6.0 Process Scheduling

Process scheduling deals with the sequencing of operations in batch processes. Pro-Designer provides facilities for handling process scheduling and identifying scheduling-related bottlenecks. This chapter describes the process scheduling features and capabilities of Pro-Designer. More specifically, Section 6.1 of this chapter provides definitions of variables related to process scheduling. Section 6.2 provides information on the scheduling data that are related with each procedure, operation and the entire recipe. Section 6.3 describes the interface for initializing and viewing scheduling-related data. Finally, section 6.4 provides a brief description of the key scheduling calculations.

6.1 Definitions

Setup Time: the amount of time (per cycle) spent before each operation is carried in preparation for the actual execution of the operation. It may involve actions like cleaning, vacuuming, setting up of equipment, etc. which the user opted not to model explicitly.

Process Time: the amount of time (per cycle) during which the actual processing is done. The process time is either specified by the user or calculated by the program if the hosting equipment is in rating mode (the size/capacity of the equipment is specified). For some purely cyclical unit operations, such as chromatography, the process time is always calculated. For inherently continuous unit operations (operating semi-continuously in a batch plant), the cycle time is always specified.

Turnaround Time: the amount of time (per cycle), that the operation´s equipment is being prepared for the next cycle (cleaning, transferring of material, sterilization, etc. that is not explicitly modeled but simply lumped up inside an operation).

Operation Cycle Time: the amount of time it takes for an operation's cycle to be performed. The Operation Cycle Time is the sum of the Setup Time, Process Time and the Turnaround Time.

Procedure Cycle Time: the amount of time it takes for an entire procedure (i.e. the sequence of all the operations inside the procedure) to be carried out once. The Procedure's Cycle Time is equal to the time elapsed between the start of the first operation in the procedure and the end of the last operation in the sequence. Note that a procedure's cycle time is not necessarily equal to the sum of the operations' cycle times because some operations may overlap in time.

Number of Cycles: the number of times a procedure is repeated in order to process the amount of a batch.

Procedure Time: the total amount of time it takes for a procedure to be completed. It is equal to the product of the Number of Cycles times the Procedure Cycle.

Start Time Shift: the time elapsing between the start of an operation and a reference point in time. The reference point can be:

(a) the start of the batch

(b) the end (or start) of the previous operation in the sequence (whatever that may be)

(c) the end (or start) of another operation in the same procedure

(d) the end (or start) of another operation in another procedure

Start Time Reference Operation: if the Start Time of an operation is not defined with respect to the start of the batch (absolute start time), then it is defined with respect to either the start or the end of another operation (in the same or another procedure).

Holdup Time: when a batch (cyclical) procedure, (e.g., chromatography), operates in a continuous flowsheet, the user must specify its holdup time. The holdup time represents the time interval required to accumulate as much material as needed to be processed per cycle of this cyclical procedure. Naturally, the specified value of holdup time must be greater or equal to the calculated cycle time of the batch procedure.

Container Equipment or Host Equipment: the physical piece of equipment used to carry out a procedure. Every icon depicted in a flowsheet represents a procedure that is being executed in one or more pieces of equipment (transportation steps present an exception since they have no associated process equipment).

Equipment Sharing: In a batch process it is common to utilize the same piece of equipment for carrying out multiple procedures (equipment sharing). This is particularly common with vessels that are used for handling mixing of materials, heating, cooling, reaction, evaporation, extraction, crystallization, etc. By default, whenever a procedure is introduced in the flowsheet, the system assumes that the procedure is carried out in its own piece of equipment. However, you have the option of selecting one of the existing equipment items that are compatible with the procedure.

Equipment Cycle Time: the total amount of time that a given piece of equipment is being occupied during the production of a single batch. If the equipment hosts only one procedure, then it equals its procedure time. However, if the equipment is utilized by multiple procedures, then it is equal to the time elapsed between the start of the earliest scheduled procedure and the end of the latest scheduled procedure carried out in that piece of equipment.

Annual Operating Time: the amount of time annually that the equipment associated with this recipe (process) has available to run this recipe (process).

Recipe Batch Time: the time elapsing from the start of the first (earliest scheduled) operation to the end of the last cycle of the last (latest scheduled) operation required to carry out a single batch.

Recipe Cycle Time: the time between the start of two consecutive batches. It is always smaller or equal to the Recipe Batch Time and larger or equal to the Minimum Recipe Cycle Time. If a batch is started right after the previous one is ended (but not before) then the cycle time equals the batch time. If a batch is started before the previous batch is ended (more typical) then the cycle time is less than the batch time. Note that there is a constraint as to how soon we can start a batch (while the previous is still in progress).

Recipe Cycle Time Slack: The difference between the recipe cycle time and the minimum recipe cycle time (must always be positive). To maximize the number of batches per year, the cycle time slack should be 0.0.

Minimum Recipe Cycle Time: the minimum time possible between the start of two consecutive batches. It is equal to the longest Equipment Cycle Time amongst all pieces of equipment involved in this process.

Maximum Number of Batches: the maximum Number of Batches possible to process in a calendar year. This Number of Batches can be achieved when the process operates under the Minimum Cycle Time (or the Cycle Time Slack is 0.0).

Number of Batches Per Year: the number of times a batch is processed in a calendar year (within the available operating time window for this recipe).

Campaign: a string of uninterrupted batch executions (of the same recipe) during a calendar year. Oftentimes, a specific product produced in batch, is produced annually in several campaigns. During the time between campaigns for this product, the equipment is utilized for the execution of recipes leading to other products.

Number of Campaigns: the number of uninterrupted sequences of batches produced each year.

Scheduling Bottleneck Equipment: the equipment with the longest cycle time. The scheduling bottleneck equipment determines the minimum recipe cycle time and the maximum possible number of batches per year.

6.2 Scheduling Data

Scheduling data are specified:

(a) at the Operation Level (e.g. start time shift, setup time, etc.)

(b) at the Procedure Level (e.g. number of cycles)

(c) at the Recipe Level (e.g. annual operating time, cycle time slack, number of campaigns, etc.).

6.2.1 Scheduling Information for an Operation

For each operation (assuming the overall operating mode is batch) you must specify the following information:

(a) Setup Time

(b) Process Time
(sometimes process time is calculated by Pro-Designer, see Notes below),

(c) Turnaround Time

(d) Start Time Shift, and

(e) Start Time Reference Operation.

The operation level scheduling information can be set using any of the three scheduling interfaces:

Scheduling Interfaces

1. The operation's scheduling tab (see section 5.2.3)
2. The Operations Gantt Chart (see later in this chapter); from that chart you can not only see the contribution of each operation to the total scheduling of the process, but you can also edit the scheduling parameters of any of operations.

NOTES:

a. The process time is either specified by the user or calculated by the program if the equipment is in rating mode (the size/capacity is specified).

b. For continuous procedures in an overall batch mode of operation for the process, the process time is taken to be equal to the cycle time and the start time is taken to be the beginning of the batch.

c. Setting the setup time, process time, turnaround time and/or number of cycles may affect the outcome of the scheduling calculations (plant batch time, number of batches etc.) as well as the simulation results (sizing of process units, capital cost, etc.).

d. Oftentimes, the timing (duration) of an operation is totally dependent upon the duration of another operation (e.g. the transfer time to a filtration unit is totally regulated by the rate of filtration). In this case, you may assign a master-slave relationship between the two operations: i.e. designate the transfer operation to be the slave of the filtration operation. Having done that, then all three duration parameters of the transfer operation (setup time, process time and turnaround time) will be assumed as equal to the filtration's equivalent times and whenever the filtration parameters change, the transfer operation's parameter will change as well.

6.2.2 Scheduling Information for a Unit Procedure

The only scheduling information at a procedure level specified by the user is the number of cycles and, under certain circumstances, the holdup time. You may set the number of cycles through the **Procedure Data…** dialog by right-clicking on a procedure icon.

The Number of Cycles

Setting the number of cycles in a procedure to anything other than 1 implies the following:

(a) the amount of material processed per batch will be divided equally amongst each cycle (thereby reducing the processing load per cycle),

(b) the sequence of operations in that procedure will repeat themselves as many times as the number of cycles

Tip

Setting the number of cycles to anything other than 1 can have effects on both the sizing of new equipment (or the equipment utilization of existing equipment) as well as the overall batch time of the recipe.

The Holdup Time

When a batch procedure (like chromatography, batch filtration, batch distillation, etc.) is set to operate in a continuous process, Pro-Designer needs to infer the amount of material that gets processed per cycle. In other words, the implicit assumption is that, in order for this procedure to function cyclically in an otherwise continuous environment, there must be a tank that accumulates material for a certain time (at least while the procedure is in progress) and then feeds the next cycle of the procedure. This time we call holdup time. Obviously, this time must be at least as long as the cycle of the

procedure (but it could be longer). For procedures whose cycle time is set directly by the user (in other words, the cycle times of all contained operations have process times, setup times and turnaround times directly set by the user), the holdup time is assumed to be equal to the cycle time of the procedure. In that case, the user does not need to supply the procedure's holdup time (and it will not be editable in the procedure's operating mode dialog). However, if at least one operation making up the procedure's cycle time is calculated by the system (as is the case for chromatography columns) then the user must directly set the holdup time (the field is editable).

6.2.3 Scheduling Information for the Entire Recipe

For the entire design case, you must specify:

a. the Annual Operating Time that is Available to this project,

b. the Number of Campaigns, and

c. one of the following {Number of Batches, Cycle Time, Cycle Time Slack}

Using the above information for the plant, as well as the process step related scheduling information for all process steps, the program calculates as scheduling outputs:

a. the Recipe's Batch Time,

b. the Minimum Recipe Cycle Time,

c. the Maximum Number of Batches Per Year,

d. the Longest Procedure in the recipe,

e. the Scheduling Bottleneck Equipment, and

f. two of the following {Number of Batches, Cycle Time, Cycle Time Slack}

The recipe-related scheduling information can be set using the **Recipe Scheduling Information** dialog (**Tasks \ Recipe Scheduling Information**).

NOTE If the operating mode of a process is set to be continuous, the Recipe Scheduling Information dialog and the Gantt chart interfaces are disabled, since, in that case, no scheduling calculations are performed.

Tip

At the end of M&E balances, the program re-evaluates all scheduling constraints (at the equipment level and at the recipe level) and updates the scheduling outputs (recipe's batch time, cycle time, etc.). If any constrains are found to be violated, Pro-Designer will notify you about the violation and will put up a warning that some (or all) of the scheduling outputs (e.g. number of batches per year, etc.) may not be feasible.

6.3 Scheduling Calculations

Based on operation scheduling data (start times and durations) and procedure scheduling data (number of cycles), the system computes the equipment cycle times, and eventually the recipe's batch time (BT) and minimum cycle time (CT_{min}). Next, using the recipe's annual operating time (AOT), and the annual number of campaigns (k) the system computes the maximum number of batches per year (NB_{max}) using the

following relationship:

$$AOT = (NB_{max} - k)\, CT_{min} + k\, BT \qquad \textbf{(1)}$$

Before performing any scheduling calculations, Pro-Designer verifies that no scheduling constraints are violated. Scheduling constraints are checked at:

- The Individual Equipment Scheduling
- The Overall Process Scheduling

At the individual equipment scheduling level, Pro-Designer will make sure of the following:

(a) no two procedures have been scheduled to execute within the same piece of equipment with overlapping procedure times. If you don't employ equipment sharing, then no constraints at the equipment level exist.
(b) All operations in a procedure, have (calculated) start time that are consistent with their execution order

The constraints at the recipe level have to do with the setting of unachievable goals. These constraints will be more apparent after we explain how Pro-Designer computes the process scheduling outputs.

First of all, Pro-Designer calculates the recipe batch time (BT), as well as the minimum recipe cycle time (CT_{min}) based on each procedure's scheduling information. The minimum cycle time is calculated as the longest equipment cycle time, or in case that there is no equipment sharing, the longest procedure time. The equipment responsible for the longest cycle time is also recognized as the scheduling equipment bottleneck. Since the cycle time slack (CT_{slack}) is defined as the difference between the recipe cycle time (CT) and the minimum recipe cycle time (CTmin), the following always holds:

$$CT_{slack} = CT - CT_{min} \qquad \textbf{(2)}$$

Pro-Designer computes the CT_{min} (if the CT_{slack} is given) or it computes the CT_{slack} if the CT is supplied by the user. Furthermore, the following relationship between the annual operating time (AOT), the number of campaigns (k), the cycle time (CT), the batch time (BT) and the annual number of batches (NB) always holds:

$$(NB - k)\, CT + k\, BT \leq AOT \qquad \textbf{(3)}$$

Since AOT and k are always supplied by the user and BT always computed, Pro-Designer uses the above relationship (as an equality) to calculate either the number of batches per year (NB) if CT or CT_{slack} has been supplied by the user, or to calculate the BT if the number of batches per year has been supplied by the user.

Furthermore, the above relationship (3) can be applied when CT is assumed to be equal to CT_{min}. In that case, NB represents the highest possible achievable number of batches per year:

$$(NB_{max} - k)\, CT_{min} + k\, BT \leq AOT \qquad \textbf{(4)}$$

The following constraints must always hold:

$CT_{slack} \geq 0$

$CT \geq CT_{min}$

$NB \leq NB_{max}$

$$(NB - k)\,CT + k\,BT \leq AOT$$

After every M&E balance calculation, the system attempts to validate the above scheduling constraints and will notify you if a constraint violation has been identified. For example, suppose you have set the annual operating time and the required annual number of batches. Then you modify the scheduling of a procedure in a way that prolongs the total batch time to the extent that in order to carry out the required number of batches the AOT is exceeded. The system will identify this constraint violation and warn you that your scheduling targets (in this case number of batches per year) may not be feasible

6.4 Scheduling and Equipment Sizing

Process scheduling decisions have an impact on equipment sizing and vice-versa. In design mode, longer cycle times for operations leading to longer cycle times for unit procedures increase the minimum recipe cycle time. Specifying multiple procedure cycles per batch result in smaller equipment capacity demands (which is equivalent to lower capital investment) but at the same time they increase the cycle time too. Increase of the cycle time results in a reduction of the maximum number of batches per year (which is equivalent to reducing annual throughput). Sharing of equipment by multiple procedures has a similar effect. Most likely it increases the batch (and possibly cycle time) but reduces demand for capital investments. In designing new facilities, one should strive for a balance between capital investment, plant capacity, and flexibility for expansion.

6.5 The Recipe Scheduling Information Dialog

It is the dialog that is presented when you select the **Tasks \ Recipe Scheduling Information...** option from the main menu. It allows you to edit the scheduling information required at the recipe level (see Fig. 6.1).

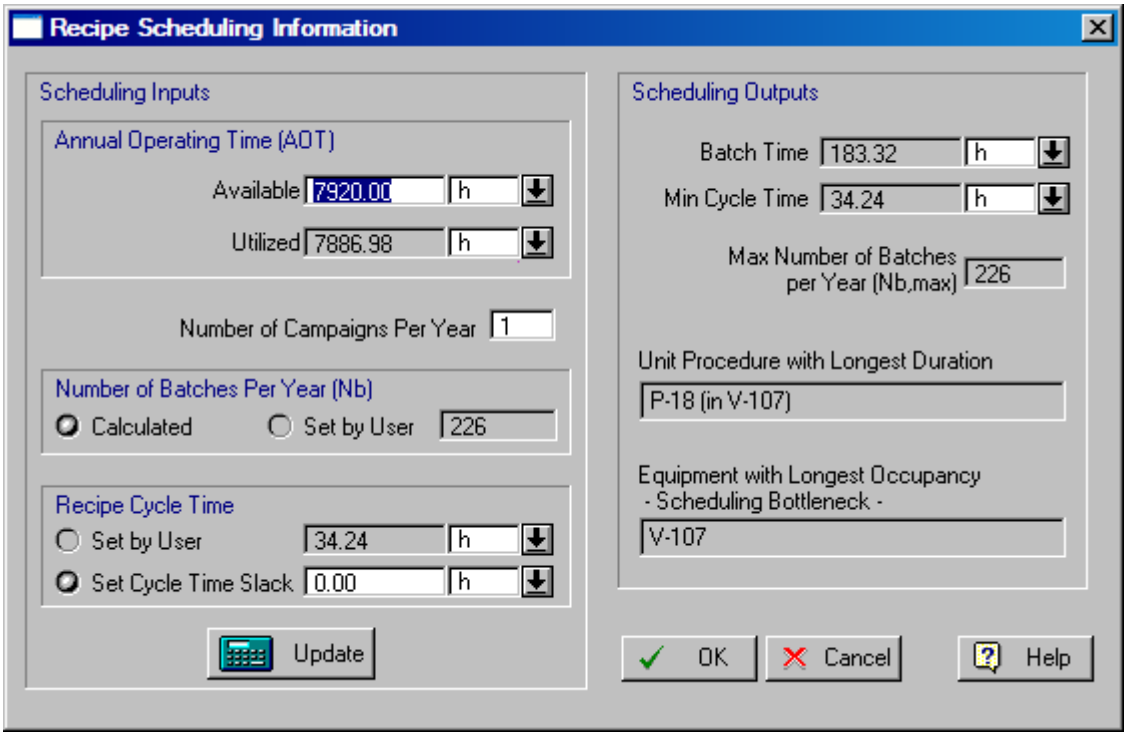

Figure 6.1: Setting the recipe-level scheduling data.

For the entire design case, you must specify:

a. the Available Annual Operating Time,
b. the Number of Campaigns,
c. whether the number of batches is calculated or set (if set specify number of batches),
d. whether the Recipe Cycle Time is calculated or set (if set specify the Recipe Cycle Time, if calculated specify the Recipe Cycle Time Slack)

Using the above information as well as the process step related scheduling information, the program calculates as scheduling outputs:

a. the Recipe's Batch Time,
b. the Minimum Recipe Cycle Time,
c. the Maximum Number of Batches Per Year,
d. the Longest Procedure in the recipe,
e. the Scheduling Bottleneck Equipment, and
f. one / two of the following
{ Number of Batches, Recipe Cycle Time, Recipe Cycle Time Slack}

6.6 The Operations Gantt Chart

The operations Gantt chart presents an overview of the entire schedule for a single or multiple batches as a Gantt chart. To display the operations Gantt chart for a single batch, select **Tasks \ Gantt Charts \ Operations GC...**

Each bar in the chart represents:

- Either an **activity summary** (i.e. an activity that can be de-composed or refined to other activities, e.g., a procedure) or
- an **elementary activity** (i.e. an activity that cannot be further refined, e.g. an operation in a cycle)

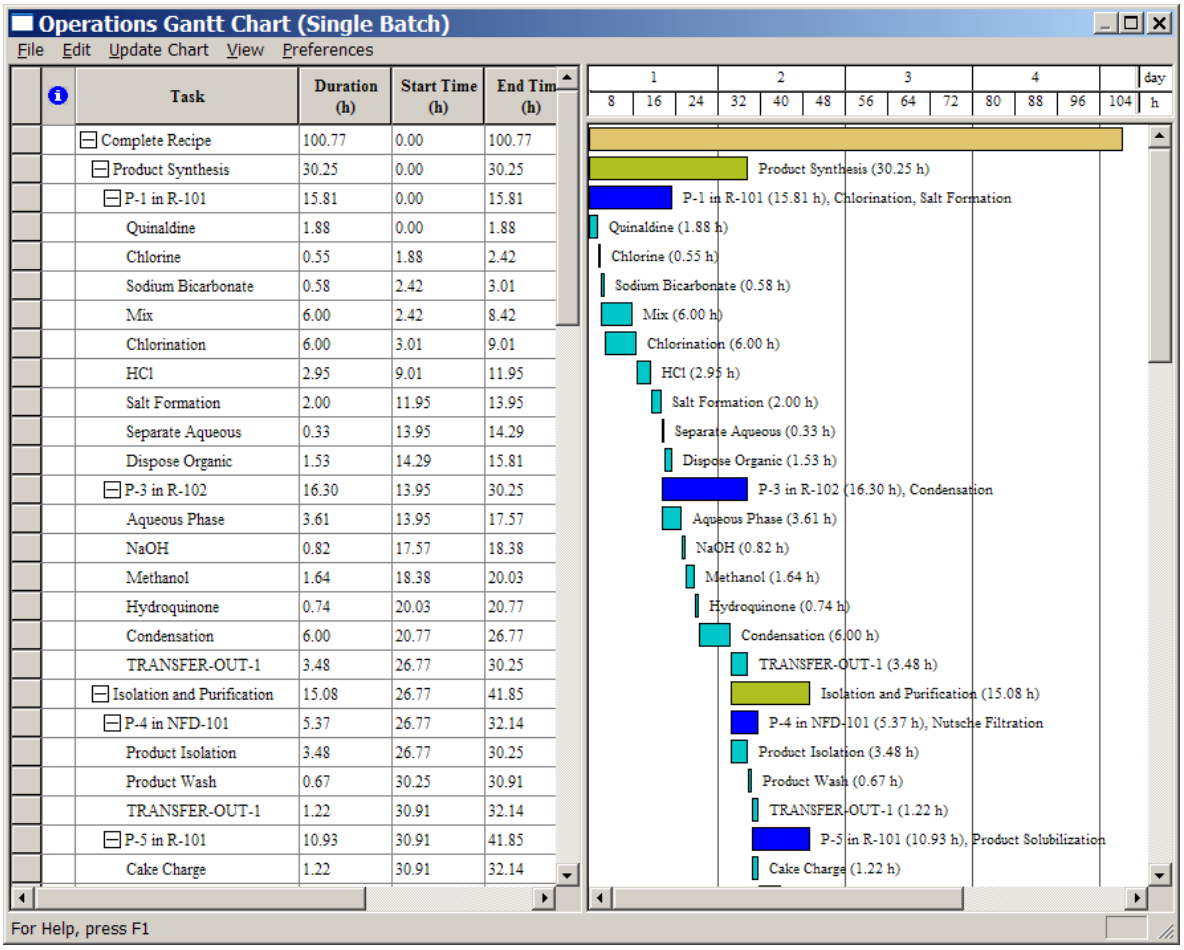

Figure 6.2: The Operations Gantt Chart.

The window is divided into two views:

(a) the left view (spreadsheet view): it displays in each line: the name, duration, start and end time for each activity whose bar line is shown straight across on the chart (all information is presented for viewing purposes only). You use the left view to expand and/or collapse activity summaries by clicking on the + or – rectangle showing at the left of the name of the activity.

(b) the right view (chart view): it displays, as a horizontal bar drawing against the time line, each activity participating in the overall scheduling and execution of the recipe. Right-click on a bar and a relevant command menu will come up. Selecting the first menu entry will bring up a dialog that will allow you to edit any scheduling information associated with that particular activity bar. At any time you can request to have the M&E balances redone and to have the Gantt Chart updated to reflect the new (calculated) scheduling settings for the recipe. Simply click on the **Update Chart** entry in the main menu of the interface. Note that since this

command will re-run the simulation, it may result in the display of several simulation error and/or warning messages generated during simulation.

When you are done working with the Gantt Chart interface, you can close it down by selecting the **File \ Exit** option from the main or simply close down the window.

You can choose to display the operations Gantt chart for a single batch or multiple consecutive batches. The second option may be of interest when there is batch overlapping (i.e., the second batch starts before the first is finished, or in other words, when the cycle time is less than the batch time). To display the Gantt chart for multiple batches, select **Tasks \ Gantt Charts \ Operations GC (Multiple Batches)**.

Tip

The number of batches that Pro-Designer displays when the multiple batches Gantt Chart first comes up, is determined so that all future batch starts will show a pattern that is already included in the chart (shifted by some time offset). This number is computed from the following formula:

Nbatces = [BT / CT] + 1 , where

BT is the batch time of the recipe,

CT is the cycle time of the recipe and

[ ] indicates taking the next integer value of the number in the brackets

You may, of course, change the number of batches shown at any time, by selecting the **Edit \ Set Number of Batches** from the main menu, or **Set Number of Batches** from the context menu of the chart.

6.6.1 Accessing Scheduling and Simulation Data

From the Operations Gantt chart interface (single or multiple batches) you can access all scheduling and most simulation data for the entire recipe. In that way, this interface becomes an alternative way ***to view and work*** with your recipe. To access the data, you must right-click over a chart's bar, and select the first entry from the command menu that pops up. The menu entry and the ensuing dialog depend on the type of bar you started.

1) **For recipe summary bars**: The dialog allows you to edit the recipe-level scheduling data (annual operating time, number of campaigns, etc.)
2) **For branch summary bars**: The dialog presents the member sections of that branch.
3) **For section summary bars**: The dialog presents all section properties.
4) **For procedure summary bars**: The dialog presents the procedure operating mode dialog that (among other things) allows you to change the number of cycles for that procedure.
5) **For procedure cycle summary bars:** The dialog presents some cycle-related information (for viewing purposes only).

6) **For operation bars**: The dialog is the same as the i/o simulation dialog that you view from the main interface of Pro-Designer. It allows you to edit the operating conditions as well as the scheduling settings for that operation.

Tip

All changes made through any dialogs invoked during the time the Gantt Chart interface is active, are permanent and cannot be reversed. You cannot cancel out of any scheduling and/or simulation data modifications made while the Gantt Chart interface was open.

6.6.2 Exporting the Chart as a Picture and the Spreadsheet as a Table

You can export the chart (as a picture) from Pro-Designer into another Windows applications (e.g. a word processor). You may also copy the spreadsheet into Excel. The export can happen with one of two ways:

To copy the Gantt Chart using the Clipboard…

1. Bring up the chart.
2. From the **Edit** menu select **Copy Gantt Chart**; alternatively, you may bring up the chart's context menu, by right-clicking on an unoccupied area of the chart, and select **Copy Gantt Chart**. Select **Copy Gantt Spreadsheet** to copy the spreadsheet data.
3. **Go to the target application and select Paste**.
   Activate the application that you would like to paste the chart picture. From the application's **Edit** menu select **Paste**. Note that **Paste Special...** and the options available to OLE items does not apply to charts; they can only be pasted (not paste-linked) as pictures. The spreadsheet is pasted is a similar way. If both the spreadsheet and the chart are copied into Excel and the height of the chart is adjusted to align with the tabular data, then one can print both the spreadsheet and the chart as one object.

To copy the Gantt Chart as a Metafile ('wmf' file)…

1. Bring up the chart.
2. **Select Export as Metafile**
   From the **File** menu select **Export Gantt Chart as Metafile**. The usual **Save As...** file dialog will appear, prompting you to type the name of a file. Type in the filename that you wish to contain the description of the chart in ´wmf˝ format. By convention, all such files should have a ´wmf˝ extension. The file need not already exist. After you have typed in the file name and clicked **OK**, wait a few seconds as the program will be creating the file and writing in it the necessary metafile-formatted description of the chart.
3. **Go to target application and import the picture**
   When this process is done, you can go to the target application and import the file you have just created. For details on how to do that consult your applications manual or browse through their help utility.

6.6.3 Exporting Scheduling Data into Excel

You can export all the scheduling information contained in a chart (i.e. all information around every procedure and/or equipment) into a file that can be read immediately by Excel (or other leading spreadsheets). Select **File \ Export Scheduling Data to Excel...** from the main menu and in the dialog that pops up specify the pathname of the file that will contain the scheduling data. Then click on **OK**. You can now start Excel and open this file directly from Excel. When you open the file from Excel you may have to adjust the widths of the columns slightly in order to view all contents of the file (without overlapping).

6.6.4 Exporting Scheduling Data into MS Project

You can export all the scheduling information into MS Project by selecting **File \ Export to MS Project...** from the main menu of the window. The exported data are deposited into the "MS Project Databank" of SuperPro. To import data from that databank into MS Project (you will need MS Project 2000 or higher), do the following: 1) Open MS Project and select **File\Open**, 2) Click on the "**ODBC**…" button, 3) Switch to "Machine Data Source" tab, 4) Locate and select "ProDesigner MS-Project DB" and click **OK**, 5) Locate the name of the project that you just exported and click **OK**. Figure 6.2b below corresponds to the chart of Figure 6.2 displayed by MS Project.

6.6.5 Exporting Scheduling Data into SchedulePro

SchedulePro is another application developed and marketed by our company that handles scheduling and debottlenecking of single and multi-product facilities in detail. Recipes developed in SuperPro can be readily exported to SchedulePro by selecting **File \ Export to SchedulePro Recipe DB** from SuperPro main menu bar. The recipe data are deposited into a "Recipe Database" and can be readily imported into SchedulePro. SchedulePro is a versatile application that can be used as a strategic analysis tool for plant throughput and cycle time analysis of single and multi-product facilities. Essentially, in this mode SchedulePro acts as a simulator complementing SuperPro. The other application of SchedulePro is as a tactical tool for scheduling production of facilities on a daily, weekly, or monthly basis (the time horizon is industry and product specific). For more information on how to export recipes from SuperPro to SchedulePro and utilize them in the context of SchedulePro, please consult the manual of SchedulePro.

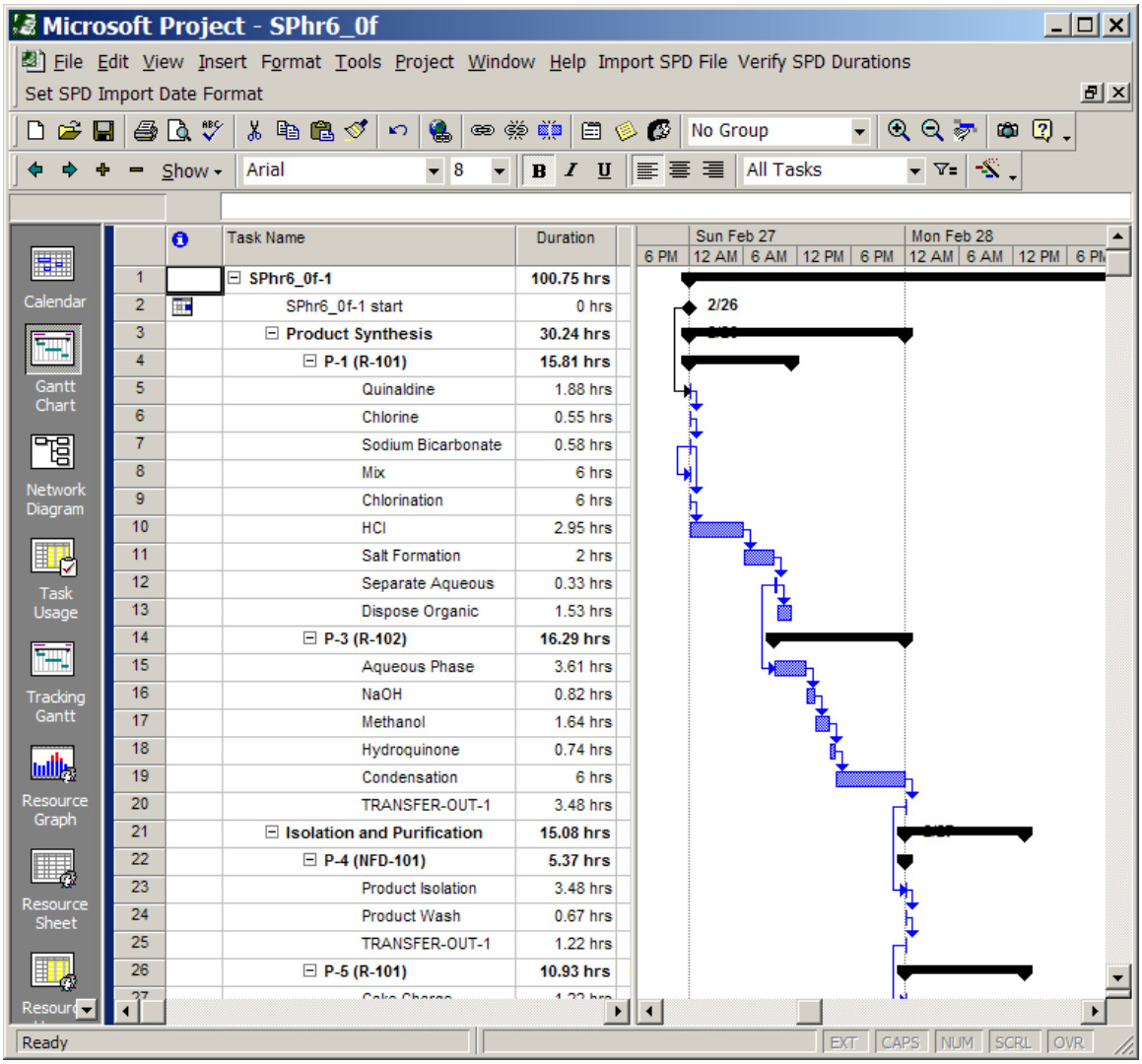

Figure 6.2b: The Gantt chart of Figure 6.2 displayed in MS Projejct.

6.6.6 Printing the Gantt chart

The chart as well as the spreadsheet can be printed by invoking the appropriate commands through the **File** menu. If you wish to print the chart and the spreadsheet as a single entity, please consult section 6.6.2.

6.6.7 Zooming In and Out

When the a chart interface first comes up, it is set into **'Fit-to-Window'** mode, which means that the entire time horizon needed to display the whole chart has been scaled down appropriately in order to fit into your window's width. If the maximum time that needs to be displayed is very large, or if the settings for minor/major scale and tickmark frequency for the time line are very small, the timeline may NOT display all minor and major tickmarks as expected. Therefore, some details along the time axis may have

been omitted. In order to see the timeline spread out as expected you must switch out of 'Fit-to-Window' mode. Simply right-click on an unoccupied area of the graph and invoke the context menu for the chart. Notice that the **Fit-to-Window** entry has a checkmark in front of it, indicating that currently the contents of the chart are scaled down so that they can fit your window's width. If you select **Fit-to-Window** option once more, then it will turn the Fit-to-Window mode off and will display the timeline according to the timeline specifications. This may result in pushing the right end of your graph off the visible area of your window, so you may need to scroll to the right in order to see the rest of the graph. If further details need to be viewed in a chart, you may further expand the time scale by issuing a **Zoom In** command. Again, from the chart's context menu, select **Zoom In**. This will scale up the timeline and will present more details along the time line but less of the total graph will be visible within your window's area. The opposite effect happens when you issue a **Zoom Out** command. You may continue zooming in or out as needed (up to maximum / minimum scale).

6.6.8 The Time Line

When drawing a Gantt chart, Pro-Designer must decide on the characteristics of the time line against which all activity bars will be drawn. The attributes that determine how the time line is drawn are the following:

- The maximum time displayed (defaults to as large as necessary)
- The unit of time used to draw the minor tickmarks (defaults to hours)
- The unit of time used to draw the major tickmarks (defaults to days)
- The minor tickmark frequency (defaults to 1)
- The major tickmark frequency (defaults to 1)

By default, the maximum time is calculated to provide a window of time large enough to accommodate the display of all activity bars. However, if you wish, you may set your own fixed maximum time, by visiting the Gantt chart's Style (see next). If you do so, you must take care that the limit set is large enough to accommodate all data otherwise some activity bars will not be shown on the chart (Pro-Designer will warn you if that turns out to be the case).

6.6.9 The Visual Style Dialog

The visual appearance of a Gantt chart can be modified through the Visual Style dialog. To access that dialog, you can either select **Preferences \ Styles \ Gant Chart** from the Gant Chart main menu, or **Preferences \ Default Style \ Gant Chart ...** from the flowsheet context menu. From this dialog you can edit all the characteristics of a Gantt chart's visual style. It has two tabs:

Through the **Chart / Grid** tab, shown in Figure 6.3, you can :

- Specify whether you want the section-level, branch-level, procedure-level, and procedure cycle level, summary bars to be included in your Gantt chart (if you are not using sections and branches to describe your recipe, you may want to exclude them from your charts).
- Specify the styles (visual attributes) of each of the activity bars; to edit any of the styles for a given activity bar (e.g. recipe bar, procedure bar, etc.), simply click on the corresponding button and describe the style that you wish in the dialog that

follows. You can access the same bar style edit dialog by right-clicking over a specific bar and selecting the **Visual Style…** option.

- Specify the grid cell height used in the left-view of the chart (the spreadsheet view). Note that the grid cell height cannot be set to anything less than the height of the tallest activity bar (if their height is set by user). Also, in case where all activity bar heights are left to be adjustable (default) the grid cell height cannot be set to anything less than the height of a character (so that it can display the text without cropping it).

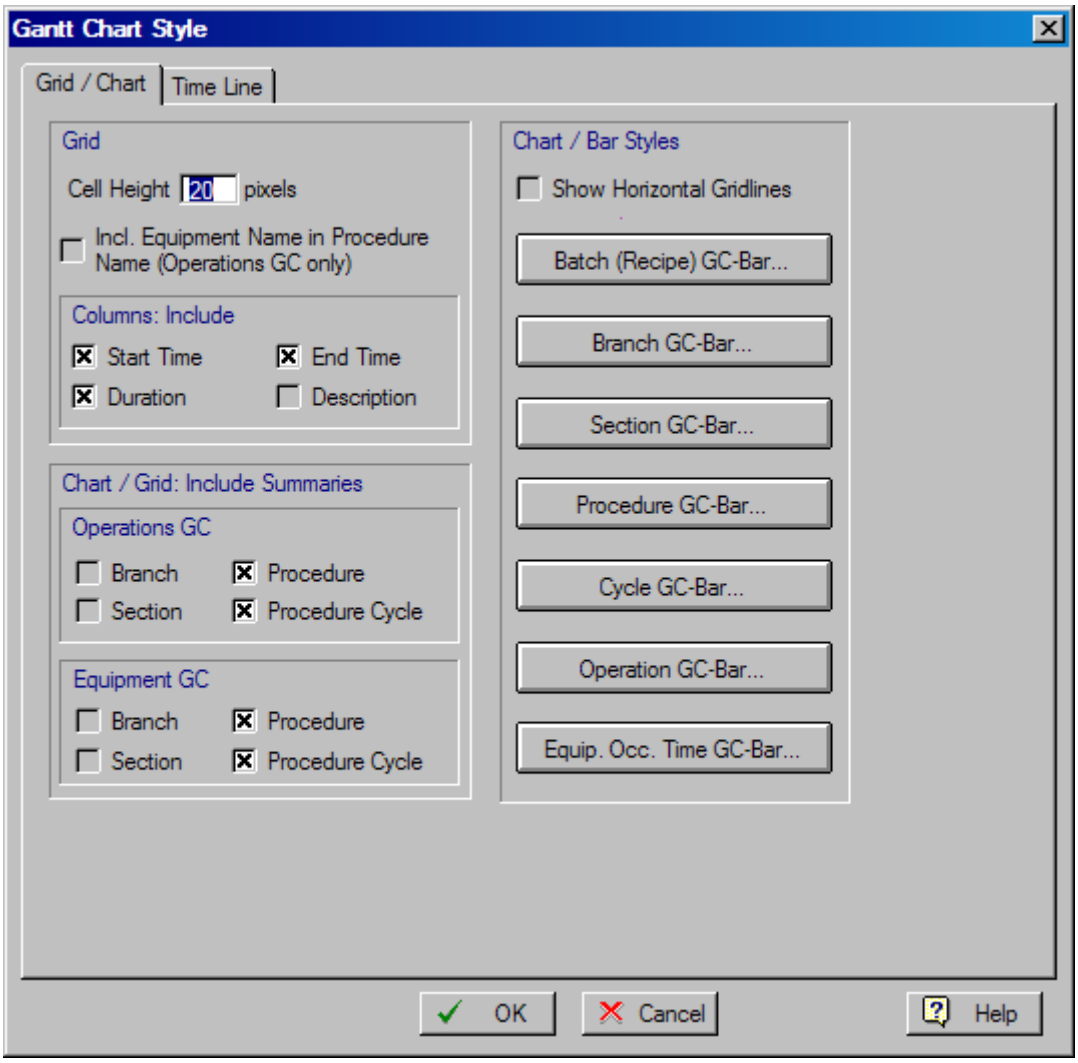

Fig 6.3: The Gantt Chart visual style dialog (Chart / Grid Tab).

Through the **Time Line** tab, shown in Figure 6.4, you can:

- Specify whether you want the time line style for this chart to follow the default characteristics or whether you want to customize its attributes for this chart alone.
- If you have chosen to use the default time line characteristics (i.e. selected the **'Use Default'** button), notice that they are displayed at the lower half (left side) of the

dialog but they are NOT EDITABLE. If you wish to modify them, then you must modify first the default timeline style. To do so, simply click on the button labeled **Edit…** next to the option 'Use default' (timeline). In the ensuing dialog, change the characteristics of the default timeline and after clicking **OK** you will be back in this tab where now the new characteristics will be displayed. Note that any changes you have made to the default time line will affect all charts that use the default time line (Gantt Charts, Resource Tracking Charts, Equipment Utilization Charts, etc.)

- If you chose to use a specialized time line for this chart, select the **'Customize'** button, and modify any of the time line characteristics you wish in the lower half of the dialog. Any changes to the time line will only apply to this chart and they will not affect the style of other time charts (Gantt Charts, Resource Tracking Charts, etc.)

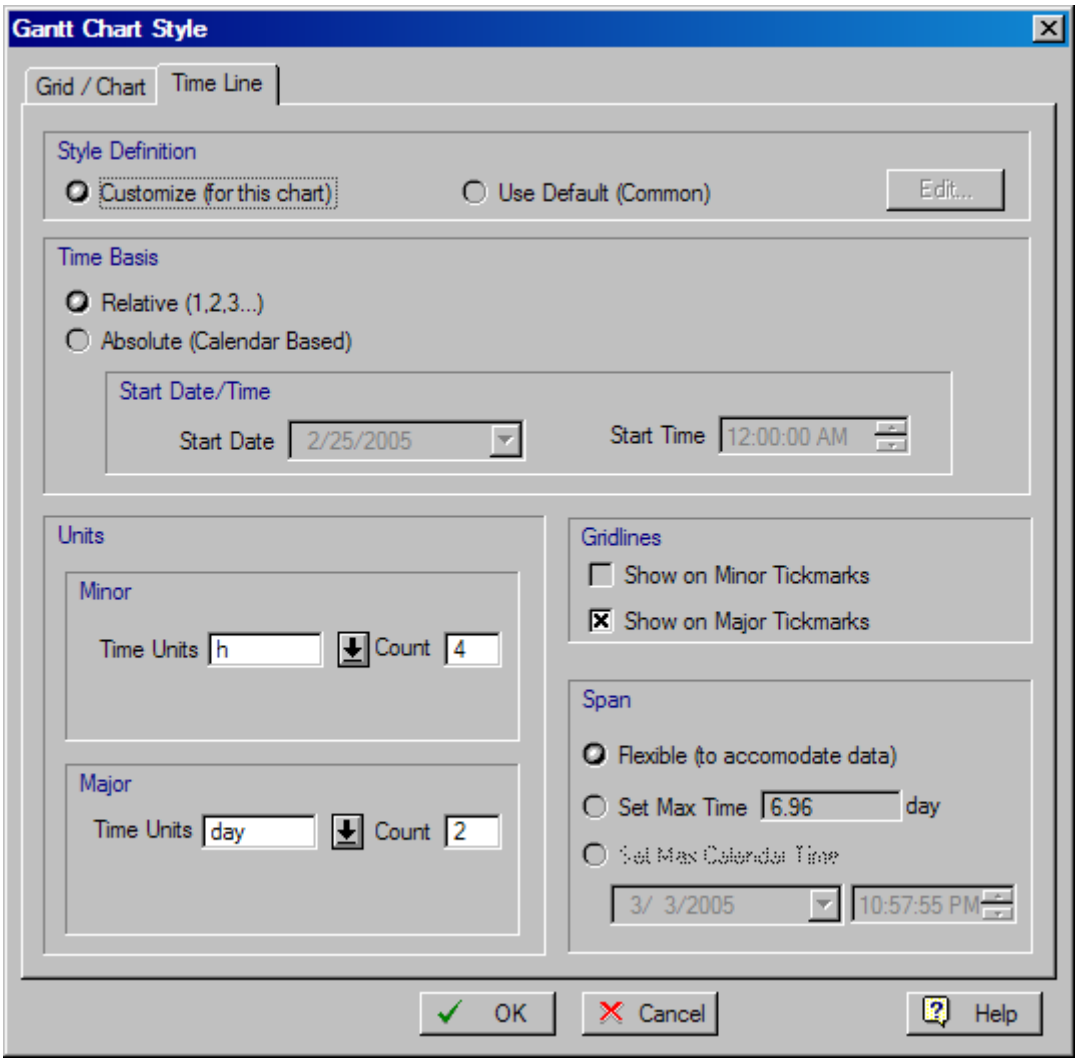

Fig 6.4: The Gantt Chart visual style dialog (Time Line Tab).

6.6.10 The Bar Style Dialog

From this dialog you can edit all the visual attributes (style) of any of the activity bars displayed in a Gantt Chart.
In an ***Operations Gantt Chart*** (single or multiple batches) the following activity types (bar types) exist

- Recipe Summary Bar
- Branch Summary Bar
- Section Summary Bar
- Procedure Bar
- Cycle Bar
- Operation Bar
- Equipment Bar

In an ***Equipment Occupation Time Gantt Chart*** (single or multiple batches), the following activity type (bar types) exist:

- Recipe Summary Bar
- Equipment Bar
- Branch Summary Bar
- Section Summary Bar
- Procedure Bar
- Cycle Bar
- Operation Bar

The dialog for each bar can be accessed from the **Preferences** menu of the Gant Chart. This dialog has three tabs:

1. Bar Options Tab

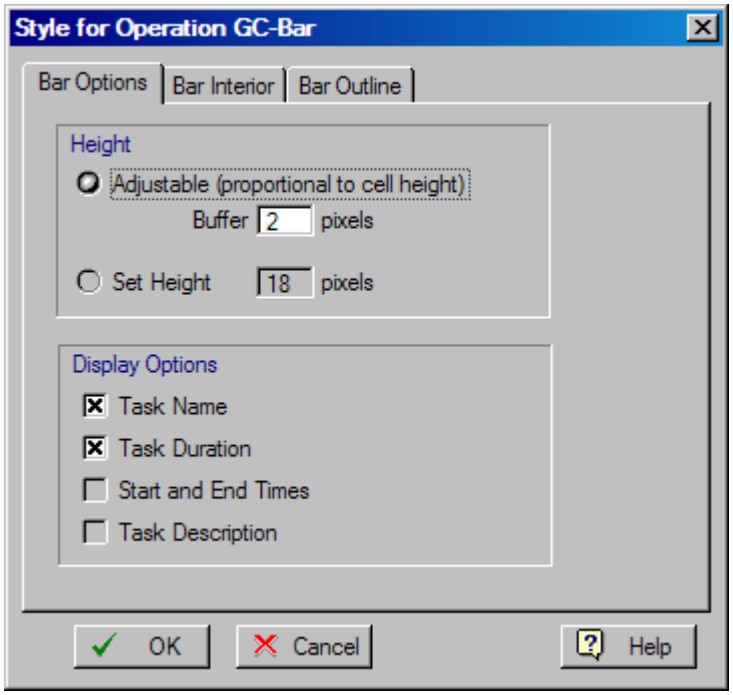

Fig 6.5: The Gantt chart visual style dialog (Bar Options tab).

From this tab you can:

- Specify if you want the task bar's height to be fixed and set the height in pixels, or if you let the bar's height to be adjustable (proportional to the grid cell's height). If you let the bar height be adjustable, then decreasing or increasing the cell height will also proportionally increase or decrease the height of the chart's bars.
- Specify if you want the name of the activity, its duration, the start and end times, and the task description, to be displayed directly on the chart (right next to the drawing of the bar itself); the name and duration are always displayed right across from the bar into the spreadsheet view of the Gantt Chart interface. However, sometimes it is desirable to have them re-drawn right next to the bar (especially in a large process).

2. Bar Interior Tab

Lets you choose options that dictate how the interior of the bar is drawn (fill-in color, fill-in pattern, etc.)

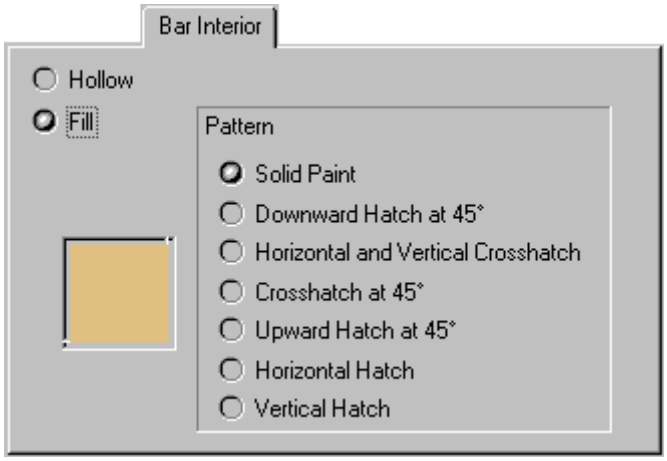

Fig 6.6: The Gantt chart visual style dialog (Bar Interior tab).

3. Bar Outline Tab

Lets you choose options affecting the outline of the bar (color, thickness, etc.)

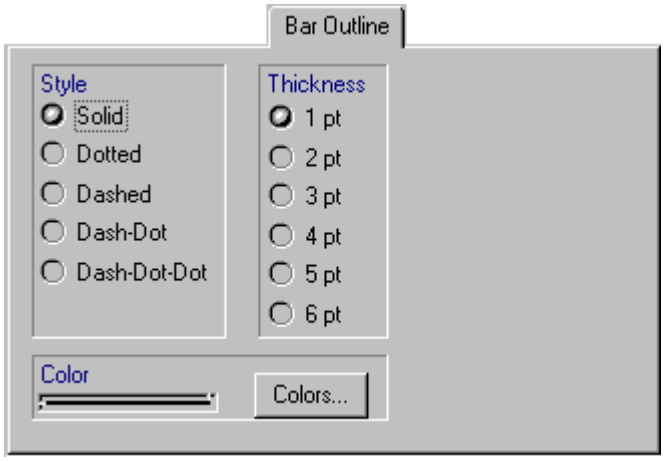

Fig 6.7: The Gantt chart visual style dialog (Bar Outline tab).

6.7 Equipment Gantt Chart

This window displays the Gantt from the equipment viewpoint. Select **Tasks \ Gantt Charts \ Equipment GC** to display this chart.

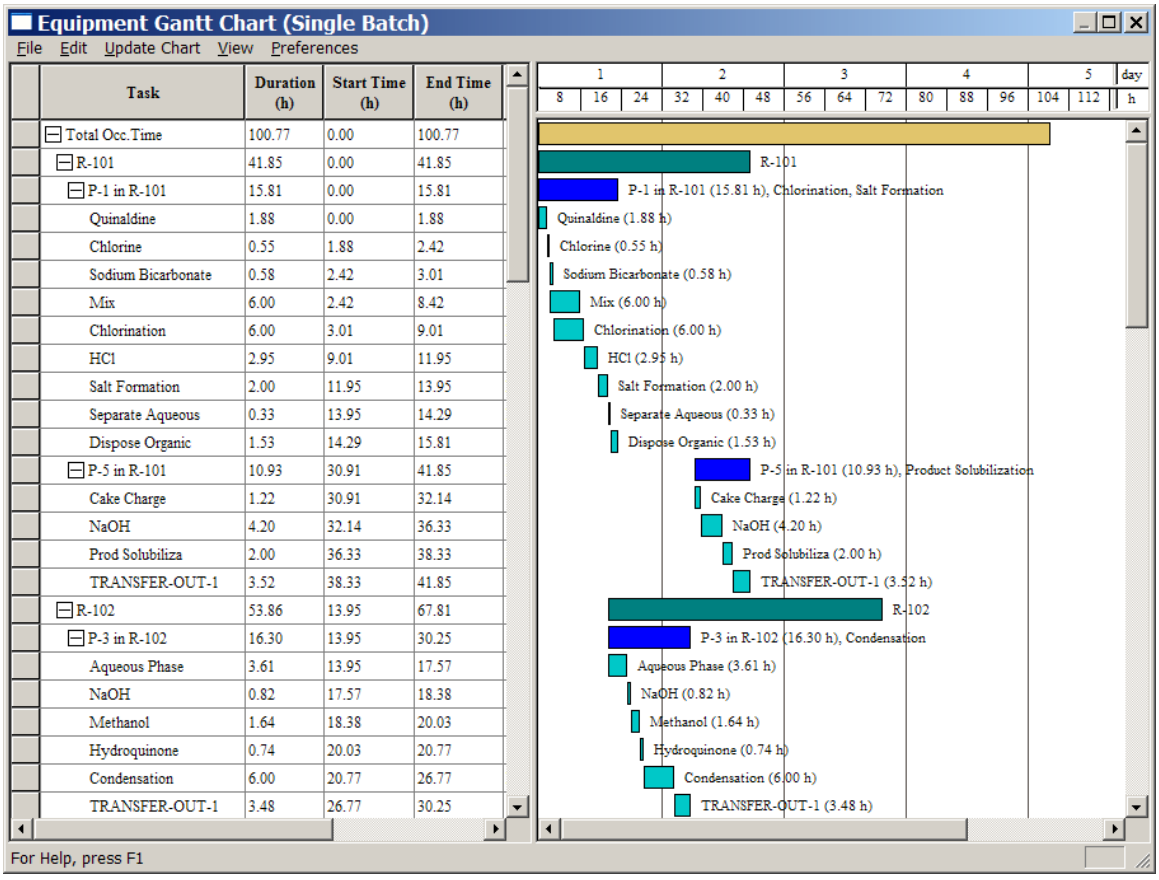

Figure 6.8: The Equipment Gantt chart.

6.8 Equipment Occupancy Chart

This chart displays information on equipment occupancy as a function of time for single or multiple batches and it enables the user to readily visualize the equipment time bottleneck. This chart comes up when you select **View \ Equipment Occupancy Chart \ Single Batch (or Multiple Batches)**. Figure 6.9 is a sample of an Equipment Occupancy chart displaying three consecutive batches (each color represents a different batch). Equipment items are listed on the y-axis and time on the x-axis. Each bar corresponds to a procedure that utilizes the equipment of that line. Multiple bars of the same color on a single line indicate sharing of that equipment by multiple procedures. That's the case for R-101, R-102, NFD-101, and R-103.

White space between color bars represents idle time. The equipment with the least idle time between consecutive batches is the **time (or scheduling) bottleneck** (R-102 in this case) that determines the maximum number of batches per year.

The number of displayed batches can be modified by right-clicking on the chart and selecting **Set Number of Batches**. The vertical black lines on the color bars designate the start and end times of the operations of the corresponding procedures. If you position the cursor over a unit procedure bar, SuperPro displays information related to that activity.

The style and contents of the chart can be modified through the **Visual Style** dialog (right-click on the chart and select **Edit Style**).

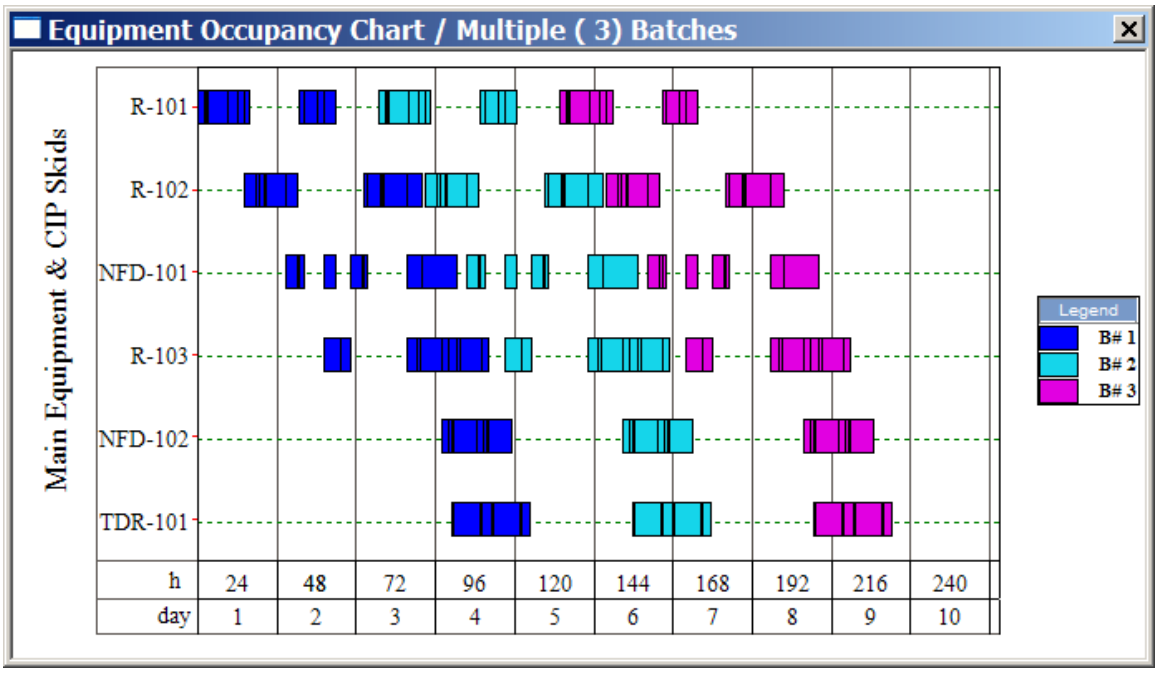

Fig 6.9: The Equipment Occupancy Chart (Three Batches)

6.8.1 Exporting the Chart as a Picture

You can export the chart (as a picture) from SuperPro into another Windows application. The export can happen with one of two ways:

To copy the Gantt Chart using the Clipboard…

1. Bring up the chart.
2. Right-click on the chart and select **Copy.**
3. Open the target application and select **Paste.**

To copy the Gantt Chart as a Metafile ('wmf' file)…

1. Bring up the chart.

2. Right-click on the chart and select **Export as Metafile**. The usual **Save As...** file dialog will appear, prompting you to type the name of a file. Type in the filename that you wish to contain the description of the flowsheet in ´wmf˝ format. By convention, all such files should have a ´wmf˝ extension.
3. Go to target application and import the picture

6.8.2 Exporting the Equipment Occupancy Data into Excel

You can export all the equipment occupancy information contained in a chart into a file that can be read immediately by Excel. Right click on the chart and select **Export Data to Excel.** In the dialog that pops up, specify the pathname of the file that will contain the scheduling data. Then click on **OK**. You can now start Excel and open this file directly from Excel.

6.8.3 Printing the Chart

The chart has its own Print and Print Preview functionality that is accessible through right-clicking on the chart. Alternatively, you may copy and paste the chart into another application (e.g., Excel, PowerPoint, etc.) and print it that way.

6.8.4 Zooming In and Out

When the a chart interface first comes up, it is set into **'Fit-to-Window'** mode, which means that the entire time horizon needed to describe the whole chart has been scaled down appropriately in order to fit into your window's width. If the maximum time that needs to be displayed is very large, or if the settings for minor/major scale and tickmark frequency for the time line are very small, the timeline may NOT display all minor and major tickmarks as expected. Therefore, some details along the time axis may have been omitted. In order to see the timeline spread out as expected you must switch out of 'Fit-to-Window' mode. Simply right-click on an unoccupied area of the graph and invoke the context menu for the chart. Notice that the **Fit-to-Window** entry has a checkmark in front of it, indicating that currently the contents of the chart are scaled down so that they can fit your window's width. If you select **Fit-to-Window** option once more, then it will turn the Fit-to-Window mode off and will display the timeline according to the timeline specifications. This may result in pushing the right end of your graph off the visible area of your window, so you may need to scroll to the right in order to see the rest of the graph. If further details need to be viewed in a chart, you may further expand the time scale by issuing a **Zoom In** command. Again, from the chart's context menu, select **Zoom In**. This will scale up the timeline and will present more details along the time line but less of the total graph will be visible within your window's area. The opposite effect happens when you issue a **Zoom Out** command. You may continue zooming in or out as needed (up to maximum / minimum scale).

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