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Introduction

In chemical and pharmaceutical plants most of the production is carried out by batch processing. It means that the physical and chemical transformation of raw materials into the final product is carried out in chemical reactor by performing various basic technological operations BPO as dosing, mixing, heating, cooling, vacuuming …

The basis for performing a batch process in a chemical reactor is a recipe. Recipe is document composed of parameters and procedures. **Parameters** are numeric values as dosing quantities, limits and ranges for physical variables such as temperatures, pressures, mixing speed, time limits for individual processes and the like. **Procedures** are the list of technological procedures required to carry out a batch process using recipe parameters.

Generating batch recipes is in the domain of factory development departments. It is an off-line process with several stages of development. The end result is a **Master recipe**, which is a validated recipe and is the basis for carrying out the technological process on physical equipment.

There are several Manufacturing Software packages on the market that include modules for off-line elaboration and maintenance of recipes such as MRP, MES or ERP.

*The major problems that arise in the operational implementation of recipes are:*

- Difficult and complicated operational transfer of a **Master** recipe to **Control** recipe which can be downloaded and executed in front-end processors (PLC, DCS), which operationally control and manipulate physical equipment of production line (valves, pumps, mixers …).

- A lack of automated documentation and production record functionality represents the biggest functional gap in the manufacturing software on the market today.

- Different process hardware and application software. Construction of chemical plants e.g. the synthesis of synthetic resins is usually carried out in several steps and over a long period of time. Due to this, we have in the same facility different vendors and different generations of hardware and application software. For classical batch execution (running in PLC or DCS processor) it means concurrent communication with different systems, trough different protocols, networks, bridges with other processors. Synchronizing the operation of batch phases is very difficult.

- Bad, not flexible handling of process equipment faults and technological corrections during batch execution.

Colbyco recipe&batch management – main features

- Our control-system-independent recipe&batch management software effectively manages complex batch processes, offers connectivity for real-time communication to any control system. The software can also manage multi-vendor control systems in the same process plant.

- It's the best software package for transformation of paper batch recipe to executable control recipe and automatic execution of it in three steps: Creating control recipe, make work order for selected production unit, load and execute it in RCP Server Execute.

- The software package has an effective tool for creating and managing control recipes and work orders. Only knowledge of the technological process and process operations is required to create control recipes. Creation and modification of recipes its job for process technologist.

- The main software module of the package is Execute, which runs in the RCP server, manages, supervises and coordinates the execution of recipes in the production units.

- The Batch Data module track batch execution, collect production data and create real time batch report, for each production unit separately. At the same time, the spent raw materials are written off by work orders, via a direct connection to the factory's business system (SAP).

- Flexible management of problems and congestion that occur on technological equipment during the execution of batch recipes. Operator is able to pause, cancel, manually override and re-launch in any step of a batch.

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- Excellent visual presentation of each process launched or in execution in production units. The graphical interface gives a clear overview of the processes and allows the operator interactive interventions in the execution of batches.

Typical System configuration
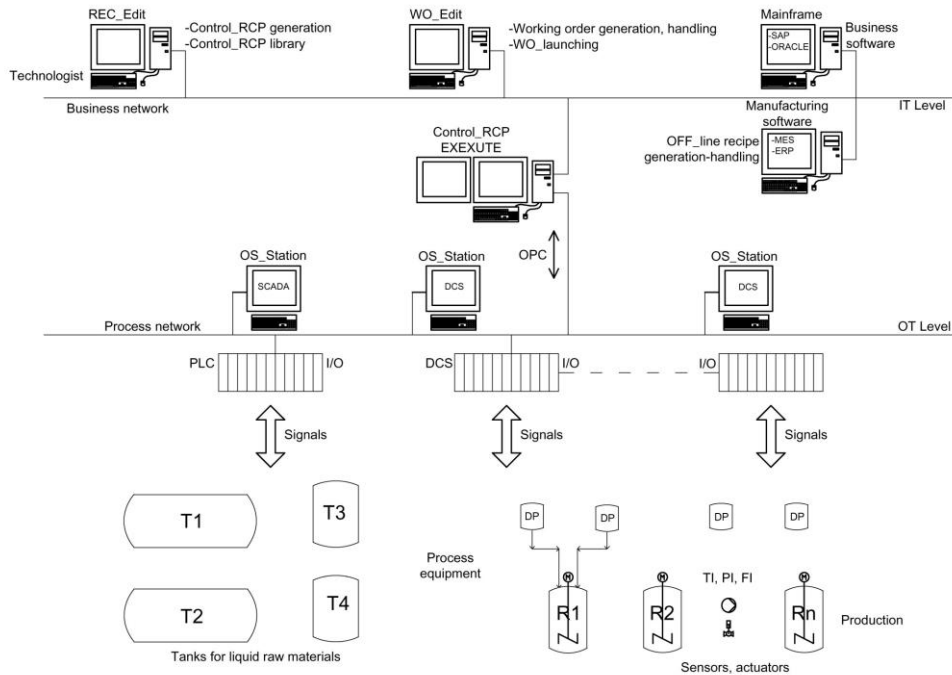
Typical Production enterprise has, to support business and production processes, an *Information Structure*, build around two networks. Business network (IT level) and Process network (OT level).

Business network connections include: business mainframe server with business software package (as SAP, ORACLE ..), and manufacturing support computers with MES or ERP software. Two R&BM modules are connected to this network REC-Edit in WO_Edit. They can run on one computer or separately on two physically separate workstations.

Process network connections include: front-end processors (PLC od DCS) with signal I/O. They are directly managing production equipment. Operator access to processes is performed via SCADA or DCS operator stations and graphical interfaces.

Recipe&batch management software modules

**REC_Edit** - Software module / Graphical interface
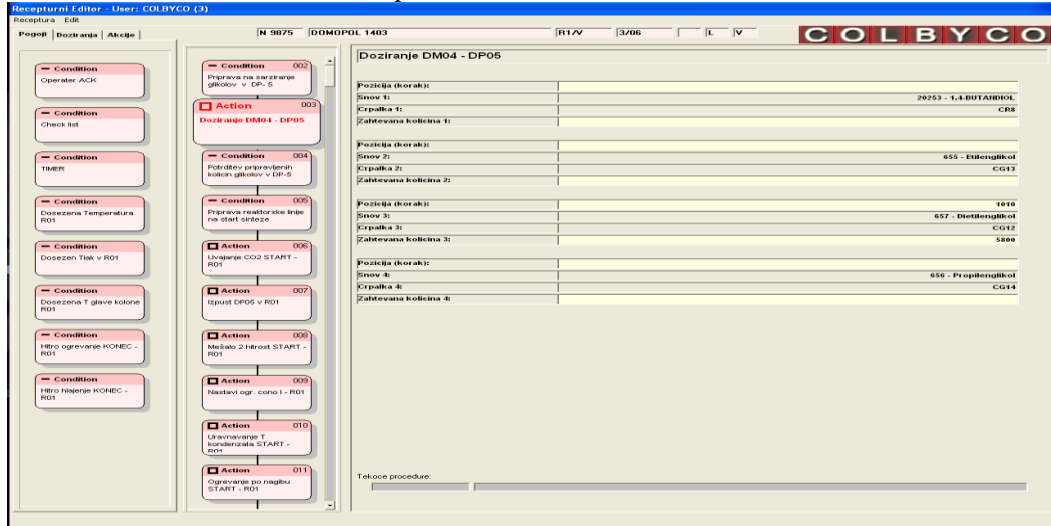
       REC_Edit - recipe editor software module is an effective tool for creating and managing control recipes, based on Master recipe. With simple drag-and-drop action the technologist builds or edits process as a sequence of predefined steps (Elements). Elements are Actions or Conditions. Included Elements may need to have additional data to be entered in the required fields on graphical interface. As the editing session is completed the Recipe is saved into Recipe Database and is available for additional editing or

verification. Each verified recipe from Recipe Database can be attached to working order and executed in target process unit – Reactor.

WO_Edit - Software module / Graphical interface
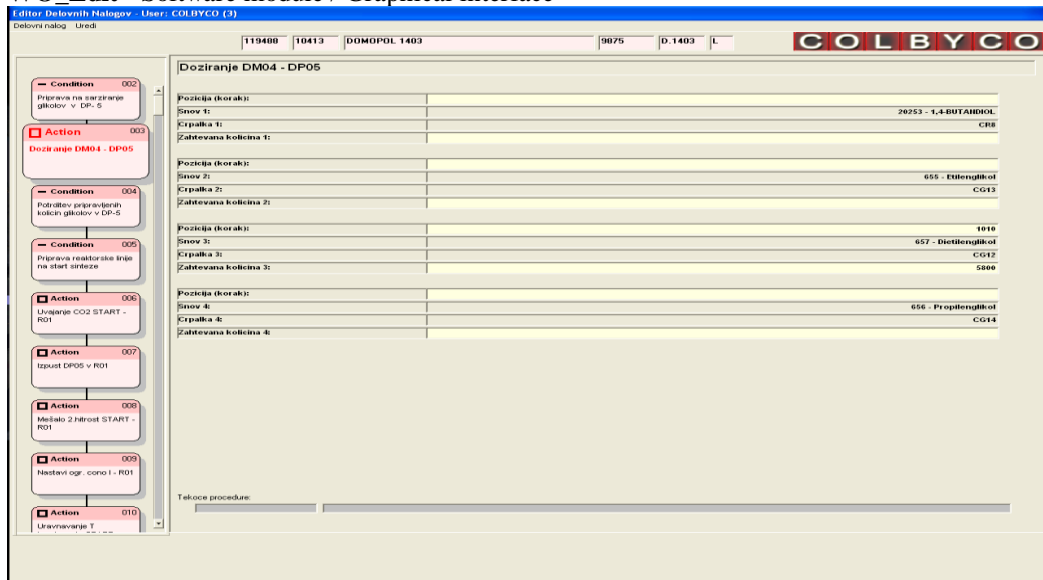
       WO_Edit – With working order software module the production dispatcher is preparing the actual Batch to be launched. It is done simply by importing an existing Recipe and updating data (quantities) according to required conditions. By marking it as Launched the saved Working Order - Batch is ready for execution in target process unit – Reactor.

RCP_Execute - Software module / Graphical interface
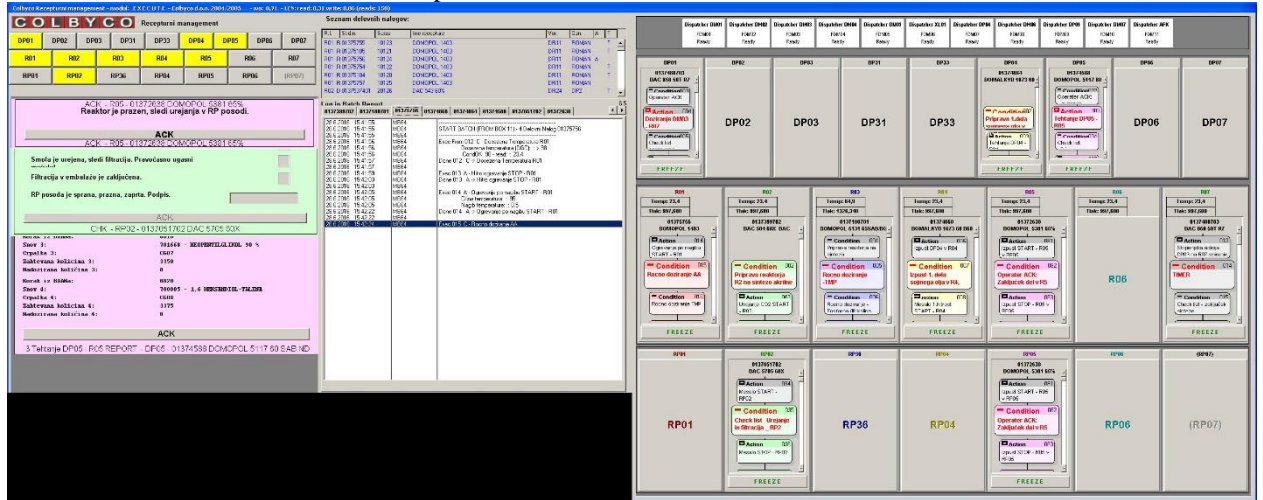
Execute is the main software module of the solution, which runs in the RCP server. It is communicating with business and process network.

Communication with front-end processors (PLC or DCS) is carried out through the process network. Through this channel the **Execute** manages, supervises and coordinates the execution of recipes in the production units, with executing predefined step actions (process phases) and checking process conditions or operator requests.

Before launching the Batch and even during the execution, operator can change some parameters in recipe if it is needed, according to the actual conditions in production facility. He can override the execution by pausing, canceling and relaunching it from a certain point in process.

Each launched Batch is visually represented as a three-steps detail in the box representing an actual reactor or other equipment in the right screen indicating previous, current and next step of the process. In this way it is used as a visual representation of the occupation of equipment in the process and is meant to be a quick reference of occupied and available resources to the operator. By clicking on the box, the operator is able to see the details of the Batch in question.

Operator can enter data and/or acknowledge process checkpoints on the left side of the left screen where dialog is performed. On the top of this section there is a group of 'warning lights' indicating that the operator action is needed. Right from the dialog section is tabbed batch-report window, where all the steps already executed in a Batch can be observed. Above the batch-report there is a short list of Batches waiting to be executed or have already been completed or terminated (available for re-launch).

Dispatcher is a sub-module of Execute program which performs the task of dispatching requests to shared equipment in first-ask first-served mode. It handles waiting lists for each of the targets and decides when conflicting calls to this equipment are made from multiple Batches. It is not usually visible on the main screen, but can be called by clicking on the indicator lights on the top of the Execute's right screen.

Recipe Elements Editor (engineering tools) is a software tool used for creation of recipe elements (Condition or Action) which are used for recipe creation with REC_Edit - recipe editor software module.

Action Elements are process bits, that actually do the process job. It can be either graphical interface corresponding to process phase (running in PLC or DCS processor) which physically executes different process operations (dosing, heating, cooling …) or direct executing command such as open valve, close valve, start mixer etc.

Condition Elements are used to stop the process execution until the condition is met. Can be either connected to read process values (temperature, pressure, etc.) and thus non-interactive or interactive (operator acknowledge, manual data input, etc.).

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Batch Report Analysis Tool

Batch Report – sample

```
12/9/2015  6:35:01 AM    DEJAN     --------------------------------------------------------------------------------
12/9/2015  6:35:01 AM    DEJAN     START BATCH - 2 Work permit no. 01366039
12/9/2015  6:35:01 AM    DEJAN        - Recipe XX095 - XXXOPOL 5142 60 SAB/DBE ND
12/9/2015  6:35:01 AM    DEJAN     --------------------------------------------------------------------------------
12/9/2015  6:35:01 AM    DEJAN     Exec 002  C - Operater ACK – dosing of glycol  to DP5
12/9/2015  6:35:04 AM    DEJAN        Acknowledging start of glycol dosing to DP5!
12/9/2015  6:35:05 AM    DEJAN        Text:      ACKFORM
12/9/2015  6:35:05 AM    DEJAN        CondOK: ACKFORM - read:       ACKFORM
12/9/2015  6:35:06 AM    DEJAN     Done 002   C -> Operator ACK - dosing of glycol  to DP5
12/9/2015  6:35:06 AM    DEJAN
12/9/2015  6:35:07 AM    DEJAN     Exec 003  A - Weighting DP05 - R01
12/9/2015  6:50:10 AM    DEJAN        Step (position) from BAAN           0010
12/9/2015  6:50:10 AM    DEJAN        Material 3: 701668 - NEOPENTIL GLIKOL 90%
12/9/2015  6:50:10 AM    DEJAN        Pump 3:  CG07
12/9/2015  6:50:10 AM    DEJAN        Wanted quantity 3:      3420
12/9/2015  6:50:10 AM    DEJAN        Dosed quantity 3:       3423.298
12/9/2015  7:30:53 AM    DEJAN     Done 003   A -> Weighting DP05 - R01
12/9/2015  7:30:53 AM    DEJAN
12/9/2015  7:30:54 AM    DEJAN     Exec 004  C - Check list - checking R in confirmation of synthesis start
12/9/2015  7:31:07 AM    DEJAN        Reactor is empty, closed in and ready for dosing.           CHECK
12/9/2015  7:31:07 AM    DEJAN        LP vessel is empty, 3way valve is in  water discharge position to LP.  CHECK
12/9/2015  7:31:07 AM    DEJAN        Valves for temp.ctrl in column are in the right position     CHECK
12/9/2015  7:31:07 AM    DEJAN        Reactor R1 is ready to start synthesis!  SIGN.              ap
12/9/2015  7:31:08 AM    DEJAN        CondOK: CHKITEM - read:       CHKITEM
12/9/2015  7:31:09 AM    DEJAN     Done 004   C -> Check list - check R and confirmation of synthesis start
12/9/2015  7:31:09 AM    DEJAN
12/9/2015  7:31:10 AM    DEJAN     Exec 005  A - Feeding CO2 START - R01
12/9/2015  7:31:15 AM    DEJAN     Done 005   A -> Feeding CO2 START - R01
12/9/2015  7:31:15 AM    DEJAN
12/9/2015  7:31:15 AM    DEJAN     Exec 006  A - Release DP05 to R01
12/9/2015  7:40:40 AM    DEJAN        Is release from DP05 to R01 finished?
12/9/2015  7:40:52 AM    DEJAN     Done 006   A -> Release DP05 to R01
12/9/2015  7:40:52 AM    DEJAN
12/9/2015  7:40:53 AM    DEJAN     Exec 007  C - Operator ACK - DP5 is empty
12/9/2015  7:40:59 AM    DEJAN        DP5 is empty, release of glycol is completed!
12/9/2015  7:40:59 AM    DEJAN        Text:      ACKFORM
12/9/2015  7:40:59 AM    DEJAN        CondOK: ACKFORM - read:       ACKFORM
12/9/2015  7:41:02 AM    DEJAN     Done 007   C -> Operator ACK - DP5 is empty
12/9/2015  7:41:02 AM    DEJAN
12/9/2015  7:41:02 AM    DEJAN     Exec 008  A - Dosing DM04 - DP05
12/9/2015  7:49:48 AM    DEJAN        Step (position) from BAAN           0020
12/9/2015  7:49:49 AM    DEJAN        Material 2:             703444 - ETILENGLIKOL
12/9/2015  7:49:49 AM    DEJAN        Pump 2:    CG_13
12/9/2015  7:49:49 AM    DEJAN        Wanted quantity 2:     1800
12/9/2015  7:49:49 AM    DEJAN        Dosed quantity 2:      1804
12/9/2015  7:58:43 AM    DEJAN     Done 008   A -> Dosing DM04 - DP05
```

This tool is used to view, analyze and compare batch reports. If you combine batch report with event logging, alarm logging, operator message records and trends (from Control System) you can analyze the course of batch synthesis down to the last details.

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Added value

Increased security of process operations. Execute performs a process security check before starting the execution of each process phase. This acts as blockades at the highest level and significantly reduces the risk of operator errors.

Guaranteed product quality and repeatability of quality with accurate implementation of the approved recipe (golden batch).

Complete traceability of the course of batch synthesis down to the last details, with help of batch report and other tools.

Real-time material withdrawals, meaning the spent raw materials are written off by work orders, via a direct connection to the factory's business system (SAP), immediately after dosing.

Reducing the number of operators in the process control room.