Visit to Nikon Nishi-Ohi Works, Aug 23, 1991

Background

Our hosts were Mr Okuda, General Manager of the Production Engineering HQ and Mr Okamoto, the Sr Assistant Manager of the CAD-CAM Center, a very astute person who may be ahead of the rest of the company's thinking on many issues.

Nikon is a diversified optical company with 7200 employees and $2.2B annual sales (at ¥150/$) . The main products are cameras (42% of sales), instruments (microscopes, theodolites, surveyors' telescopes - 7%), industrial equipment (mostly for making semiconductors and recently "very busy" - 32%) and eyeglasses (8.5%). Smaller divisions have less than 4% each and make electronic imaging cameras, magneto-optical storage disks, and bioengineering products, such as glass-coated metal dental implants.

The production engineering HQ is a corporate-level activity that makes production equipment for all the divisions. While equipment design is done at Nishi-Ohi, some of the equipment manufacture is done at the plants where it is used. Curiously, Mr Okuda does not report directly to Corporate HQ but instead to the Executive Director (VP) of the Industrial Equipment Division, who reports to the President. There is one other Executive Director, for Consumer Products, the only other main division. Mr Okuda says that reporting in this asymmetric way causes no problems. In any case, Nikon is generally typical of Japanese companies in making its own manufacturing equipment in a corporate-level department.

Mr Okamoto stressed several times that Nikon is a conservative company that serves a conservative and highly professional clientele.

Product Design Methodology for Cameras

Camera technology is changing rapidly, with microelectronics being the main driver. From a mechanical viewpoint, the main change is to styling the exterior with arbitrary sculptured surfaces. This has thrown the camera companies right into the car design arena without the car companies' years of gradual buildup of experience, attitudes, and software development resources.

Altogether Nikon has about 100 camera designers, split 70:30 mechanical:electronic. (Since the optics are designed elsewhere I do not have a good view of that process. See the Ricoh report for an optics story.) There are so many design projects going on and so little time that the staff is stretched thin.

A top of the line camera has about 1000 mechanical parts. The F4 took three years to design and occupied 10 to 15 designers full time: 5 mechanical, 5 electrical, 1 or 2 optical, and 1 software. Lower level cameras may have 600 parts. Totally new cameras are designed every two to three years, with small changes all the time on one year cycles.

Another important driver of camera design is the almost vain attempt to keep the weight from growing as optics and other features are added. The main casualty of this effort has been the die cast aluminum body, which has been replaced by a set of precision molded plastic parts, usually 20% glass-filled ABS. (The same material is the prime one for printer parts. See Seiko-Epson report.) Stress analysis would thus seem to be a prime concern, but neither Nikon nor Ricoh has enough solid modeling capability to use such techniques on a regular basis.

A third driver is price competition. Few Japanese companies can assemble cameras domestically. Assembly is basically manual and labor costs are high. Nikon, at the top of the price chain, can assemble in Japan, but it can (and must) fabricate only the critical plastic parts in-house. For the others, it makes use of (to us) a dismaying array of mom and pop shops scattered around town and country, working in poor conditions and subject to dismissal at any time. For this reason, among others, the influence of production engineers in the design process is not typical for Japanese companies, since they are not representing in-house people and it is difficult to predict the capabilities of such suppliers. Incoming inspection is a big effort.

The last driver is the design of a very complex and oddly-shaped flexible printed circuit that holds several custom IC's and lots of little components. This must snake around to link several locations on several of the functional elements inside the camera (film drive, range finder, autofocus, autoexposure, LCD display, flash, and so on.) Design of this flex circuit is tedious and not well supported by CAD.

The camera design process (same at Ricoh) begins with "industrial design" of the exterior. As many as ten outer shell prototypes are made by hand from wood or styrofoam. Each such prototype takes a week to carve and finish. Design is difficult because hand-feel is important and peoples' hands are such different sizes. Especially US and Japanese people are quite different in body size. No solid modeling is used for these explorations because it is "too slow." At least, the car company engineers tell Mr Okamoto that! He also worries that no solid modeler could hold all the data for a camera's interior. Again, this mirrors car company opinion.

Stereolithography is not used. They have heard of SOUP (see Fujitsu report). For them, SOUP's 3 days is also too slow. (Yet they wait a week now??) But other SL machines give results in 2 - 3 hours. I was told this at Ricoh and shown the parts. They have rougher outsides than SOUP's, which is to be expected. Perhaps camera and phone designers must have the fine detail and smooth finish that take 3 days to create.

An important issue is weight and balance, which must be judged when outer shape is designed. Current and past data are both lacking on internal part weight and especially location of centers of gravity, a major shortcoming according to Mr Okamoto. But the decision must be made anyway, usually by top management on a date set in advance on the master schedule.

When the outer shell is approved, a solid (actually surface) model is made and all subsequent engineering and preproduction prototypes are designed using CAD. "We pay more attention to feature lines than the car companies do."

The interior of a camera is divided into "blocks." We would call these subassemblies although each likely has several subassemblies of its own. The main blocks are the mirror box (for SLR cameras), the shutter block, the rewind spool and fork, and the takeup mechanism. Autofocus motor and gears are inside the detachable lenses of Nikon cameras. The size and shape of these blocks drive the shape of the interior of the camera. Dividing up the detailed functions of the camera among these blocks is "difficult" and no systematic procedure seems to exist. However, there is not too much room for change, and much of the arrangement of past cameras is copied in new ones. Each block is usually the responsibility of one designer, who rotates to another block on the next design cycle. Thus there are no "shutter gurus" and so on.

The main factors driving new block arrangements and shapes are elimination of the aluminum frame and radically new camera shapes, such as ones with vertical formats. (Videocameras in horizontal format have appeared as well.)

It is surprising to see little or no solid modeling in use to attack these problems or those of checking that all the parts will fit. Mr Okamoto sees the potential very clearly but says that the camera companies are debating how to best approach the problem. In the meantime they make use of 2D CAD's ability to generate lots of cross section drawings, which they compare by eye with automatically generated sections of the solid model of the shell.

Once the outer shell is approved, the interior is designed and one or two engineering prototypes are built. All such design is on 2D CAD. About halfway through this cycle a co-located production tryout team joins the process. They will build preproduction prototypes before outside contractors and assemblers are launched. The designers visit the factory where the current models are made to learn about any problems they should avoid. Production people attend design reviews near the end of the design process but their comments are usually applied to the next camera. New designs are coming along all the time with so much overlap and so little major change that a phase shift of one design does not matter in applying the factory comments, or so says Mr Sasagaki, the assistant manager of the camera design department. Major disasters are obviously prevented, and the designers learn to anticipate most other problems. Whether this approach would work at Canon with its more radical changes and faster design cycle is not clear.

They have heard of Concurrent Engineering but associate it with solid modeling, not with a different kind of design process.

Use of Computers in the Design Process

Most of the factories and other design divisions use CADAM or CATIA, running off a total of 6 large IBM mainframes (3090, 4341 or 9370). All the mainframes are linked by Ethernet and all the terminals in a factory or design center are on some kind of LAN.

Nikon uses Computervision for most of its camera CAD and CAM. Newer software such as a few seats with SDRC's I-DEAS level V operate on DEC or H-P workstations. "Solid modeling" of the exterior parts is actually surface modeling with NURBS (non- uniform rational B- splines). Realistic shaded images are possible, though not as good as Toyota's.

These sculptured shapes are made by injection molding but, although Moldflow software is available in-house, it is not in use. Mr Okamoto hears that it is hard to use. (Like many people in many companies, he could use better information than he can get.) The data for molded parts is converted from CV to CATIA in order that NC can be used to make the molds. The recently established Mito plant does all the mold design, fabrication and part production for the company. CNC and DNC are used in the mold machining process.

CV's 2D drafting is used to design all the other parts, but the mom and pop shops do not have NC and usually employ hand tools.

Part of Mr Okamoto's job is to modify commercial CAD software for internal use. This takes three forms: improving the user interfaces, creating data translation code, and integrating in-house special CAE software. An example of the latter is code written by Mr Sasagaki to permit shutter kinematic analysis. It is not graphic but merely the engineering calculations. No animation is supported. They tried using IGES to transfer files but too much useless detail came along and the result was too big.

The flex circuits are designed using CV software. Mr Okamoto says that CV is especially good at this aspect, but he admits that it does not support automatic routing or checking of node lists. These are pretty basic steps in complex circuit design that are supported fully or partly by other commercial software, but here the designer does it all by eye. All the software does is smooth the lines and check design rules like line width and spacing. The example circuit he showed had two layers and a very complex curved perimeter shape, plus about 100 parts including 6 IC's. It took "a very expert person" 2 months to design it but "visitors usually guess it took a year."

The CV software then computes a good route for the NC drill software for putting the holes in the circuit. For 332 holes, this step took about 5 minutes. Lens design is done in another department using Nikon's own ray tracing software operating on a

UNISYS computer. In Mr Okamoto's department, a simple geometric ray tracer is on hand to discover design problems like hoods that interfere with the image. He is equipped to handle customers' inquiries on such things by phone in real time.

Mr Okamoto has some software R&D responsibilities as well and would like to try many things that the company is reluctant to support or which he fears the designers would not use. Among these are use of solid modeling to check interferences and to support various kinds of DFM and DFA. Assembly planning is especially interesting but no one else seems to support him. He also wants to try AI for helping the circuit board routing process and for converting 2D drawings into solid models. He is dissatisfied with current AI research on these topics since none of the methods appear fast enough.

The company has its own assembleability evaluation method, similar to Hitachi's, but the camera designers do not use it. The production engineers do, and complain that the designers don't. It is a manual method, not connected to CAD, though he would like to make this connection. "It will save enormous time and effort."

Other CAD/CAM

In the software R&D lab I was shown

• CAT (computer aided testing; when mechanical engineers in Japan use this term, they mean computer-aided surface inspection of mechanical parts using a coordinate measuring machine (CMM))

• CAD of eyeglass frames

• Conversion of 2D drawings to 3D models

• Reverse engineering of arbitrary shapes (scan part and create computer model)

CAT has been improved by providing offline programming of the CMM's that Nikon sells. The goal was to create a computer screen imitation of the CMM's control console plus an easy graphical user interface. CAD data about the part to be measured are used to drive the software. Animation of the machine's actions and pictorial images of available measuring probes are also available. He hopes that this software will enhance sales of CMM's, which are slow.

CAD of eyeglass frames is done on a color Silicon Graphics console using a drawing program similar to many now available on the Macintosh. A very skillful woman demonstrated this. It permits lens shapes and frame shapes to be designed. Both can be colored realistically, and nice advertising-style drawings can be made. NC data for cutting molds for plastic frames is also generated. Several features of the process are dimension-driven, but it was not clear if any constraints can be imposed.

Conversion of 2D models to 3D is done interactively. The user can apply some primitive feature-based design while selecting which portions of a drawing to convert. The process carries along some extra lines which the user removes with mouse clicks. This would be a useful companion to the CAT software but it is still under development.

Reverse engineering is done by using the CMM to scan a part, such as a clay model for a camera. (Ricoh uses a laser.) They have no confidence that any future CAD will permit direct camera design on a screen.

Future Needs and Problems

Mr Okamoto is worried that Japan is falling behind. "The US is 10 years ahead in use of solid models," he says. But he knows that faster and larger product variations are coming, and the design cycle must be shortened. The designers do not see the wave about to break over them. Just introducing solid modelers will not be the answer, because the entire design process must be thought through and restructured. There must be more standardization, reuse of past designs and data, and more systematic methods. These changes cannot be imposed from above because Japan is too bottom-up oriented, meaning that the rank and file must get behind the effort first.

As if to underscore the problem, Mr Sasagaki says that standardization will hurt designers' creativity.

Specific future needs Mr Okamoto sees are use of solid modeling and feature-based design to drive a true link between CAD and production engineering, plus better ways to engineer tolerances. He comes out of the CMM world and is thus highly sensitive to tolerances and inspection. His main hope for FBD is that it will create an engineer's interface to solid modelers and make them more acceptable to designers. Overall, he has a broad view of the possibilities for integrating the product realization process.