DFMA: DESIGN FOR MANUFACTURE AND ASSEMBLY

America's newest "secret weapon" boosts quality, lowers costs and beats the Japanese at their own game.

by GERRY KOBE

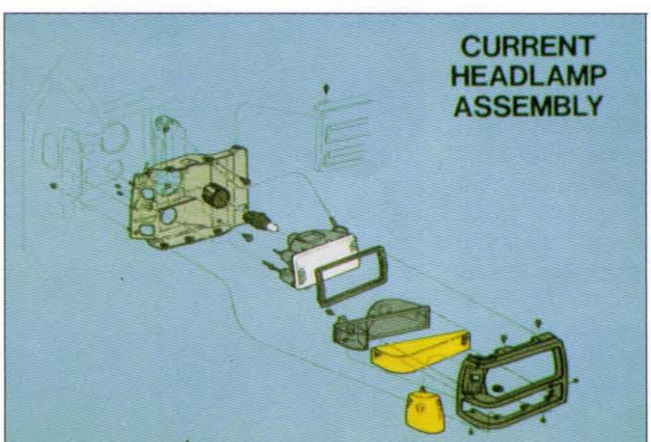
For years Japan has been accused of doing cheap imitations of US designs. But nothing could be further from the truth.

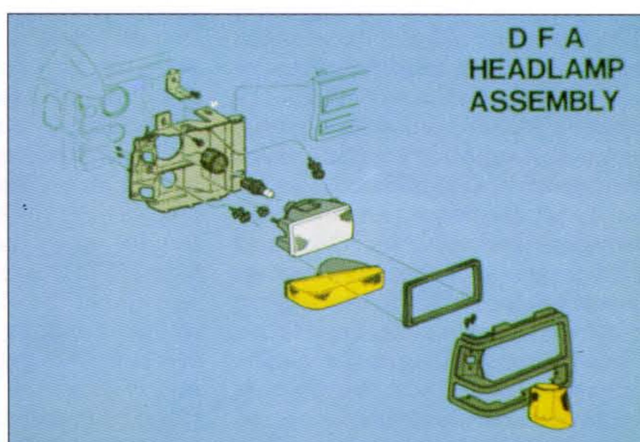
In fact, the Japanese have been careful NOT to copy American designs, opting instead to look at how the product can be made better and easier. As a result, Japanese products reflect a high degree of simplicity and quality, while offering an inexpensive alternative.

The name of this approach is Design For Manufacture and Assembly or DFMA. And it's becoming a way of life in many American industries. "One of my customers – a truck manufacturer – went from 800 parts to 120 on one assembly, and quality improved dramatically," says DFMA expert Sandy Munro, president of MTS for Productivity Inc. "Also, a machine tool company we've worked with went from 120 parts down to four!"

Although existing automotive examples may be less dramatic, a good illustration might be one-piece door stampings (Fig. 1), which Japanese automakers pioneered in the early 1980s. Then current American designs were using a complicated three-piece configuration that added cost and quality-robbing variability to the door – a mistake the Japanese resolved. In simple terms, the Japanese were using DFMA principles to ask the question: How can we design complexity (cost) out, and quality in?

As simple as that question sounds, it



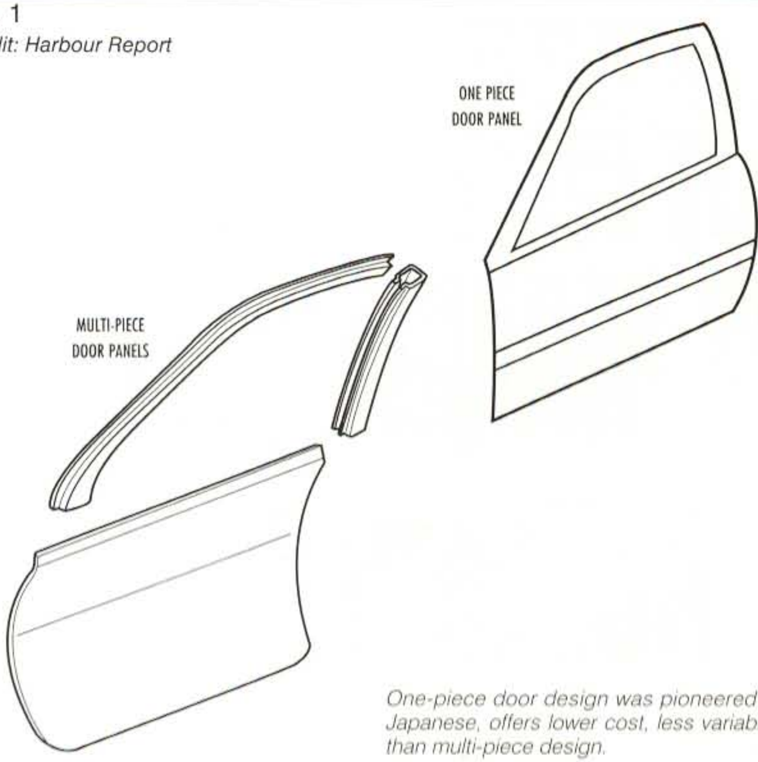


Ford Ranger headlamp benefits from DFMA analysis. Number of parts reduced 22%, assembly cost reduced 52%, materials reduced 2%.

Reprinted from Automotive Industries, March 1990 issue.

Fig. 1

Credit: Harbour Report



One-piece door design was pioneered by Japanese, offers lower cost, less variability than multi-piece design.

has taken a long time for domestic automakers to catch on to the secret of Japan's success. And now that they *have* caught on, automakers must position themselves to implement what they've learned.

The first order of business, then, is to formulate "clean sheet" product life cycles that are competitive with the Japanese – currently four years. Chrysler's Dennis Pawley, general manager, advanced manufacturing engineering, notes, "...You're limited as to what you can do by maintaining the same platform. New technologies that allow for a more efficient manufacturing process cannot be implemented unless designed into the product."

Pawley's insight illustrates how the Japanese capitalize on their quick turnaround time to take advantage of new materials, designs and manufacturing methods. When cost-cutting technology is available, the Japanese incorporate it quickly. In contrast, current domestic product life cycles run from eight to 10 years for a complete redesign, often at a cost of being nonresponsive to customer needs.

That's the bad news.

The good news is that successful DFMA is growing rapidly in the US auto industry. In fact, when compared to the combined efforts of the Big Three, Japan may – for once – find itself playing catch-up.

On one end of the scale, Chrysler is focusing its DFMA efforts on major operations: stamping and trim/chassis/final assembly. Roland Mueller, manager of manufacturing feasibility at Chrysler's advanced mfg.operations says, "We had a philosophy at one point, and that was during the K-car program. The philosophy was to maximize the size of the stampings and minimize the number of parts. We have reversed on that," he confides. "Now we want to minimize the number of stamping operations."

Chrysler has learned one of the most important lessons of DFMA, and that is to analyze the *entire* process to determine where the greatest gains can be made. In this case, their analysis revealed that the costs of making large panels – requiring up to nine stamping operations – negatively offset the savings of a reduced part count. In contrast, body panels for the upcoming LH platform are running at an average 3.9 hits, and will be done in higher efficiency transfer presses.

The same platform also promises improved techniques for final assembly. John Hinckley, program manager for Chrysler's LH-LX platforms, says the new vehicle was designed to eliminate the need for workers to perform operations over their heads. "We decided we wanted to take the chassis and build it [engine, front suspension, exhaust system, brakes, etc.] at ground level, where we can get good lighting, load parts simply, and get our tools on it. And we wanted to build it on a pallet." Hinckley then offers that the body and chassis will be assembled automatically, using all vertical at-

DFMA DESIGN TIPS

Sandy Munro, president of MTS for Productivity, Inc. offers these design tips:

TEST FOR MINIMUM NUMBER OF PARTS

- Do parts move relative to each other?
- Must these parts be made of different materials?
- Would combination of these parts prevent assembly or disassembly of other parts?
- Has servicing of the assembly been adversely affected?
- If the answer to all questions is no, consider combining the parts.

GOOD DESIGN PRINCIPLES

- Teamwork – the difference between good and bad designs.
- Minimize the number of parts.
- Design so the assembly process can be completed in a layered fashion – preferably from above.
- Consider easy part handling.
- Design mating parts that are easy to insert and align.
- Avoid expensive fastening operations; i.e. screwing.
- Avoid part designs that will cause tangling with identical parts.
- Make part symmetrical to aid in automatic orientation.
- If symmetry can't be achieved, exaggerate asymmetrical features.
- Avoid adjustments.

tachments – effectively reducing assembly time and improving quality.

No Silver Bullets?

One of the more promising applications of DFMA comes in the form of software programs – run on PCs – that allow engineers to do a part-by-part design for manufacture and assembly analysis. And of the systems available, one – Boothroyd Dewhurst – distinguished itself among engineers as being the most comprehensive and powerful. Moreover, we discovered that for the past several years, this system has been named the "Number One technology" at Ford, and is currently spreading through GM like wildfire.

We contacted Gary Cowger, manufacturing manager at Cadillac and corporate champion of the Boothroyd Dewhurst approach. "BDI [Boothroyd Dewhurst Inc.] software is another tool – that's all," Cowger says. "There's no one great big thing that you go out and learn, and that's part of the problem – people think there's a silver bullet."

Cowger's point is well taken, but since he put on his best poker face when the topic turned to BDI – we think he might be sandbagging. You be the judge.

"It's magic," boasted a B-O-C engineer who spoke on condition of anonymity. "It's spreading like crazy around here!"

"Getting the voice of the assembler up front," says Cowger, "It's the little things – the bunts and the singles."

"You guys hit a home run when you keyed in on this," said a nameless Delco employee. "This is hot stuff!"

"DFM is an enabling technology," Cowger opines, "It's evolutionary rather than revolutionary."

"It's like we're re-learning the design process," says a secretly satisfied C-P-C user. "Only this time we'll do it right!"

"It's the removal of two screws here, or the addition of a lap joint (Fig. 2) there that makes a difference," says Cowger.

"I can't talk about it, but BDI has made a big difference...real big!" says a Saturn insider.

"You're looking for minutes...even seconds," Cowger offered.

"We've pulled 35% out of the assembly time on that [1993 GM] car." – satisfied BDI user.

Silver Bullets!

If we had any doubts in our minds that we were onto something, they were gone by the time we left the office of Don Smith, senior computer applications engineer at Ford's robotics center. Ford has been involved with Boothroyd Dewhurst DFMA principles since Sandy Munro – now with MTS for Productivity – brought it to the company in 1983.

"Look at the comparison (Fig. 3) between the 1980 Fairmont/Zephyr AC unit and the DFA'd redesign in 1986," Smith boasts. "The numbers are dramatic, but we usually tell people to expect a 20%-30% improvement."

We spoke with Munro about Smith's claims and he was even more optimistic. "When I was at Ford we used to think that if we got a 15% reduction we were really doing something. But every time we looked at an assembly we got another 15%. Now I won't accept 15% anymore, I look for 40%, 60% and in some cases 100% – that's where we eliminate a sub-assembly completely and do something else."

Smith points out that the software helps balance out the relationship between assembly and manufacturing. "It may cost a little more to manufacture a more complex part," Smith says, "But the point is this: If the new part costs more to make, you have to consider how much it would have cost to assemble the old one. Invariably, when you compare unified parts to separate, the unified part is cheaper."

Smith says that as of the 1990 model year, virtually every vehicle in production at Ford has had some involvement with DFMA. Some cars like Taurus/Sable had extensive analysis (40% of vehicle), and yet it probably won't be until MY 1994 that Ford produces a vehicle that has been analyzed from bumper to bumper. Even so, side-by-side comparisons reveal that a typical Taurus has hundreds fewer parts than a GM-10 car – most of them fasteners!

If you have doubts that there is a payback in such an extensive process – and there is still resistance to DFMA – Munro can ease your fears. "One of the years I was at Ford I was nominated for an award and we had to find out how much DFMA had saved or deferred in costs," Munro says. "When we came up with a figure of $1.2 billion, that let us know it was the right thing to do."

Fueled by Munro's numbers, we asked Smith to talk us through the BDI analysis process – a request that he answered with a full-blown demonstration of the system.

Unlike other analysis systems on the market, one of the virtues that recommends BDI is that it uses terms that can be easily understood. It deals in dollars and cents, minutes and seconds – words that are meaningful.

The first thing the program asks is cost per hour, so it can calculate your labor costs. Then it wants to know if you wish to analyze the part during as-

Fig. 2 *Art Credit: Harbour Report*

Japan pioneered lap-joints to replace flanged butt joints. Design maintains joint quality while allowing for panel variation.

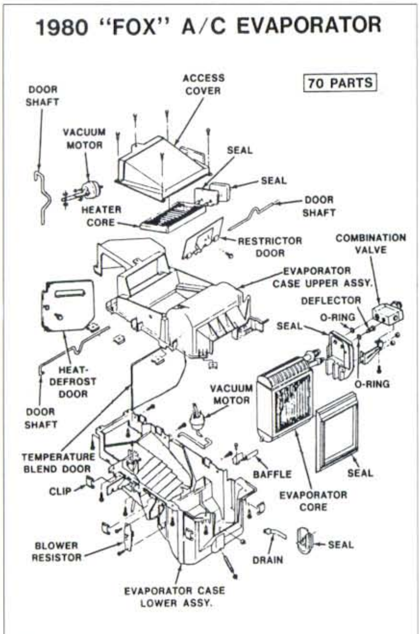
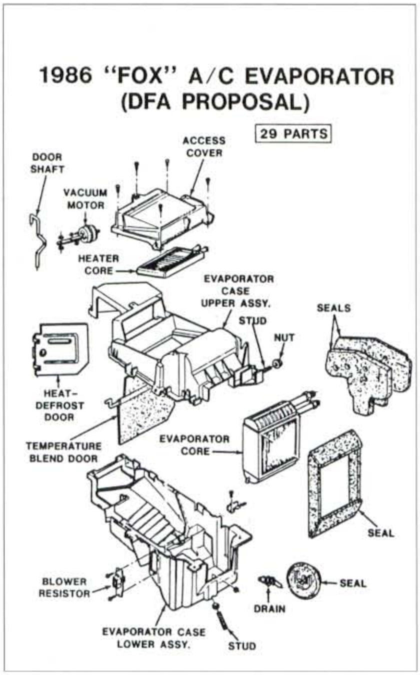


Fig. 3 *Credit: Ford*



Ford A/C evaporator was analyzed with BDI software. Assembly shows 20% quality improvement, 59% part reduction, 22% cost savings.

sembly or disassembly. The reason for this feature is to accommodate analyzing existing designs – which you can do during disassembly – or new designs as they are being built.

For demonstration purposes, Smith chose to analyze during assembly.

The first prompt is to name the initial part in the assembly, in this case a "block." It then asks information about the block such as: Is it rotational? What are its dimensions? Is it easy to grasp? Insertion symmetry? (when the part is in correct insertion position, how many degrees must it be rotated before it is in correct position again)? Is there a clear view of mating locations? Good access? Easy to align? and so on.

As each question is answered, the program builds a "profile" of the part to determine the cost of assembly, and the necessary relationship of that part to those around it.

As the next part is brought into place, the software "examines" its relationship to the first part. And since the "key" to the software is that it keeps track of parts that are potential candidates for elimination, it forces you to justify the reason for the design.

It does this by asking three basic questions: 1. Does this part need to be separate because it moves relative to parts already assembled? 2. Does it need to be a different material or isolated from parts already assembled? 3. Would combining this part with previous parts make assembly or disassembly impossible? If you answer "yes" to any of the questions, the software accepts that the part must be separate. But if you were able to answer "no," when the software is finished with its analysis it will flag the part as a candidate for elimination.

As each part is added, the software looks closely at any "irregular" answers. For instance, if you were to answer that a part was difficult to grasp, the program would want to know why. In this case a window appears and asks what sort of problem it is. Is the part heavy? Oily? Does it tangle easily? Nests with other parts? Too flexible? Sharp? Too small? etc. The program then considers how much time the special handling adds to assembly, and figures it into the cost of that step.

When all the parts have been logged into the system, the software produces a chart that – aside from doubling as a process sheet – evaluates design efficiency and highlights parts that could be eliminated. The designer can then go back and evaluate the software's recommendations, interacting with the program so that he can assess the improvements.

If it sounds simple, that's because it is. Admittedly, we've only been given a thumbnail sketch of how one of the software programs operates. What we haven't mentioned is that this program is just part of a series of modules that work together to consider: DFMA; Assembly System Economics and Machine Simulation; Design for Robot Assembly; Design for Automatic Assembly and Handling.

In addition, BDI has software packages for: small metal stampings; plastic injection molding; machining; printed circuits. Future programs will include powdered metals, die casting and possibly large panel manipulation.

Munro says DFMA has impacted everything he's tried it on, and that the biggest gains are yet to be made. "I'll tell you what, if you really want to find a way to where the big money is," Munro says, "look at those sub-assemblies that the auto companies farmed out because they couldn't find a way to manufacture them economically. Look at *those* products with DFMA and you'll be looking at cost reductions of 50% or 60%."

Because Munro is unable to talk about his current involvements, he offers a challenge: "I'm looking for a company that has a product that at one time had a large market share, but has fallen on hard times. I'm willing to donate my time to turn the company around in exchange for having the freedom to talk about how it was done. If that happens, then you'll hear a really amazing story!"

To accept the challenge or learn more about DFMA contact:
Sandy Munro
MTS for Productivity
911 W. Big Beaver
Troy, MI 48084
313-362-5110
(Tell him *AI* sent you). AI