte dans lequel sont réalisés les projets d'automatisation. Le site industriel de Monthey se caractérise par le degré d'automatisation élevé de ses installations et une standardisation poussée des concepts et systèmes d'automatisation.

La standardisation 'matérielle' (ordinateurs, interfaces industrielles, automates programmables, logiciels) apporte principalement ses bénéfices au niveau des coûts de maintenance, par la rationalisation des pièces de réserve et la spécialisation des équipes d'entretien.

La standardisation 'conceptuelle' a un impact plus important. D'une part, elle



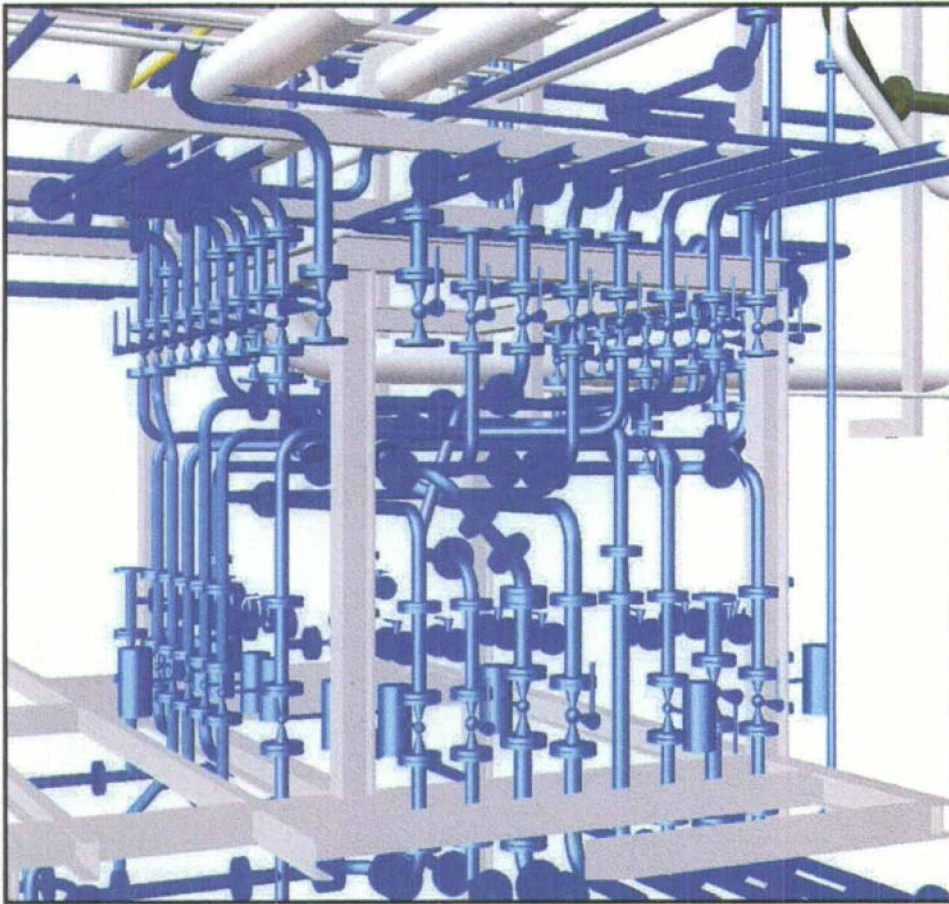


Fig. 2. Gare de distribution des liquides

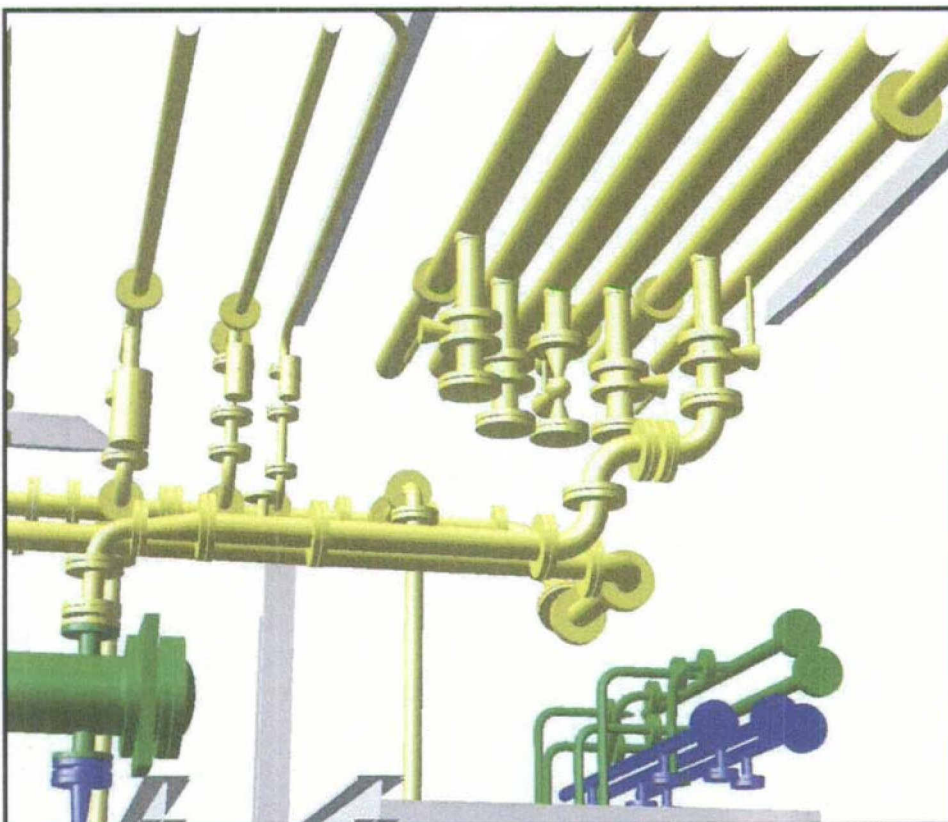


Fig. 3. Gare de liaison des événements gazeux aux collecteurs des unités de traitement

permet de réduire de manière drastique les coûts d'étude et de réalisation d'un projet d'automatisation. Les concepts de surveillance, de câblage, de commande etc., mais aussi les règles de programmation et les modules de programmes, sont définis globalement et réutilisables de projet en projet. D'autre part, elle instaure un langage commun entre tous les acteurs, et établit une base de collaboration entre les spécialistes de l'automatisation, de la chimie ou de la mécanique.

Cette stratégie est rendue possible par l'évolution sans rupture du système d'automatisation depuis plus de 20 ans. Grâce à la continuité des investissements sur le site, le système FOCLAN [1] a pu évoluer et s'adapter aux nouvelles technologies et à l'évolution des besoins des utilisateurs. Deux facteurs sont à mettre en exergue dans cette approche :

- En garantissant la compatibilité ascendante du logiciel, on préserve les investissements importants consentis dans les programmes 'applicatifs' (la description de ce que doit faire le système d'automatisation).
- Par la mise à jour systématique des systèmes d'automatisation du site, on fait bénéficier toutes les installations de production des améliorations et nouvelles fonctionnalités, et on rationalise la maintenance des systèmes (une seule version installée).

L'organisation est centralisée pour les activités de conception, de projet et de maintenance. Ainsi, un groupe restreint de collaborateurs est en charge de l'automatisation pour les sociétés du site industriel de Monthey, avec la 'masse critique' lui permettant de poursuivre la stratégie définie. L'action du service automation est prolongée dans le terrain par les 'opérateurs software', qui constituent un lien indispensable entre les services centraux et les exploitants. Possédant une formation de base dans le domaine de la chimie, directement rattaché à un bâtiment ou à un secteur de production, l'opérateur software maîtrise la programmation du système d'automatisation. Il permet donc à l'exploitant une autonomie importante dans l'évolution et l'optimisation de ses installations et procédés.

#### 4. Les Contraintes de l'Automatisation Polyvalente

L'automatisation d'une installation polyvalente diffère en de nombreux points d'une réalisation classique. Pour satisfaire les contraintes du projet en termes de sécurité, de flexibilité et de poly-

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valence, les concepts d'automation ont évolué vers une meilleure utilisation des possibilités du système d'automation, une plus grande modularité des programmes 'applicatifs' et un découpage strict entre la description de l'installation (la mécanique) et celle du procédé (la recette).

#### 4.1 Contraintes de Sécurité

La gestion des alarmes d'une installation polyvalente doit distinguer la sécurité 'mécanique' (les alarmes liées aux contraintes physiques des appareils) de la sécurité 'procédé' (les alarmes liées aux produits). La sécurité est donc entièrement gérée par le système d'automation, qui doit garantir que la sécurité 'mécanique' est toujours assurée, tandis que les paramètres et comportements associés aux produits sont chargés et déchargés en fonction de l'occupation des équipements.

Lorsque l'analyse de risque l'exige, la mesure, l'acquisition et le traitement de certaines valeurs, critiques pour la sécurité, sont doublés par une chaîne indépendante de sécurité. La concordance entre les valeurs traitées par le système d'automation et les valeurs traitées par le système de sécurité est contrôlée et déclenche les actions de sécurité. La polyvalence impose donc au système de sécurité, comme au système d'automation, de prendre en compte les modifications des seuils d'alarme, surveillances et actions

liés aux produits.

Les concepts classiques de mise en sécurité de l'installation sont généralement hiérarchiques: déclenchement général du bâtiment, arrêt général de fabrication, mise en sécurité d'une ligne de production et arrêt d'urgence (local) d'un équipement. La polyvalence ajoute un niveau de mise en sécurité 'produit'; cette mise en sécurité est traitée par le système d'automation et conduit dans un état prédéfini toutes les unités occupées par la même recette. Une gestion dynamique des configurations en fonction de l'occupation des unités est donc nécessaire.

#### 4.2 Contraintes de Flexibilité

La flexibilité 'mécanique' de l'installation trouve son pendant au niveau du système d'automation. Cette conception est conforme aux recommandations de la norme S88 [2] avec une terminologie adaptée aux besoins de l'entreprise.

Au niveau du modèle conceptuel de l'installation (MCI) [3], la conception modulaire a conduit au découpage en:

- Unités d'organisation (UO)
- Unités autonomes (UA) [4]
- Unités fonctionnelles (ou fonctions unitaires, FUN) [5]

L'unité d'organisation (UO) est composée d'une ou plusieurs Unités autonomes (UA) qui sont interconnectées *définitivement* entre elles. Cette notion représente une restriction vis-à-vis d'une flexi-

bilité maximale vue sous l'angle de la polyvalence, mais a été définie dans un but rationnel, organisationnel et de simplicité de façon à s'adapter au plus près à la réalité, c'est-à-dire à la marche réelle de l'outil de production.

L'unité autonome (UA) est un appareil ou un ensemble d'appareils pouvant être considéré comme une unité indépendante et indissociable au niveau fonctionnel. Chaque appareil est lui-même composé d'une ou plusieurs unités fonctionnelles. Par exemple, une unité autonome peut être composée d'un appareil principal seul ou d'un appareil principal avec 1 à n appareils auxiliaires, si ces derniers ne fonctionnent que pour et qu'avec cet appareil principal.

L'unité fonctionnelle (FUN) est, et gère, un ensemble d'éléments physiques qui travaillent toujours ensemble pour réaliser cette fonction. Par exemple, fonction 'chauffage', 'brassage'. Il faut relever que cette notion est physique, mais contient déjà toute l'intelligence nécessaire à son traitement (séquencement, régulations, modes de marche, sécurité 'mécanique' et marches dégradées intrinsèques à la fonction). L'unité fonctionnelle agit sur les dispositifs et les éléments (vannes, moteurs).

Cette approche modulaire a permis de développer, au fil des projets, une bibliothèque de modules de programmes 'applicatifs', décrivant entièrement le com-

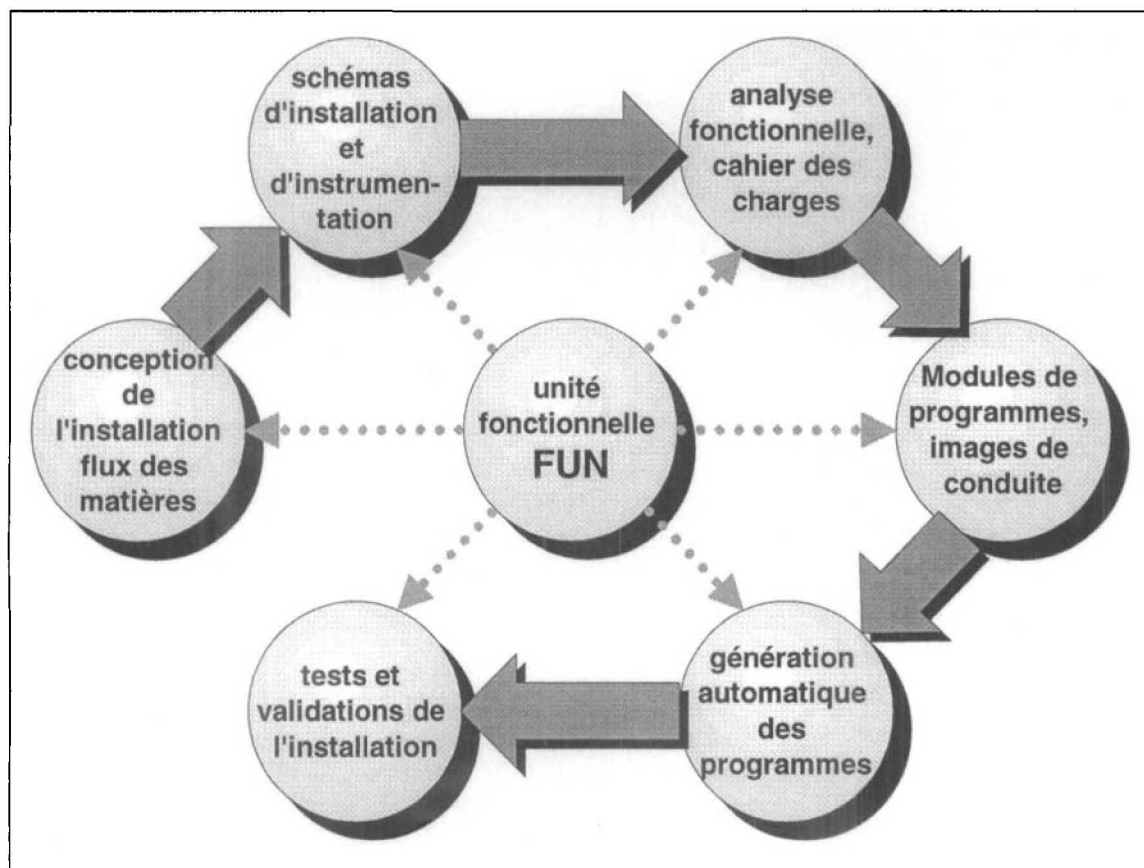


Fig. 4. Unité fonctionnelle, module de base pour la conception des installations

portement d'une unité fonctionnelle, et utilisée comme brique de base lors de la conception de nouvelles installations (Fig. 4).

Pour satisfaire aux exigences de flexibilité de l'exploitant, les modes de marche des unités ont été conçus afin de lui permettre de prendre la responsabilité de la conduite du procédé (modes manuels). La fonction est le plus petit objet manipulé par les opérateurs lorsqu'il conduit l'installation en mode 'manuel'. Le mode 'manuel libre' n'impose aucune contrainte spécifique à un procédé: seuls sont actifs les alarmes, surveillances et verrouillages liés aux contraintes physiques des appareils. En mode 'manuel procédé', par contre, l'unité est 'occupée' par un procédé. Les alarmes, surveillances et verrouillages associés à la recette sont actifs, et l'opérateur ne peut changer l'ordonnement de l'activation des fonctions que dans la mesure où la recette l'autorise. Dans ce mode de travail l'opérateur peut, de manière simple, réactiver le mode 'automatique' dans lequel la recette conduit l'installation sans intervention des opérateurs.

#### 4.3 Contraintes de Polyvalence

Le modèle conceptuel de l'installation a son équivalent au niveau de la recette: c'est le modèle conceptuel de la recette (MCR) [6]. La stricte séparation entre la description de l'installation et la description de la recette est la clé de la polyvalence de l'installation. Un nouveau procédé doit pouvoir être décrit sans aucune intervention sur la programmation des unités et des fonctions.

Une recette [7] contient et décrit les matières mises en jeu, ainsi que tous les processus chimiques, physiques et physico-chimiques nécessaires à la fabrication d'un produit. La recette est composée d'étapes [8], qui elles-mêmes sont une suite d'opérations [9]; elle décrit la séquence dans laquelle les étapes et opérations sont effectuées.

Une attention particulière doit être portée sur les mécanismes d'allocation des unités et des services. La réservation, l'occupation et la libération d'une ressource doit satisfaire aux exigences d'utilisation des services partagés (arbitrage), et optimiser les transferts des produits.

Les choix d'implémentation suivants ont été réalisés dans les projets d'automatisation d'installations polyvalentes:

- Les lavages sont des recettes indépendantes à part entière. Ces recettes de lavage sont lancées entre les campagnes de production et permet-

tent d'optimiser les changements de campagne.

- Pour une installation de synthèse avec des campagnes de production relativement longues (1 à 4 mois) et exploitant un nombre limité de procédés (10 à 20), l'utilisation d'un outil spécifique dédié à la gestion de recettes n'a pas été jugée nécessaire. Les recettes ont été décrites à l'aide des outils d'automation standards à disposition, tout en respectant la séparation des programmes entre la description de l'installation et celle de la recette.
- La standardisation des opérations chimiques de base réalisables sur chaque unité permet une programmation simple et rapide d'un nouveau procédé.
- Les opérateurs pilotent l'installation à l'aide de vues 'procédé' (suite des opérations, état d'avancement) et de vues 'mécaniques' (vue de l'installation, état des unités et des fonctions), et disposent de raccourcis pour passer instantanément des unes aux autres.

#### 5. Conclusions

Une approche intégrée dans le dimensionnement d'une unité de production pour la chimie fine amène à la prise en compte de l'automation dès la conception du projet. Le résultat est l'exploitation d'installations et de procédés vraiment optimisés, car plusieurs aspects sont considérés dans le développement du projet, des conditions normales de travail aux déviations des conditions optimales. Il en résulte des procédés plus robustes contre les déviations.

La réalisation de nouvelles installations est grandement facilitée dans les sites industriels où la standardisation est forte et où l'expérience des projets d'automation est importante.

L'évolution vers la polyvalence des installations met en évidence l'importance de la modularité de la solution, et de la stricte séparation entre la description de la mécanique (le modèle physique) et celle du procédé (la recette), conformément aux recommandations S88.

Reçu le 12 octobre 2000

- [1] Foclan est un logiciel de conduite de procédés industriels propriété de Cimo, développé à partir de composants matériels et logiciels standards
- [2] ANSI/ISA-S88.01-1995 'Batch Control, Part 1: Models and Terminology'
- [3] S88: Physical Model
- [4] S88: Unit
- [5] S88: Equipment Module
- [6] S88: Procedural Control Model
- [7] S88: Procedure
- [8] S88: Unit Procedure
- [9] S88: Operation