Six Sigma and the Well-Behaved Design

by Jim Buchanan of PTC

August 2006

Article from **PTC Express September 2006**

As a design engineer, you don't have to be told that consumers, manufacturers, and pretty much everyone else in business today is taking the concept of product quality more seriously than ever before. And you probably know that Six Sigma, a quality standard originally defined by Motorola 20 years ago, has now become a principle methodology for maximizing and measuring the quality of products and services.

What you may not know is how a unique functionality in Pro/ENGINEER can help you apply Six Sigma techniques to your own product design. This functionality is Pro/ENGINEER Behavioral Modeling Extension, or BMX.

Essentially, BMX is an application that can calculate the optimum values for your design, based on multiple parameters. Say you are designing a container. You tell BMX what conditions you need to satisfy and what dimensions or parameters in your design are allowed to vary. A few seconds, and a few thousands iterations later, BMX has given you a design solution for holding the prescribed volume of liquid while still honoring given constraints.

BMX works this way because it's fully integrated and associative across multiple functional areas of Pro/ENGINEER. The application can refer to your design, assigning new values based on its calculations, and these are then used to inform the next series of calculations. Without BMX, CAD designers typically write scripts of macro instructions, and scripts can be both time-consuming and error-prone.

Six Sigma: fits like a glove. BMX fits the Six Sigma product-design methodology like a glove, according to Charlotte Lenfest, Product Manager at PTC.

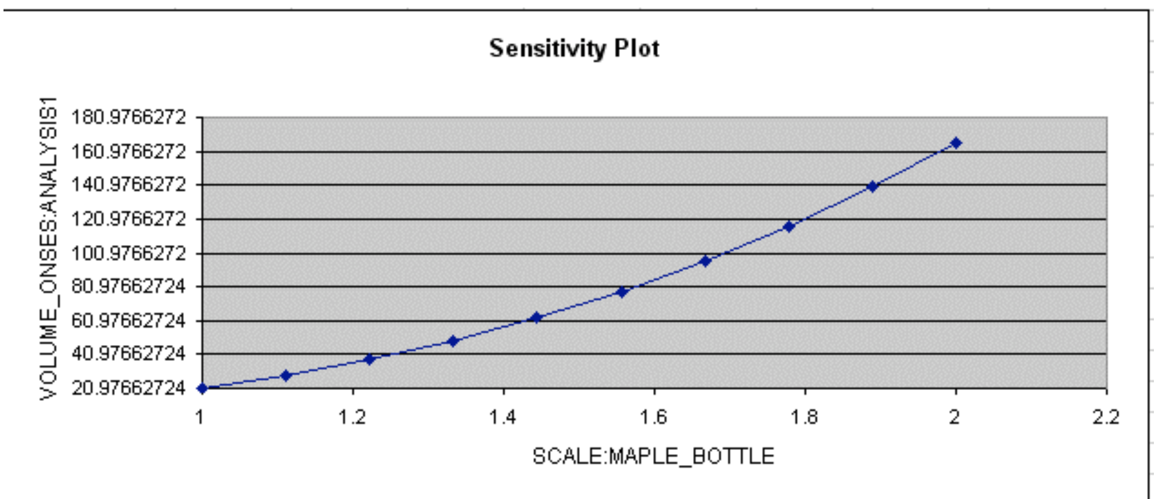
"The Six Sigma methodology is very specific," she says. "It starts with defining the quality goals you want to achieve, and then you compile the metrics that will be used to measure whether those goals have been met. Then you analyze the results, and make the improvements necessary to meet the quality goals.

BMX has a direct impact on all these steps. It lets you create what PTC calls analysis features — which are embedded in your design model as if they were geometric features. An analysis feature contains information about the model, or a part of the model and will update as changes are made to your design. It could, for example, be a measurement of a surface area, a clearance distance between two parts in an assembly, or perhaps the location of the center of gravity.

After creating your analysis features, you can use these as goals to improve your design through an optimization study. You select the parameters that you think will affect the goal, enter your constraints, and run the analysis. BMX even selects parameters for you. A sensitivity study will tell you which parameters will have the greatest effect on moving the model to its optimum value.

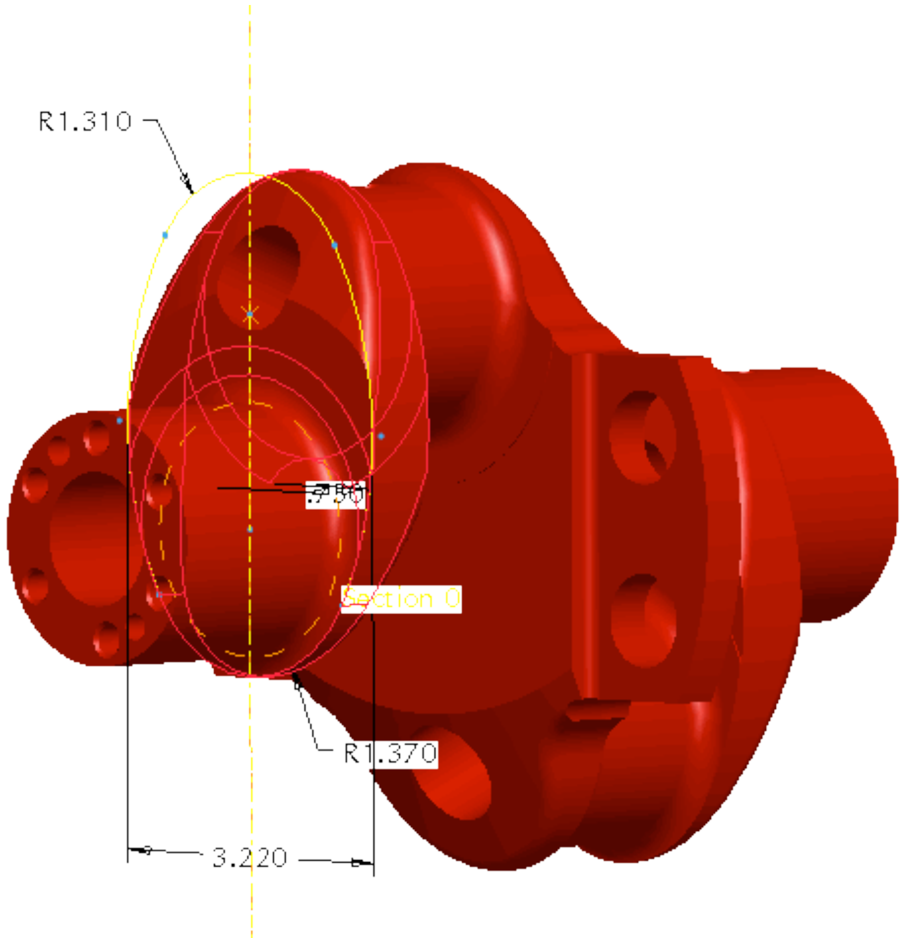
Spinning the crankshaft. For a simple example of how BMX works, Lenfest suggests an analysis of a crankshaft for a typical automobile's internal combustion engine.

The crankshaft is the heart of the engine, spinning around as the pistons move, and delivering power to the car's drive train. The more efficiently the crankshaft moves; the greater the power and engine's life. Because of this, it's critical that the crankshaft be well balanced, with its center of gravity as close as possible to its axis centerline.



SCALE:MAPLE	VOLUME_ONSES:ANALYSIS1
1	20.97663
1.111111111	28.69499
1.222222222	38.11504

Graph showing a BMX sensitivity study



A BMX optimization study for a crankshaft

“Here, you’d create the analysis feature in BMX to measure the distance from the center of gravity to the crankshaft’s axis of rotation.” says Lenfest. “Then you’d specify what dimensions BMX could modify, things like the size and shape of the counterweights, and the allowable physical area of the oil pan”

“Then you run the analysis and see the results. BMX tweaks the parameters until you get the center of gravity where you want it, based on making the distance between the center of gravity and the centerline axis zero.”

It sounds simple, but the beauty of BMX is that it can perform with very complex models, Lenfest says, where you might be dealing with dozens, or even hundreds, of different parameters.

“This is a place where the sensitivity study would be helpful,” she says, “because it would help you eliminate the non-important parameters.”

You and Six Sigma: hitting goals. So how do you know whether you've achieved Six Sigma? Officially, Six Sigma calls for a reduction in product defects to below 3.4 defects per one million opportunities. This can extend to any endeavor — it might mean fewer than 3.4 product returns, for instance, or, in service, fewer than 3.4 customer complaints per one million phone calls.

Lenfest notes that much of the value of Six Sigma lies in formalizing the approach itself, and coming as close as possible to perfection.

"By subscribing to a Six Sigma design methodology, users win in a number of ways," says Lenfest. "They win in the market, because quality is a real competitive advantage. They win because a quality design — what we call a well-behaved design — reduces the likelihood of downstream changes in the physical prototyping or manufacturing stages. These can be very expensive and time-consuming. They can even spell the difference between success and failure for a product line."

"And by using BMX, by tweaking different parameters, finding which are relevant and which are not, and so on, you're learning more and more about the behavior of your design under different conditions. The better you know your design, the more effectively you can build it — as well as the next design — to optimize its quality."