The right mix

Industrial^{IT} improves gasoline blending at Preem refinery

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Preem's refinery in Gothenburg, Sweden, is one of the most modern in Europe. Among its many products are LPG, motor spirits, heating oil and fuel oil. These must be carefully blended, usually involving tiresome blend header sampling, long pauses for laboratory analysis of the sample, and manual recipe correction.

Recently, Preem decided to upgrade its blending operations with ABB's Industrial^{IT} solutions for Advanced Blend Control (ABC) and Regulatory Blend Control (RBC), plus an ABB Analyze^{IT} Fourier Transform Infrared (FTIR) analyzer. As a result, on-spec blends are now produced at minimum cost.

Besides doing away with procedures and delays that were unavoidable in the past, these solutions have eliminated reblending and reduced giveaway and inventory.

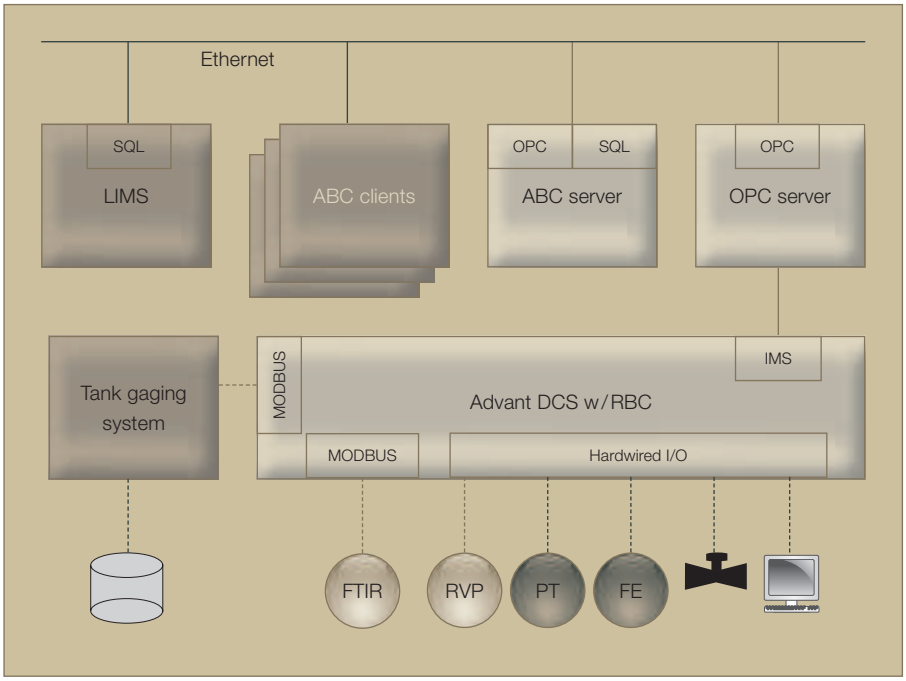
Preem's Gothenburg refinery has a crude capacity of 100,000 BPSD (barrels per stream day). At present, its main processing units in the refinery supplying components for blending gasoline are crude distillation units, hydrotreaters, a catalytic reformer, an isomerization unit and a reformate splitter (see box below).

Preem currently has three blend headers: one each for gasoline, gas oil and fuel oil. Over 22 components are blended and more than 20 products and 100 grades produced. Altogether, the blender equipment consists of some 65 component tanks, 33 product tanks, 22 flow stations and 29 pumps. Booster pumps are used when the product has to be blended directly to a product tank or ship, some 6 km away. However, the product lines to the harbor can be the cause of significant hold-ups, as they usually have to be flushed to the previous destination with the initial flow of the current blend product.

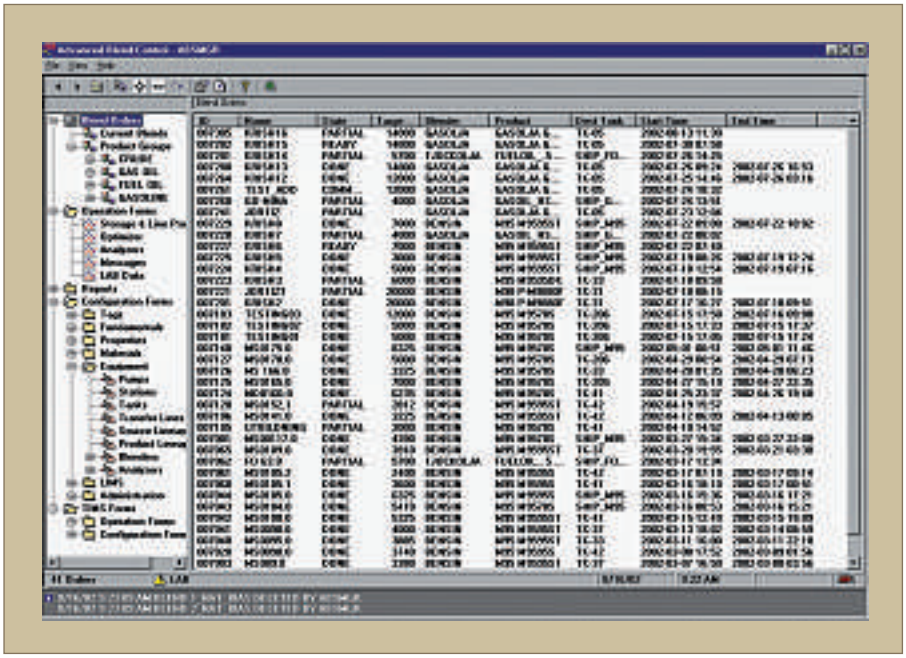
In the past, blending at Preem was optimized offline; there was no online optimization. A problem was that the property correlations used in Excel-based offline optimizers had become outdated over the years due to the addition of new units and components. This resulted in a large difference between the actual blend properties and those predicted by the offline optimizer. Correction of the blend recipe was based on the laboratory analysis of the header sample, so the blender had to suspend blending until the laboratory results came back. In addition to lost production time, this approach also resulted in frequent property violation or giveaway in the blended product.

In 2000, Preem initiated an investment program targeting a modernized and more economical blending process, plus the capability to quickly adapt to

1 Blender control schematic

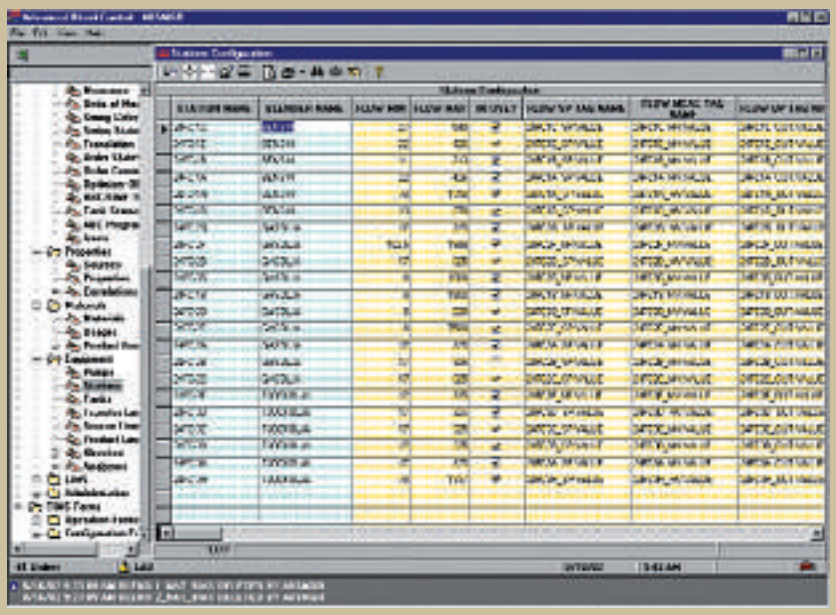


2 ABC navigator display



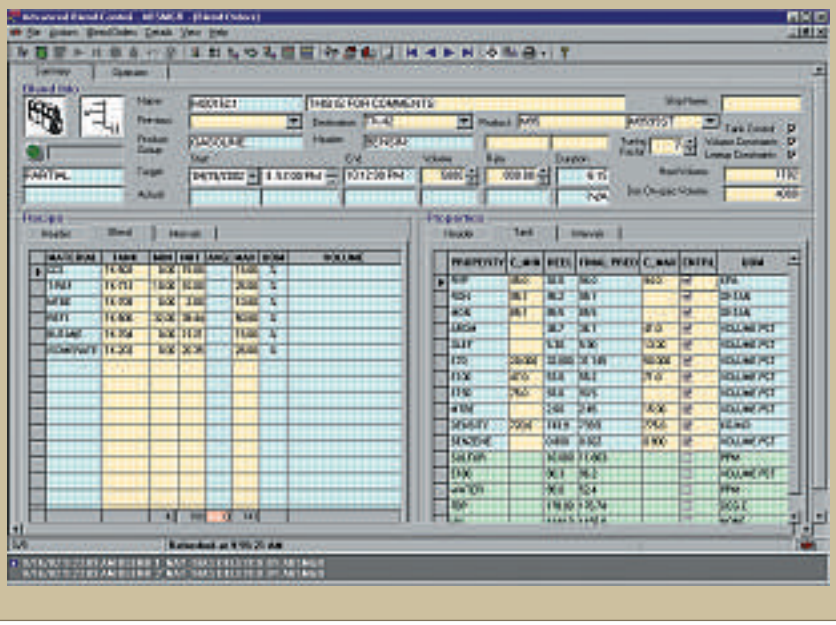
Isomerization and catalytic reformer units are just two of the several 'conversion units' that produce blend stocks. A typical gasoline blender will blend 4 to 12 such components. Conversion units include reaction sections that alter the molecular structure of hydrocarbons (in general, to improve octane) and fractionation sections (eg, **reformate splitters**) that separate the reactor effluent into streams of differing properties (eg, boiling points) and values.

3 Typical configuration display



stringent and constantly changing product specifications in Europe. This was to be achieved by introducing online optimization with continuous analyzer feedback. ABB was selected as the vendor for a totally integrated package that comprised:

4 Blend order summary display



- Advanced Blend Control (ABC) for blend order creation, offline optimization, blend order management, online property control and optimization, tank property integration and client-server communication.
- Regulatory Blend Control (RBC) for base regulatory, ratio and sequential control.
- An FTIR analyzer for online and continuous measurement of key blend properties.
- An Advant Distributed Control System (DCS) for monitoring, operation and control, interfacing with all plant field instrumentation.

The overall solution allows Preem to add new equipment, components and products, and to fine-tune parameters without assistance from ABB in the event of plant or operational changes.

The three blenders were all upgraded with ABC, RBC and DCS. To minimize the initial investment, the online NIR analyzer and online optimization were included only for the gasoline blender. Commissioning took place in October 2001. Since then the blend production time has been reduced by more than 30%, and most blends are produced with no property violation and minimum giveaway.

System overview

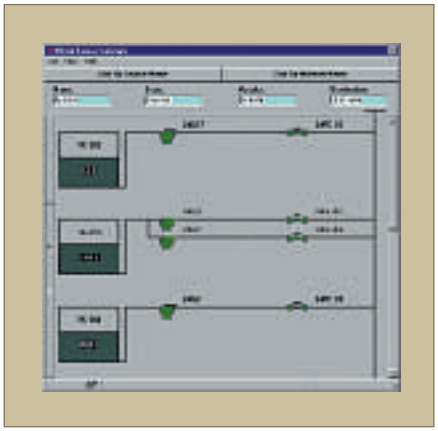
1 shows the architecture for the integrated blending control system at Preem.

The RBC resides in the ABB Advant DCS and interfaces with all the field instrumentation. ABC resides in a Windows NT server and interfaces with the DCS through a network gateway and OPC DA 2.0 server. It is also interfaced to the refinery laboratory information system (LIMS) database. The program reads process and operation information, product analyzer measurements and component lab data, and downloads optimized recipes to the RBC.

Advanced Blend Control

The ABC package allows planning and operations personnel to create, optimize, execute and store individual blend orders for the products. It can

5 Blend source lineup display



also receive blend orders from off-line multi-blend optimization, planning, and scheduling systems. ABC downloads approved blend orders to the RBC for execution, then, once on-line, blends products to meet product specifications at the lowest cost.

Relational database

ABC makes use of a custom-built, relational data model in an Oracle database, organized along the lines of equipment (header, meters, controllers, etc), property (octane, RVP, etc), material and blend order data.

The heart of the ABC data model is the blend order. It is the set of all information associated with a particular blend, including the input information needed to create the blend order in the first place, as well as information collected and calculated throughout the optimization and execution of the blend. A completed blend order, therefore, contains a very large amount of data.

Graphical user interface

The ABC *navigator display* 2 allows the user to access all ABC operations and configuration displays. Blend orders can be selected according to their product group or status.

ABC provides a number of *configuration displays* for user-friendly configuration of the database 3.

The primary ABC *operational display* is the blend order display, which allows the creation, modification and monitoring of blend orders and contains all relevant information, such as target and actual blend rates, volumes, components and recipes, and the blended properties and specifications 4.

The optimizer tab shows both interval and average recipes, min/max recipe constraints in play, min/max header targets, predicted header properties, etc.

There are several displays that can be called from the main blend order display. 5 is a component equipment lineup display that an operator can use to change pump or flow-station selection before downloading the blend order. 6 shows a property trend chart, including analyzer value, bias, tank prediction, optimizer min/max header target, feedback, and so on.

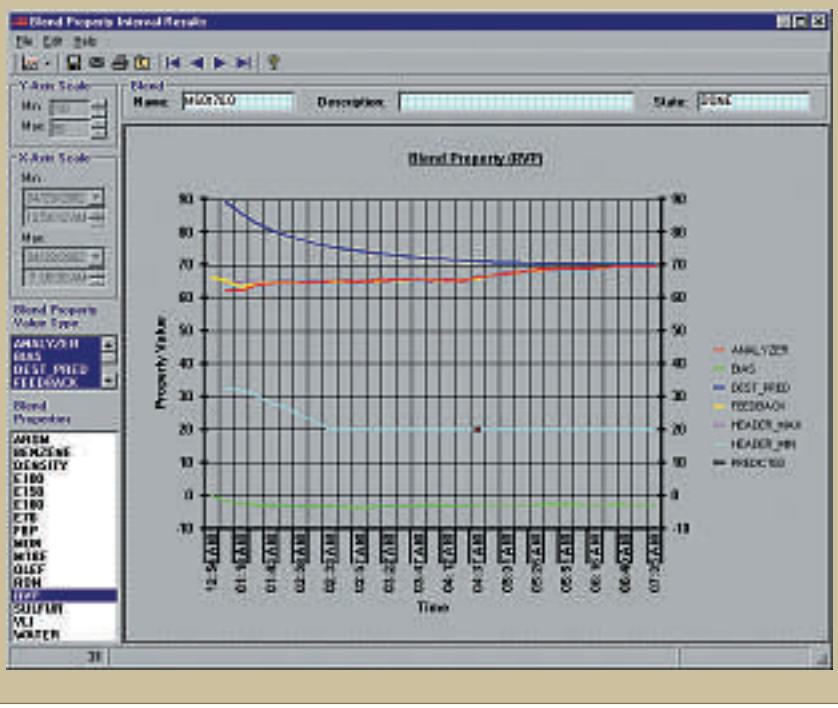
Modeling and optimization kernel

Blend optimization requires the combination of blend models and an optimizer. The blend models calculate the properties that result from a recipe. The optimizer searches through the feasible recipe space to determine the recipe that minimizes blend component cost, property giveaway, and/or deviation from the planned recipe.

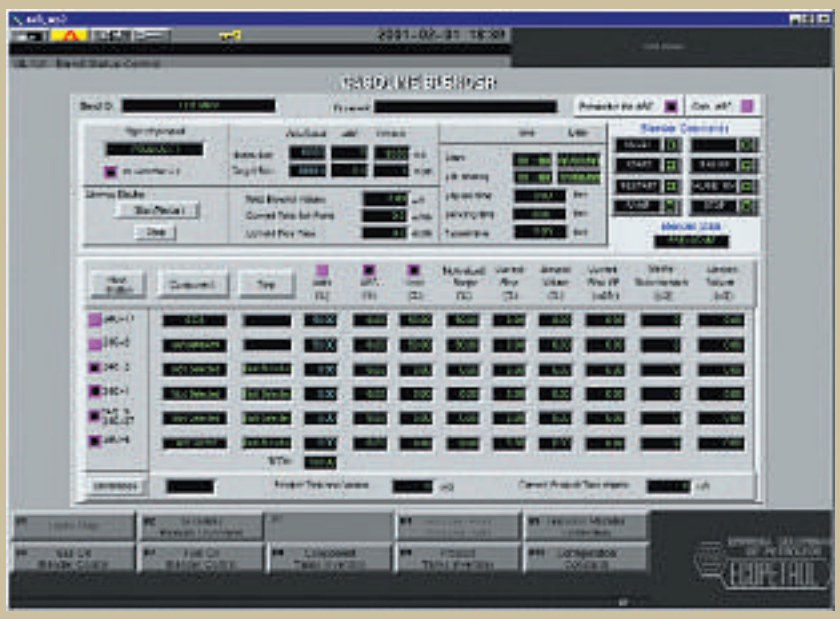
ABC has been designed to support any suitable modeling and optimization technology and the product has been released with both in-house and third-party software versions of GAMS (Generalized Algebraic Modeling System) kernels. GAMS is used to formulate optimization objectives and constraints (including the blend models and property specifications) and provides an integrated nonlinear solver.

The ABC implementation at Preem included integration with StarBlend optimization technology, which is supplied as a standard option for the product.

6 Property chart in blend order display



7 RBC blend control summary



StarBlend is an offline multi-blend optimization and planning software package, developed by Texaco and Shell.

Background programs

The ABC software package includes several programs for executing and optimizing the blend.

The *blend monitor* is responsible for downloading the blend order, sending commands to the RBC, monitoring the blend, creating data intervals, and recipe and bias calculations.

The *analyzer monitor* processes analyzer signals to ensure they are valid before they are used for bias calculations. The program scans each analyzer to determine if it is online or offline, and if it is measuring a component stream or the blend header. It reads the current value of each online analyzer and ensures that the new value is within the validity limits, is not jumping rapidly, and is not frozen. It also provides dead-time, filter and offset processing.

The *tank monitor* integrates product tank properties, which can then be used by the optimizer to calculate a new header recipe.

The *optimization monitor* is responsible for both offline and online optimization processing and interfaces with the GAMS optimization routines. It has routines to determine what the current header minimum and maximum values of each property should be if the final tank value is to be within the specified minimum and maximum. The header property targets are determined based on the volume and quality of the material already in the tank, the amount of material still to be blended, the specifications, the interval length, etc.

> "ABC has reduced the gasoline blend production time by more than 30 percent, because frequent pauses for header sampling and correction are no longer necessary."
>
> Tomas Astrom, blend system engineer, Preem

Interfaces to outside systems

Offline blend orders can be created either with the ABC interface (as used at Preem) or the StarBlend interface. StarBlend orders are transmitted through an SQLnet connection directly into the ABC Oracle database. An automatic routine is used to translate the optimization output from StarBlend into an ABC blend order. Transmission is initiated by a request from the StarBlend offline user.

ABC can receive laboratory test results from the LIMS for any product or component tank configured in ABC. If there is no LIMS available, the user can enter laboratory results directly into the same display used in ABC to approve LIMS updates.

ABC communicates frequently with the RBC. Via this bi-directional interface ABC can both read from and write to the blender. The primary communication between ABC and the RBC involves writing recipes, reading flows, totals and digital data from the RBC, and reading values and digital data from analyzers.

Regulatory Blend Control

The RBC package was designed to run on the ABB Advant Master DCS and also communicate with ABC. In remote mode, the RBC accepts downloads of complete blend orders from ABC, including optimized recipes, equipment selection and future swing tank information. If ABC is not implemented or network communication with ABC is temporarily suspended, the operator can manually create a complete blend order, select the equipment and start the blend. When the blend is started, the RBC runs a validity and mode check of the blend order data and equipment and opens the necessary valves. When all required paths are open, the component pumps are started one by one. The logic then ramps the

Benefits of ABC

Some of the benefits Preem has realized with ABC are:

- The giveaway in RON[1], MON[2], RVP[3] and other properties has been minimized, and blends are produced without property violation.
- It is no longer necessary to pause blends for feedback from the lab or frequently correct the re-blend of the final product. This has made it possible to increase the production rate for gasoline by 30% or more whenever higher demand for product exists.
- The operations group can now produce blends that meet specifications without intermediate assistance from the planner.
- Direct on-spec blending to tanks and ships in a harbor 6 km away is now possible thanks to ABC's line-flush features.
- All refinery groups can now monitor the status of blends.
- Preem engineers can now keep the blend software up-to-date whenever plant operations or product requirements change.

[1] RON = Research Octane Number
[2] MON = Motor Octane Number
[3] RVP = Reid Vapor Pressure

blend rate to the target blend rate by ramping individual flow station flow set points. When the required batch size is reached, the RBC shuts down all equipment. 7 shows the main blend control display used in the RBC for the gasoline blender. Many other displays can be accessed from this display for more operational details.

FTIR analyzer

The Bomem Advance FTIR process stream analyzer has high wavelength accuracy and precision to guarantee model transferability between analyzers. This is extremely important as it allows project schedules to be accelerated through the use of laboratory bench units during the model calibration phase. It also ensures that models do not require mathematical manipulation after instrument maintenance.

The certification of the gasoline product at Preem is still based on the results of conventional laboratory methods. However, Preem is investigating the possibility of switching over to the NIR analyzer for certification in the future.

Planning and work flow

Earlier, the planner entered the laboratory data into an Excel-based optimizer, prepared a blend order using property biases from the previous blend and faxed it to the control room. The operator manually entered the blend order in the old version of the RBC display and started the blend. The blend was paused several times to wait for the results of the header sample, so that the planner could provide a corrected recipe.

Now, the planner logs in as a Windows NT client to the ABC server from a desktop or laptop. The next step is to create a blend order using information provided by the sales or supply department. Looking at the tank inventories in ABC from TIMS[1], and future sales orders, appropriate recipe constraints can be set and the order optimized. When satisfied with the results of optimization, the planner approves the blend order. The blend operator is logged into the same ABC database and can select the available equipment lineup (tanks, pumps, flow stations), re-optimize the blend order to verify that the order is still feasible, download the blend order to the RBC, and execute the blend. The status of current and finished blends can be safely monitored by anyone in the refinery with login access to ABC. The final blend tank is sampled and certified by the laboratory.

[1] Tank Information Management System

Investment payback within one year

The investment payback time for the ABC is usually less than a year. Typical savings for a 100 KBD refinery can be higher than $3 million per year when all blenders are optimized and use well-calibrated analyzers. Preem is already seeing significant savings with the gasoline blender optimization, and expects to see more in the future when the gas oil and fuel oil blenders are also optimized with analyzer feedback.

> "ABC automatically corrects the blend recipe based on analyzer feedback, so most blends are produced with no violation and minimum giveaway in RON, MON and RVP."
>
> Tomas Astrom, blend system engineer, Preem

Future plans

Due to its impressive success in gasoline blending, online optimization is now being considered for the gas oil and fuel oil blenders in the Preem refinery. Currently, ABC is only used with these blenders for blend order management and storage of plant data feedback. Since the Preem commissioning, ABB has continued to expand the ABC software to include more features and flexibility.

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