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Chris Haslego
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SPECIAL NOTES FOR NEW USERS OF EZZE DRYER/SIM

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TERMINOLOGY

In the EZZE SIM program there is some terminology used which may not be familiar to you. Definitions and significance of calculated parameters can be found in the references listed below or the tutorial.

TECHNOLOGY

EZZE SIM contains two Monte Carlo Dryer (fluid bed & spray) simulations which use random process variable distributions, process correlations and process theory to emulate reality. The simulations can be used for your drying application or as templates to assist you in the development of your own process simulation. If your process can be described mathematically (mass - energy - process correlations) you can simulate the process!

Without the aid of simulation, a spreadsheet model will only reveal a single outcome, generally the most likely or average scenario. Spreadsheet risk analysis uses both a spreadsheet model and simulation to automatically analyze the effect of varying inputs on outputs of the modeled system. This is the power of simulation - you can try it first on the simulator to determine if there are any "potential problems" to be resolved before trying it in the real world.

FYI QUOTE IN REPORT DELIVERED AT A SIMULATION CONFERENCE - WINTER 2002, SWEDEN

Despite significant cost savings and the stride towards developing and implementing the Virtual Factory, few companies have managed to fully integrate simulation as a daily tool in their engineering processes.

EZZE SIM REFERENCES

3. Www.spraydrying.net/About_Nubilosa/Spray_Drying/spray_drying.htm
6. Www.taygeta.com/random/gaussian.html 'Generating Gaussian Random Numbers'
7. Www.oulu.fi/atkk/tkpalv/unix/ansys-6.1/content/thy_pds.html'Probablistic Design'

1 USERS NOT FAMILIAR WITH SPC/SIMULATORS SHOULD REFER TO OTHER SOURCES FOR MORE DETAILED INFORMATION TO ENSURE YOU HAVE THE TOOLS TO UNDERSTAND AND CAN INTERPRET DATA PROVIDED BY THE EZZE SIM TEMPLATE

2 READ "TUTORIAL" BEFORE USING THE EZZE SIM PROGRAM

3 DATA ENTRY
DATA ENTRY CELLS ARE HIGHLIGHTED N.A. ALL CELLS CAN BE MODIFIED
What is a Monte Carlo simulation?

Monte Carlo Simulation is named after the famous Casino in the Mediterranean Principality of Monaco. However, the use of the name "Monte Carlo" does not mean to imply that the method is either a "gamble" or "risky". It simply refers to the manner in which individual numbers are selected from valid "representative collections of input data" so they can be used in an iterative calculation process. These "representative collections of data" are some sort of a "Frequency Distribution" that is converted to a Probability Distribution. Monte Carlo Simulation methods are primarily used in situations where:

The system being studied can be mathematically described by a metric, which can be either parametric or analytic. The Input Data can be written as some sort of a frequency distribution. The "answer", or Output, must accurately represent the Input Data; the calculated distribution histogram of the "answer", or Output, must accurately reflect the Input data; and the calculated uncertainty in the "answer", or Output, must be an accurate measure of the validity of the model.

Since Monte Carlo is a Simulation technique, let's first define exactly what we mean by Simulation.

A true Simulation will merely describe a system, not optimize it!

(However, it should be noted that a true simulation may be modified in a manner such that it can be used to significantly enhance the efficiency of a system.)

Therefore, our primary goal in Simulation is to build an experimental model that will accurately and precisely describe the real system.
Monte Carlo Simulations are "True Stochastic Simulations" in that they describe the "final state" of a model by just knowing the frequency distributions of the parameters describing the "beginning state" and the appropriate metric that maps, or transforms, the beginning state to the final state. They can also be either static (easy) or dynamic (more difficult). If a prediction were required, then "every possible" option would have to be considered with a number of iterations for each required.

Statistical simulation methods may be contrasted to conventional numerical discretization methods, which typically are applied to ordinary or partial differential equations that describe some underlying physical or mathematical system. In many applications of Monte Carlo, the physical process is simulated directly, and there is no need to even write down the differential equations that describe the behavior of the system. The only requirement is that the physical (or mathematical) system be described by probability density functions (pdf's). For now, we will assume that the behavior of a system can be described by pdf's and process parameter equations (see below). Once the pdf's are known, the Monte Carlo simulation can proceed by random sampling from the pdf's. Many simulations are then performed (multiple "trials" or "histories") and the desired result is taken as an average over the number of observations (which may be a single observation or perhaps millions of observations).

What happens during a simulation?

EZZE SIM has two programs "controlling the simulation" - the process equations within the spreadsheet which define the interactions and operation of the DRYER and the VBA (simulator) program which turns the static process equations into an active entity with change defined by distribution functions and correlation equations interfacing the simulator theory with reality.

The VBA program is used by both Simulator programs and interfaces with the simulation sheets at cell locations defined in the VBA program. In EZZE SIM these locations are identified and must be used for the simulation to work properly. This will be explained in more detail later.

A simulation calculates multiple scenarios of a model by repeatedly sampling values from the probability distributions for the uncertain variables and using those values for the cell.

For each uncertain variable (one that has a range of possible values), you define the possible values with a probability distribution. The type of distribution you select is based on the conditions surrounding that variable. Distribution types include:

- **NORMAL**
- **EXPONENTIAL**
- **WAYBILL**
- **UNIFORM**
HOW DO YOU ANALYZE THE RESULTS OF A SIMULATION?

A forecast is a formula or output that you want to simulate and analyze. In EZZE SIM you can watch a histogram of that output quite simply. Assume that the value you wish to track is located at M54. To track it go to cell P55 (E3) and enter "=M54". Cell P55 is a portal to the program for tracking values and generating a histogram. Associated with the histogram is cell F56 (FAIL BENMK) this is where you enter the success or failure limit for the histogram.

The Simulator page has a table of probability distributions to consider using in your simulation. Each has a brief description of where, when and how you would use them. The ones of special interest to this simulator are highlighted. To apply a specific variable simply cut and paste the equation into the VARIABLE DISTRIBUTION section. Check the distribution parameters, random number parameters and adjust to suit your variables normal 'reading range'. Run your Simulation by left clicking the "RUN SIMULATION" button on the SIMULATOR KEYPAD.

EZZE SIM simulations can consist of as many trials (or scenarios) as you want - each requiring just a few seconds. Time depends on computer configuration, complexity of your simulation and the number of iterations you wish to run for each scenario. During a single trial, EZZE SIM randomly selects a value from the defined possibilities (the range and shape of the distribution) for each uncertain variable and then recalculates the

HOW DO YOU ANALYZE THE RESULTS OF A SIMULATION?

For every spreadsheet model, you have important outputs that you want to simulate and analyze. You define those outputs as forecasts.

A forecast is a formula or output that you want to simulate and analyze. In EZZE SIM you can watch a histogram of that output quite simply. Assume that the value you wish to track is located at M54. To track it go to cell p55 (E3) and enter "=M54". Cell P55 is a portal to the program for tracking values and generating a histogram. Associated with the histogram is cell F56 (FAIL BENMK) this is where you enter the success or failure limit for the histogram.
The program also calculates energy and gas balances and links this data to your report sheet.

In addition to the histogram, EZZE SIM creates CONTROL CHART DATA of the variable of interest in the simulation plus process SPC data for the studied variable plus 2 other variables select by you using the cell = link to the following program graphics portals F88 & F89. Spec limits for these variables are linked to the data and used to calculate SPC data. Imbedded on the worksheets are graphs of the variables for visual correlation checks of any 2 variables linked to the program portals. THE GRAPHS ARE ALSO LOCATED ON THE SIMULATION CHARTS & REPORT PAGES AS LINKED DATA.

The program is limited to generating 1 histogram per simulation. To generate another value(variable) use the "=" method to refer the next variable to the histogram portal and click the run simulation button.
A RECYCLE GAS MODULE IS AVAILABLE TO EVALUATE RECYCLE RATIOS FOR THE SPRY DRYER SIMULATION.

How do you change inputs? (fluidised bed dryers also)

There are four variables which randomly change within the simulation, three (slurry and dry product moisture plus exhaust gas temp) are pdf, one (slurry feedrate) is a random fixed variable. Pdf inputs are changed by changing their mean and distribution limits. For slurry water content you could change its mean to 50.

Next check its distribution limits. They are 61.75 and 73 obviously you would have a problem if lower limit is not <50 and conversely the upper >50.
FIXED VARIABLES YOU CHANGE THE OUTPUT VALUE + THE MIN AND MAX VALUES

For example if you change the feed rate to 9000 you must change the minimum and maximum values to "straddle" the feed value you wish to use.

FINE TUNING THE SIMULATOR

For each product you wish to simulate collect 8 hours of plant operating data (SPC charts, lab data, etc) do correlation analyses of the data and establish at minimum one key correlation equation - e.g.,

PRODUCT MOISTURE  = X*Win - (Y*Tout + Z*Tout^2) - (C*P + D*P^2) + E*F

X,Y,Z,C,D,E are constants for Win - water in slurry feed(F) at nozzle pressure (P) and exhaust temp (Tout)
The equation is entered into the program and we run a simulation. If we're lucky it will react like the actual unit if it doesn't - determine is it not at all or only occasionally & under what conditions etc. and make corrections to compensate for deviation then rerun the simulation. The goal is to create a simulation which approximates reality.

Simulations are done of each product in case there is a difference in their operating characteristics. If there is a difference, it may be an opportunity to optimize process settings by determining why settings are different especially if you cannot find an assignable cause/ reason.

With an accurate simulator model you have a powerful process tool which can be used for process optimization and troubleshooting. With the simulator you can make plant experiments more efficient by prescreening your trial on the simulator to identify potential problems and reduce the amount of information required from the trial (experiment).

REPORTS

There are two reports (ie 1 report per simulator) - SIMULATOR REPORT & SIMULATOR REPORT (2) the reports are linked to the simulator worksheets and consequently require minimal setup
THE MACROS FOR PRINTING REPORTS AND NAVIGATION IN THIS TEMPLATE ARE LISTED
HOW TO CREATE A NEW SIMULATION

In order to create a new simulation you must 'lose' a simulation. There are two simulators to select from. In this template each of the simulations is comprised of two programs - the process equations within the spreadsheet which define the interactions and operation of the DRYER and the VBA program which interacts with the process equations through "portals" to bring the simulation to life. So what we want to do is replace the old process' equations with the new process equations and maintain the portals to interact with the VBA program to create the new simulation. Sounds complicated but it's not - if you look at the two templates you will see one is multi stage (fluid bed) and the other single stage (spray dryer) processing. Make your template selection - now you are ready to create your simulator.

PLAN YOUR SIMULATION!

1 If you spend a few minutes laying out your simulator page you will make it easier to debug and reduce the probability of making mistakes (e.g., Inconsistent units of measurement, spreadsheet cell reference errors, etc.).

2 Determine the links between your equations to assist you in laying out the equations in logical order.

3 Determine your key process variables and which ones do you wish to vary randomly and which will be secondary variables influenced by the primary (random) variables. As you will recall you can use a probability density function (pdf) to define how each random variable will vary.

4 Write/type your process equations and variables on paper - Many times a simple 'typo' will give you hours of grief. (HINT - Type your equations as "text" first. It's easier to check for typos then if it's in the formula bar. After you've checked you can cut and paste the text into a formula cell.). Check and recheck your brackets because a misplaced bracket can make a big difference - Excel highlights bracket couples when you scroll through the equation on the formula bar which tells you the order that Excel uses in processing your equation.

PREPARING THE SIMULATION PAGE

5 In order to help you set up simulation you need to know where to find and how to use the portals to the VBA program. Following is a cell colour code to assist you.

MACRO LIST

<table>
<thead>
<tr>
<th>ctrl +</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>GO TO SIMULATOR START BUTTON</td>
</tr>
<tr>
<td>b</td>
<td>GO TO SIMULATOR(2) START BUTTON</td>
</tr>
<tr>
<td>c</td>
<td>GO TO SIMREPORT</td>
</tr>
<tr>
<td>d</td>
<td>GO TO SIMREPORT</td>
</tr>
<tr>
<td>h</td>
<td>GO TO HELP PAGE</td>
</tr>
<tr>
<td>i</td>
<td>GO TO README FIRST TUTORIAL PAGE</td>
</tr>
<tr>
<td>q</td>
<td>PRINT SIM2REPORT</td>
</tr>
<tr>
<td>p</td>
<td>PRINT SIMREPORT</td>
</tr>
</tbody>
</table>

NAME + NUMBER = GRAPHICS PORTAL (see above)
NAME + NUMBER = RANDOM VARIABLE NUMBER GENERATED BY VBA
NAME + NUMBER = RANDOM FIXED VARIABLE LIMIT USER ENTRY
NAME + NUMBER = NORMAL FORMULA OR CONSTANT USER ENTRY
NAME + NUMBER = NONLINKED USER DEFINES USE AND VALUE(NUMBER)
NAME + NUMBER = USED ENTRY LINKED TO VBA PROGRAM FOR ADVANCED USER PROGRAMMING IN THE VBA PROGRAM. DEACTIVATED IF YOU KNOW HOW TO ACTIVATE YOU HAVE THE ABILITY TO USE IT
NAME + NUMBER = USER DATA ENTRY TO 'P' DISTRIBUTION FOR ADVANCED
6 In the Simulator Page there are two areas which are useful areas to exercise care when you delete old simulator data. The area names are 'Process Simulator Summary' and 'Testing Temporary Notes.' The later is for you to jot reminder notes of what you are doing so that you can troubleshoot your simulation with a better understanding of what has been done or discovered while doing the simulation. The former is a link to the simulator report and the spc graphs created in the program so checking the cell links to this area is especially useful in preparing your report and graphs.

7 The simulator page has a histogram graph which is linked to the data in the histogram portal and therefore should not be erased. In addition there is a picture file of a process flowsheet which is also used in the report page. This picture file can be erased and replaced by a picture file showing a flowsheet of your process. A flowsheet is not essential for your simulation but does make the simulation look more professional and easier for others to understand.

8 When you have reviewed the old sheet and have decided what you can use from the old data you may erase the old data in preparation for your data.

9 Enter all your process equations and constants in the following areas—EQUATION VARIABLES, DISTRIBUTION CONSTANTS, AND MISCELLANEOUS VARIABLES BEFORE entering variables in the RANDOM AND RANDOM FIXED VARIABLES. REREAD THE SECTION ON HOW TO ENTER THESE VALUES IN THIS TUTORIAL.

10 As you enter data and work with your simulator periodically save your file. It may seem to be a bother to do so until the first time you 'muck up royally' and lose cells due to accidental erasure etc. This is a good thing to do before you try your simulator for the first time. Pay special attention to the graphics portals. This is how you decide which parameters you wish to use to generate SPC data.

11 Once you have the simulator set up the how to use your simulator instructions should apply to your new simulator.

GOOD LUCK WITH YOUR SIMULATOR!

SUPPORT

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