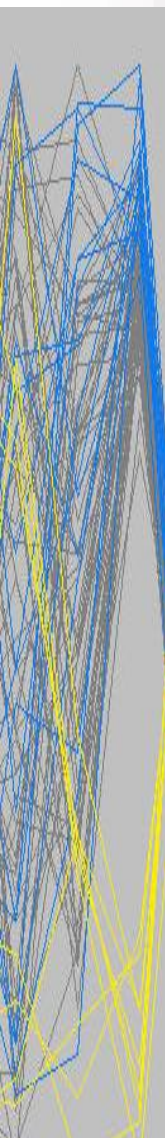




Process Analytics

*Improve business performance
and profitability
by understanding complex processes*



OVERVIEW

Process Analytics Technology enables better understanding of variability within complex manufacturing systems, including petrochemical refineries, chemical or pharmaceutical plants and other industries. It is becoming one of the primary routes to increased competitiveness and sustainability. Reactor stability, raw material variability and operator performance are just some of the many issues which can be addressed, leading to improved quality, consistency and yield.

Developed in conjunction with world-leading specialists in multivariate analysis based at the Centre for Process Analytics and Control Technology (CPACT) at Newcastle University, the MS2 system combines advanced analysis and visualisation techniques including parallel coordinate visualisation and principal component analysis with an extensive set of data integration and pre-processing tools.

Created in response to the needs of an initial 15 companies which were regarded as development partners, its development has always been highly problem-led. Therefore it is directly applicable to a huge range of opportunities for improving production performance through understanding the variability inherent in the process. Tools have been provided to clearly view data relationships from a mass of data representing hundreds of variables or thousands of samples.

For **batch processes** in particular, single value parameters such as final quality results can be integrated with multiple value parameters such as temperature and pressure trends to give a highly visual and totally integrated interpretation.

Pre-processing rules can be applied to remove obvious outliers, handle missing data, and enable non-numeric data such as shift identities or raw material batches to be included in analyses. Parameters may need to be shifted in time to enable a clear analysis and this, with MS2, is a simple function - there are many others.

Data from disparate sources such as commercial systems, process control and plant historians can be integrated to provide simple visibility of complex issues.

MS2 is designed for plant people - chemists, engineers and managers. The complex mathematics needed for multivariate analysis are there but are transparent to the user - only the results are visible. Above all, MS2 is easy to use. It is designed for applications in any size of factory, making it beneficial to small companies and multinationals. It is cost-effective and scaleable; in some projects payback can be achieved in just a few days.

In addition to supplying the system, we provide training, consultancy and many other services. Our pilot project scheme enables rapid assessment of the applicability of the technology at low cost and risk.



Aesica Pharmaceuticals Ltd, the Active Pharmaceutical Ingredients company based in Cramlington, Northumberland, supplies customers on every continent. Since the 1970's it has been the supplier of choice for customers ranging from small start-ups to the global giants of the pharmaceutical industry, a position achieved through advanced technology and manufacturing excellence.

"The ability of the MS2 process analysis system to co-display a multitude of variables simultaneously then quickly identify interactions has already proved to be very useful. Whilst confirming some previously held beliefs there have been some genuine surprises in some of the causes behind process variability. It is this ability to handle and analyse diverse data sets in a user-friendly format which I believe will yield significant benefit to our many processes"

John Budge,
Aesica Pharmaceuticals Ltd

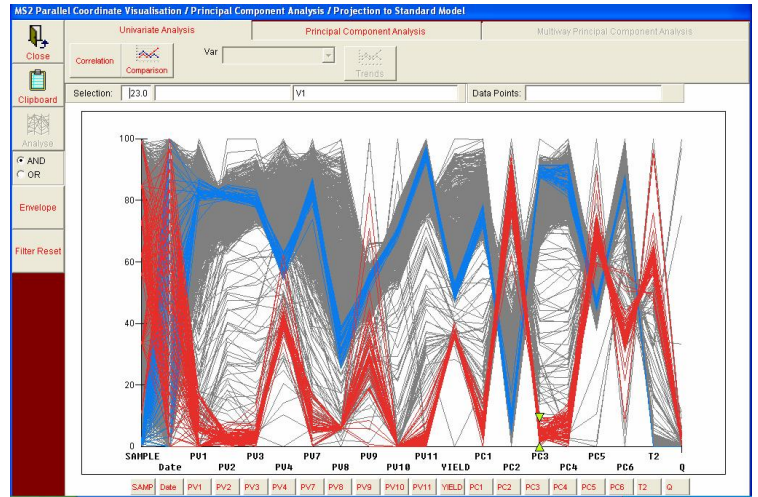


THE MS2 PROCESS ANALYTICS SYSTEM

MS2 is a sophisticated system which models the production process, both batch and continuous. It integrates and analyses data from other systems. A wide range of statistical analysis tools and visualisation methods have been developed to pinpoint critical process influences. The system incorporates powerful techniques such as multivariate principal component analysis and parallel co-ordinate visualisation.

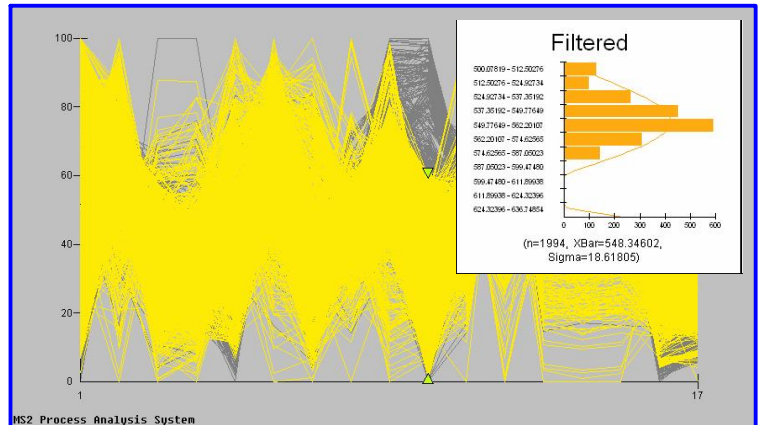
Parallel Co-ordinate Visualisation (PCV)

This technique provides a view of relationships between many diverse process variables, for instance quality parameters such as pH and viscosity, process parameters such as maximum pressure or temperature and calculated values such as operation duration or shift identity.



An example of MS2's PCV plot

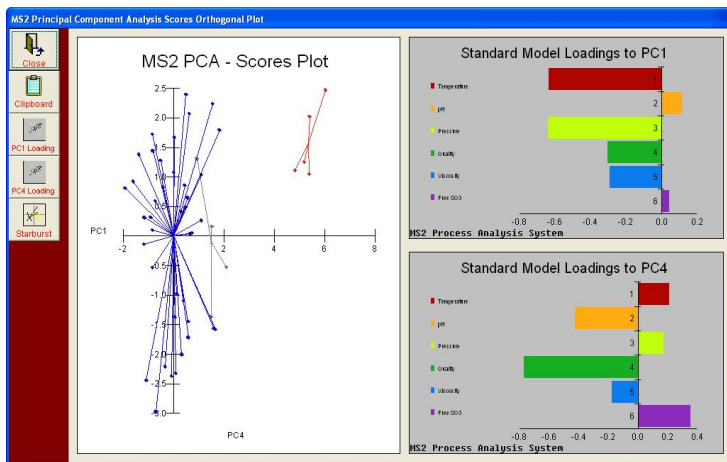
In addition to the basic PCV plot, other tools are provided which show, for example, the detailed distribution of results for each variable.



An example of MS2's distribution Plot

Principal Component Analysis (PCA)

Whilst parallel coordinate visualisation is a powerful technique enabling simultaneous observation of many variables, it is univariate. Hence it is of limited applicability where covariance is present, which is very frequently the case. PCA provides a method of reducing the complexity of large data sets to identify the principal causes of variability, and MS2 makes multivariate analysis using PCA a very simple process. It can display the results in the same plot as other, primary variables. In this way, complex causes of process variation can be readily identified.



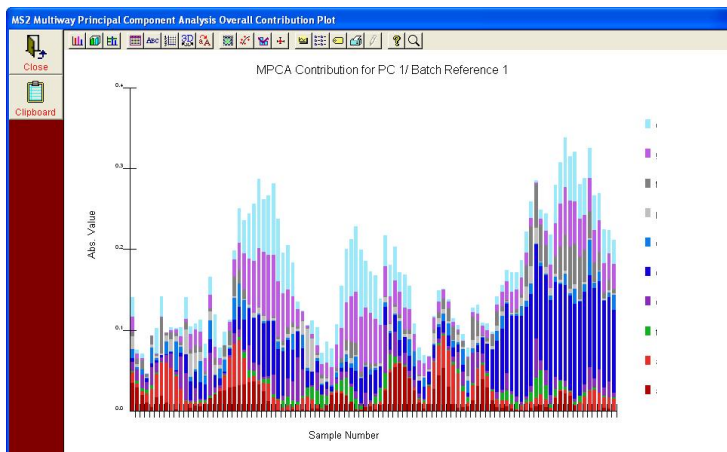
An example of MS2's PCA Scores Plot

MS2 provides a highly integrated set of visualisation tools which enable "drill-down" between displays. In this way it is possible to identify and visualise the underlying causes of a process problem very simply.

The results of MS2's PCA include, in addition to standard scores plots, contributions for individual samples, the Q statistic (Square prediction error), Hotelling's T2 (the D statistic), principal component score CUSUM analysis and time series plots.

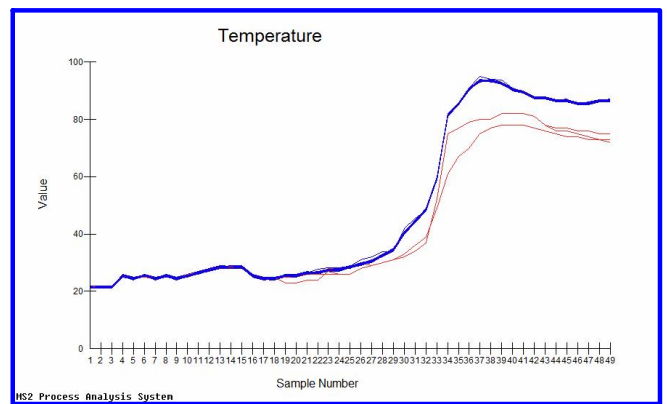
Multivariate PCA

Where batch production is involved, it is common for trend data to be recorded, for instance temperature and pressure measurements within the reactor, but including these results in an overall analysis is complex. MS2's Multivariate PCA algorithms make this a simple process and, again, the results can be displayed with other analysis conclusions, thus providing a totally integrated view of the analysis. Very powerful integration functions can be used to bring together data from several systems to enable a single analysis. For instance, quality data from a commercial system or a laboratory system and trend data from a plant historian can be linked to sequence data from a batch control system, making the complex process of incorporating multivariate trend data into an analysis a simple one.



An example of MS2's MPCA Contributions Plot

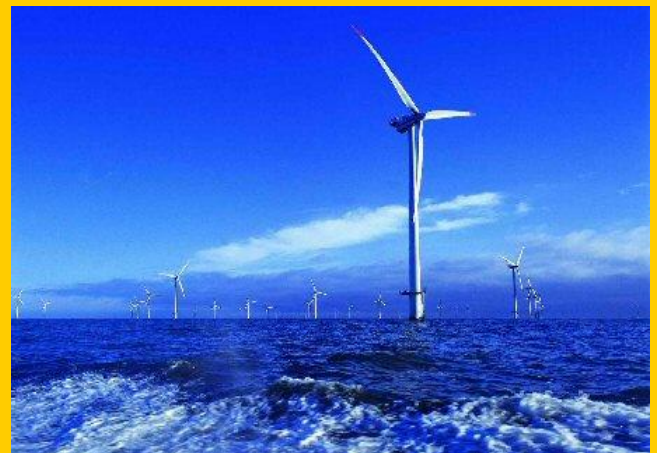
MS2's totally integrated approach to visualisation dramatically reduces the time taken to understand a complex data analysis. For example, poor quality batches can be selected, and the trend curves for those batches highlighted. Alternatively, abnormal trends can be selected, and the relevant final quality parameters highlighted.



An example of MS2's trend analysis, highlighting batches with poor quality

CASE STUDY—FIBRES WORLDWIDE

Fibres Worldwide Limited is a manufacturer of Acrylic fibres for industrial and speciality end uses based in Grimsby, NE Lincolnshire. The business focus is in two areas: Carbon Fibre Precursor and Speciality Textile Fibres. Carbon Fibre is processed into flame retardant and insulating materials, carbon-carbon composite aircraft brakes and aerospace components as well as other Carbon Fibre applications.

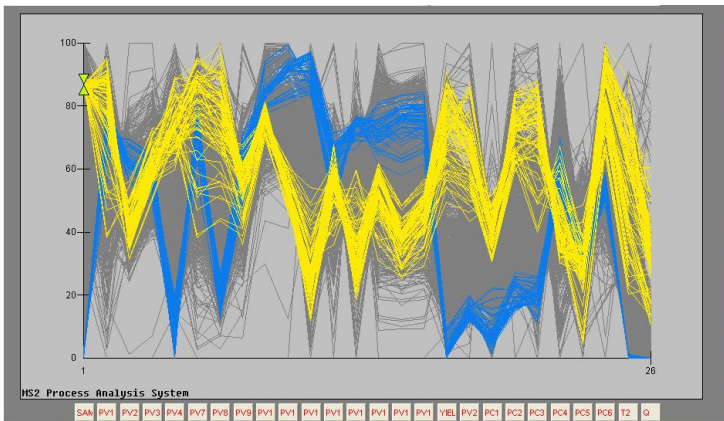


"Following our introduction to the concept of Data Mining and Multivariate Analysis we were aware of the potential benefits to a process as complex as ours but we were concerned about the suitability for a continuous process. By working closely with AJM, they were able to manipulate data from a large number of databases and produce a Parallel Co-ordinate Visualization with a timescale. Subsequent analysis including Principal Component Analysis has yielded valuable information about Key Process Parameters and has also shown where data that is difficult and expensive to collect is adding little or no value. We are looking forward to continuing to work with AJM to further develop the package and are now considering including Customer Data also."

Neil Barker,
Fibres Worldwide Ltd

Data Pre-Processing

One of MS2's most appreciated features is its ability to screen data prior to analysis. Simply by selecting from a set of rules, the raw data set can be prepared for analysis - often a most time consuming and repetitive activity. Specific rules and other functions allow complex visualisations to be created very simply. For example, it is frequently the case that a period of good operation is to be compared to a bad one.



An example of MS2's ability to compare operational periods

The rules and associated functions in MS2 have been developed specifically to model many situations found in process plants. It is this ability, together with the advanced analysis algorithms and visualisations, which enables the system to be used to provide an insight into the causes of variability. This facilitates substantial improvements in quality, yield and efficiency.

Formed in 1990 we have over 100 clients in the UK, Europe and North America. We specialise in assisting our clients to create manufacturing advantage through IT. We focus on the process sector - chemicals, pharmaceuticals, plastics, surface coatings and food.

SOME OF OUR CLIENTS:

- | | |
|--------------------------|-----------------------------|
| • ABB | • Imerys |
| • Arthur D Little | • J R Crompton |
| • AEA Technology | • Manro |
| • Aesica Pharmaceuticals | • Norsk Hydro |
| • A H Marks | • PICME |
| • BP | • PSE |
| • British Sugar | • Roche |
| • British Paper & Board | • Scott Bader |
| • Cambridge Consultants | • Servelec |
| • Carbon Trust | • Severn Trent Water |
| • ConocoPhillips | • SIRA |
| • DEFRA | • Strategem Consulting |
| • DTI | • Stepan |
| • Eli Lilly | • Synthomer |
| • Fibres Worldwide | • Technical Absorbents |
| • Fuji | • Tensachem |
| • GlaxoSmithKline | • University of Newcastle |
| • Hickson | • University of Sheffield |
| • Holliday Pigments | • University of Strathclyde |
| • Humber Chemical Focus | • UMIST |
| • ICI | • Yorkshire Forward |

CASE STUDY - SYNTHOMER

Synthomer is a world-class supplier of synthetic polymers. At its manufacturing plant at Stallingborough, it produces a wide range of synthetic latex products which are used in many types of industrial applications. The company has grown rapidly in recent years by being faster and more innovative than its competitors and quality is paramount.

Achieving this consistently high quality means understanding the variability inherent in a modern, complex manufacturing process, and Synthomer selected the MS2 Process Analytics System from AJM Consulting to assist in the identification of causes of variability between multiple reaction vessels.

"We initially asked AJM Consulting to investigate a process issue in which two reactors had differing characteristics which we did not fully understand. We had plenty of data, but interpreting it was a problem because it was derived from several systems and could not be integrated. The MS2 system integrated the data from our commercial, process control and plant historian systems and provided both an effective visualisation of the problem and an analysis of its cause, enabling us to implement changes which have resulted in increased consistency and quality."

"We are now implementing MS2 across the plant."

Stuart Askham
Synthomer Ltd

AJM Consulting is a member of:

- Institute of Measurement and Control
- Humber Chemical Focus
- Yorkshire Chemical Focus
- North East Process Industry Cluster
- CPACT



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