



One integrated framework for all your discovery data

XLfit and John Deere

A White Paper

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IDBS XLfit White Paper

Company background

In 1837, John Deere founded a one-man blacksmith shop that was incorporated as Deere & Company in 1868. Since then, Deere & Company has grown into a corporation that today does business around the world and employs approximately 47,000 people. It is one of the oldest industrial companies in the United States.

John Deere's Agricultural Equipment division is the world's leading manufacturer of farm equipment. The company offers a complete line of farming services and solutions with products sold and serviced through the industry's premier dealer network.

John Deere and XLfit

Engineers at John Deere's Agricultural Equipment division have been using IDBS' curve fitting and statistical analysis tool XLfit to benchmark the performance of their combine harvesters since 2004. Using XLfit as a data analysis and quality control tool, XLfit has helped John Deere to improve the efficiency of its performance tracking process.

The information that XLfit has helped the engineers to generate is used to compare performance of the company's combine harvesters to those manufactured by competitors and to previous generation Deere harvesters, as well as for internal quality assurance and improved decision support.

Data capture and analysis

Performance data from each combine harvester is collected using a set of scales on a trailer that feeds the data directly to Microsoft® Excel spreadsheets for calculations and analysis. The data is interpreted by plotting into graphs to analyze and measure key performance indicators such as fuel economy, grain size, fuel load, grain cut in a second, rotor speeds, optimum feed rate to minimize grain loss and grain loss at different speeds and power outputs.

The engineers create up to 12 different data plots, one for each performance indicator being monitored. The x axis displays the performance indicator, for example, the rate of crop harvested into the combine harvester, and the y axis displays the percentage of loss of

grain at a given speed or feed rate. In this example, at a low speed such as 1 mile/hour, grain losses are high but reduce as the machine goes faster, and then increase again as the machine speeds up further.

Each plot for a combine harvester performance indicator typically involves 4-8 test components representing results from a particular combine harvester, and the data points for each component - or combine harvester - are fitted to curves.

Prior to using XLfit

Previously to implementing XLfit, John Deere's engineers had to use several different programs to plot and analyze the Excel spreadsheet data. Viewing and analyzing data involved a series of manual steps including the constant transfer of data from one application to another.

The engineers could not superimpose curve fits on one plot, and trends in the data were difficult to see and understand. Each curve fit required an individual graph which was printed in isolation for manual comparison with other curves for the same plot. The engineers were faced with drawing lines on each graph printout to represent additional curve fits, raising issues of non-standardized display both between graphs and plots.

This difficulty in comparing data within a performance indicator plot, and between plots, made the detection of performance trends a lengthy process and report creation time-consuming and tedious.

How XLfit helps in the field

John Deere required a curve fitting and statistical analysis tool that works within Excel and was programmable.

Lee Hipwell, IT Analyst at John Deere, commented in 2004: "XLfit is programmable, which was an essential requirement. We also needed an application that would work in Excel for convenience."

Dealing with the complex mathematical equations and functions required to measure the key performance indicators, it was essential that the curve fitting application that the company chose could incorporate custom curve fit models and equations.

"We have some equations for which you can't calculate an inverse function," commented Lee. "It is mathematically very complex to find an intercept value for those equations. XLfit helps to facilitate this task."

XLfit's ability to allow users to add their own curve fit and statistics models, and to modify existing models, enabled the engineers to create the necessary proprietary equations with all the required functions.

The proprietary XLfit routines in Excel analysis templates, including polynomial, exponentials and second degree curve fit equations, enable the engineers to monitor combine harvester performance benchmarks and track performance trends in a more efficient and productive manner.

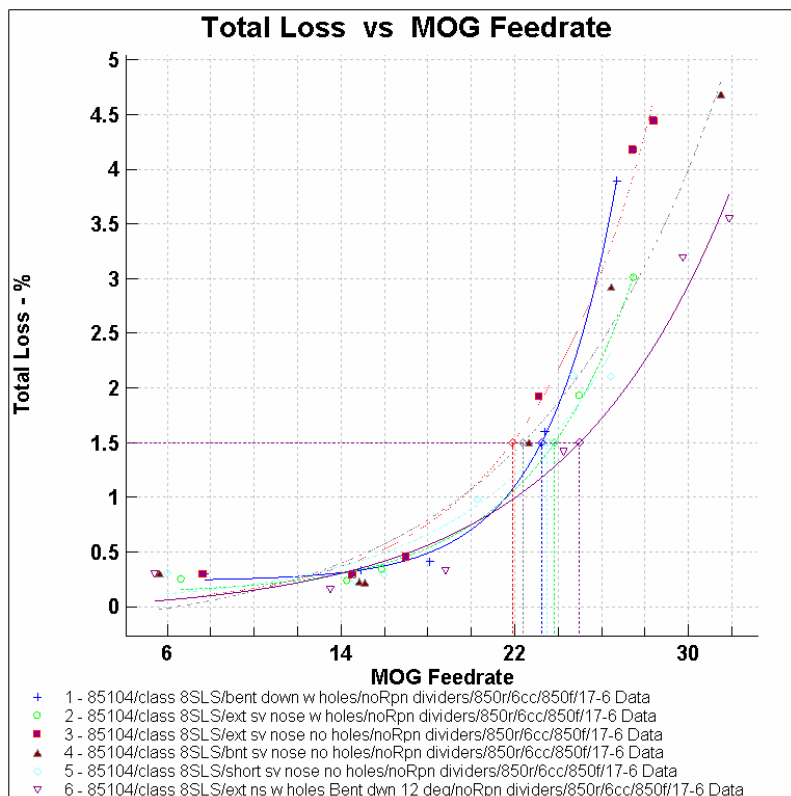
XLfit's functionality has benefited the benchmarking process in several ways.

Multiple curve fit overlays

XLfit's multiple curve fit and chart overlay functionality allows the engineers to superimpose and compare curve fits - or test components - within a plot with ease, and clearly view and compare each curve.

With point and click curve fit selection, the engineers can fit individual curves to data for each test component - or combine harvester - and view each curve superimposed - or overlaid - on each other. Comparison of results for each machine is easy because all the curves are displayed in one performance indicator plot. Intercept values for each curve fit equation - indicating, for example, the optimum combine harvester speed for minimum grain loss - can be easily viewed and compared.

The example below shows a plot measuring the percentage total loss of grain against the MOG (Material Other than Grain) feed rate of a base combine harvester versus a test combine with 5 different components. The total loss measurements include the percentage of grain lost by the separator and cleaning shoe. The grain loss is based on the yield of the crop and the amount of grain collected in the loss samples.



Plot Date 8/17/06 9:50 PM
ARIZONA
WHEAT

Series #	Mach #	Series Dates	Equation	
1	4110	85-807	17-Aug-06	503
2	4111	85-104	17-Aug-06	503
3	4112	85-104	17-Aug-06	503
4	4113	85-104	17-Aug-06	503
5	4114	85-104	17-Aug-06	503
6	4115	85-104	17-Aug-06	503

Series #	Mach #	Feedrate Level (%) @ 1.50				
		Max	80% Conf	Avg		
1	4110	85-807	26.70	22.89	23.57	23.23
2	4111	85-104	27.49	23.14	24.53	23.84
3	4112	85-104	28.41	20.68	23.10	21.89
4	4113	85-104	31.50	20.56	24.18	22.37
5	4114	85-104	26.42	22.13	24.87	23.50
6	4115	85-104	31.88	22.99	26.99	24.99

Series #	Mach #	% Capacity @ 1.5		#VALUE!	
1	4110	85-807			
2	4111	85-104	101%	104%	103%
3	4112	85-104	90%	98%	94%
4	4113	85-104	90%	103%	96%
5	4114	85-104	97%	106%	101%
6	4115	85-104	100%	115%	108%

A typical performance indicator plot showing combine harvester performance data as superimposed curve fits

Outlier knockout/in

A particular XLfit feature that the engineers find beneficial is the data point knockout/knock-in feature, which allows the user to remove potentially erroneous data points or outliers from the curve fit. The curve is automatically redrawn by XLfit, minus the outlier's value. A knocked-out data point, which is shown 'grayed out', can be easily reinstated if required. The fact that the data point is still visible, although not included in the plot, is particularly useful to the engineers.

Jeff Payne, Test Engineer at John Deere, commented: "Knock out is a nice feature that really helps. You can see the outlier is still there but is not contributing to the plot any more."

Curve fit model selection and customization

The wide range of curve fits available from the XLfit library have also helped the development of a model library that is applicable to John Deere's benchmarking process. XLfit's in-built models are easy to customize and adapt to the engineers' needs.

Since implementing XLfit in 2004, the company has developed several more custom models each year to apply to different crops that require new approaches to performance and trend analysis. The standard XLfit models most used by the engineers include the 1-phase exponential decay model 503, which is used about 70% of the time, with the occasional use of polynomial models 150 and 151.

Fit Designer

The Fit Designer is the most used XLfit feature at John Deere, enabling easy graph building by displaying a preview that updates as data content is added and fit models applied. The point-and-click curve fitting allows engineers to view changes in trends as they fit test points to a curve, select new fit models to apply and knock data points out or back in.

Best Fit Search

In addition, the engineers also use the XLfit's Best Fit Search that provides a list of fit models that most closely meets their fitting requirements. The Best Fit Search enables XLfit to search all of the models for a selected dataset and return the F Test, T Test, Chi Squared and r^2 statistical values for each of the models. This information can then be used to select the appropriate model for the data.

"Typically we would fit around 5 test points to a curve in the Fit Designer then use the knock-out feature to remove outliers and the curve moves accordingly. We then use the F Test to scroll down through the Best Fit Search list and find the proper fit," says Jeff. "This is often Model 503 so we accept this model to fit the curve."

Easy report creation

A major benefit that XLfit has brought to the whole benchmarking process is the drastic reduction in time it now takes to create a report - 3 hours - compared to the 8 hours that report generation used to take prior to XLfit. As management reports are generated twice a week, the easier report creation saves the engineers a significant amount of time. "This is a great improvement and offers us huge time savings," Jeff commented.

The reports are presented directly to management, who can immediately see from each plot how John Deere combine harvesters are performing in all key areas, whether performance is competing successfully with other combine harvester manufacturers and whether performance is meeting business goals.

As well as providing this kind of management decision support, the XLfit reports also provide helpful customer support. Using the information that the engineers generate, John Deere can advise customers on the range of settings that give most efficient performance

for their combine harvesters, and also highlight areas in which product improvements could be made.

Summary

Overall, XLfit has simplified the entire benchmarking process by giving John Deere engineers an “easy-to-learn” tool that has removed a time-consuming manual process and replaced it with a more efficient and productive approach. Proving “very beneficial” to the company, XLfit has also improved decision support for management by providing reports that are faster to generate, easier to understand and so more able to translate into business value.

“We’re very happy with XLfit,” Jeff concluded. “We had to do things manually before but XLfit now simplifies the process.”