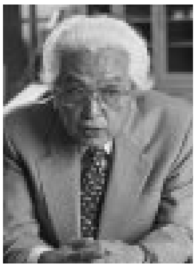
Embracing change, remaining the same

Extending a product's lifecycle

What kinds of materials are used in the products we end up enjoying for a long time? We'll consider this question by looking at two kinds of products: those made from natural materials and those made from only synthetic materials.



Sadahiko Kato, Suntory Limited., Section 1 Production Advisor. He was born in 1936, joining Suntory after graduating from Shimane Prefectural College of Agriculture (now Shimane University, Interdisciplinary Faculty of Science and Engineering). A world authority on various oak materials and whiskey barrels, he is now working to establish a voluntary association for the preservation of oak forests.

Barrels and whiskey
Going beyond preservation

Inside an office building along Tokyo's Route 7 beltway is a room containing so many chairs, cabinets and dining tables, it looks like the furniture section in a department store. The only thing different is waist-high barrels located in one corner.

Only one of the many dining tables is made of unfinished wood. According to Mr. Sadahiko Kato: "Some people worry about it getting dirty, but I think unfinished wood furniture is just a personal preference in style. People might appreciate unfinished wood, for example, because it can reveal things like the handprints your grandfather may have left there as a child."

Mr. Kato, who retired from Suntory Limited., four years ago, is one of the few researchers in the world investigating various oak materials and whiskey barrels. He is also one of the first people to advocate using old whiskey barrels as furniture and as a construction material.

"Making a whiskey barrel begins with obtaining the choicest sections of wood from a carefully selected 100- to 150-year-old oak tree. Because this wood is such high quality, barrels can be used for 70 years on average, and it seems such a waste to throw them away afterward. I suggested we recycle this wood, which can last up to 500 years, and try to get at least 150 years of use out of it. In countries like France, in fact, using wood furniture for more than 500 years is not all that rare."

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The relationship between wooden barrels and alcohol production is extremely old. In the 8th century B.C., for example, Homer wrote that the Greeks had begun fermenting wine in wooden barrels as early as the 9th century B.C.

Wine only needs about three years to ferment. Whiskey fermentation, on the other hand, requires several decades and didn't become widespread until the 18th century. During its fermentation, a myriad of chemical changes occur. (See figure 1.)

Though a whiskey barrel appears to be sleeping soundly, inside there is a fierce chemical battle going on that results in multiple changes, each new generation battling for survival with the previous and the next.

During the life of a barrel, these battles change. When new and still smelling of raw wood, they're best suited for making bourbon and sherry. During its next phase, a barrel is ideal for malt whiskey. After four usage cycles, when the barrel is 40 to 80 years old, it is finally ready for long-term whiskey fermentation, with the type you make depending on various barrel characteristics including age. Barrels that remain in use for a long period of time must embrace constant changes along the way.

Empirical analysis of fermentation techniques
The wisdom of humility

By using modern analysis techniques to study a chemical reaction, is it possible to completely understand every aspect of the fermentation process? Can we gain pinpoint control over specific tastes and smells simply by combining the right artificial elements and materials?

Before seeking answers, let's look at some unique methodology employed by Mr. Kato, a whiskey barrel expert.

"I've read many books by whiskey experts on fermentation techniques, but find all their methods to be lacking. The main problem is they don't take into account variations in barrel material. With white oak, for example, two barrels made from the very same tree can have totally different effects on whiskey. Whether wood is taken from the south or north side of a tree can have a huge impact because of their densities. In all the books I have read, such factors were totally ignored."

Higher densities mean that more wood material is compressed into a smaller space. You might logically conclude that dense woods yield more dissolved materials in the whiskey, however, that is incorrect.

"Lower density woods have more space between their cells and the whiskey is better able to seep into these spaces. This yields more wood material in the whisky. Today the relationship between barrel material and fermentation is becoming much clearer."

Will we soon be able to understand all the factors that affect fermentation?

"No. If we considered all the factors there would be several million of them. Evaluating them all is beyond our capability, so unfortunately, we have to select those that seem most relevant."

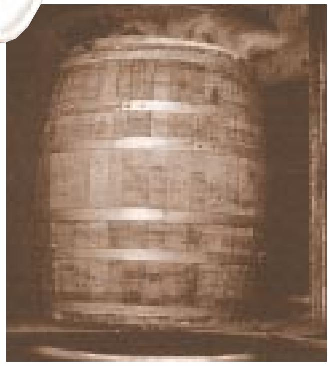
If we can never truly understand the full mechanism involved in fermentation, should we give up on trying to make a better whiskey? Certainly not. Rather, we should apply what we do know toward refining the production process.

"Japanese people are skilled at making consistently good products that meet certain standards. It's rare for a Japanese

A stand of white oak and white oak barrels more than 100 years old

The average life of a whiskey barrel is 70 years: a time full of variation.

- New Barrels: 0 to 8 years old → After the wood's surface is singed, it is used to make bourbon. The wood gives a very strong flavor.
- Phase 1: 3 to 18 years old → After the sherry and bourbon phase is "new pot" whiskey and cool whiskey phase.
- Phase 2: 10 to 30 years old → Longer fermentation whiskeys with a sophisticated wood aroma.
- Phase 3: 20 to 50 years old → Grain whiskey that has just finished the distillation process.
- Phase 4: 40 to 80 years old → Very-long fermentation malt and grain whiskeys
- Phase 5-6: 60 to 100 years old → After reburning the inside of the barrel it can be used for long-fermentation whiskeys.



Burning or roasting the inside of a barrel can bring out certain desirable qualities. Coal is used to absorb undesirable smells. Using heat in this way alters the characteristics of the wood.

Suntory Exhibition Hall "The Story of a Barrel" Tokyo, Japan

product to be so substandard it can't be sold to consumers. On the other hand, Japanese people have great difficulty in coming up with truly extraordinary products, ones that really stand out above this average. For this reason, I always tell young people to try out experiments that are unique or unusual, ideas that come from a part of the mind that's not thinking about analysis or theory. Then, if we get some unexpected results, we can move forward by analyzing them."

Because whiskey takes so many years to ferment, Mr. Kato's desire to experiment with new ideas takes on a special significance. Once, instead of making whisky barrels from North American white oak, he used Japanese oak from the northernmost main island of Hokkaido. This was in spite of the fact the North American white oak, whose properties he has studied for years, is renowned as an excellent whisky barrel material.

"For the first few years, people reacted very negatively to this whiskey. 'I can't drink this,' they complained, 'It's crude and unrefined.' But 20 years later, we were pleasantly surprised to find we had created a whiskey with a unique 'Asian' flavor."

Mr. Kato is indefatigable in his quest to expand our knowledge of fermentation. When testing new fermentation ideas, it would seem more economical to use smaller barrels. But scaling the barrel size alters the ratio of surface area to volume, making it impossible to accurately simulate a real fermentation situation. Mr. Kato, however, has developed a special technique involving a 1-liter barrel that affects fermentation in the same way as large barrels holding 180-500 liters. Only a few people in the company know about his secret technique. Still, inside his small barrel, whiskey is affected by forces far beyond anyone's knowledge.

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Sometimes when visiting friends outside Japan, Mr. Kato is surprised by comments like, "This stairwell came from my husband's grandmother's house" or "This is a door my grandfather used to use." Perhaps barrels that have fulfilled their destiny in life to make whiskey can still be enjoyed as furniture or household items.

In elementary schools that use wooden desks and chairs, children tend to be calmer. World-renowned taiko drummer, Mr. Eitetsu Hayashi was so surprised by a taiko drum made of barrel wood and he exclaimed, "This sounds as good as one of the world's finest single-wood taiko drums." Because of barrel wood's unique effects on sound, a speaker manufacturer even tried using it to make speakers.

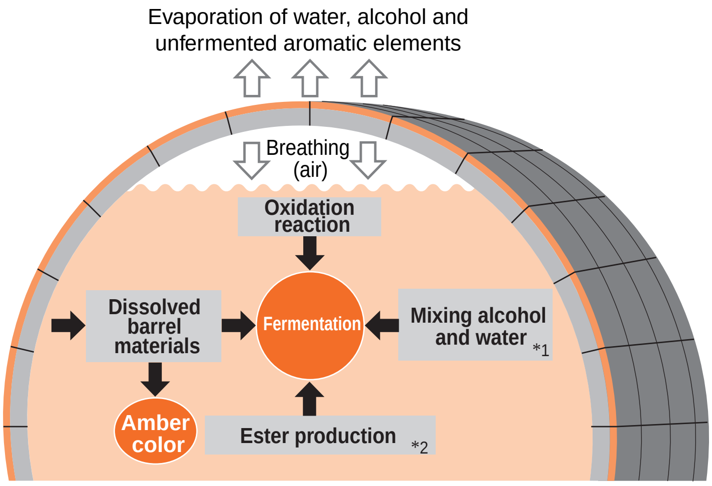
"I was curious about the validity of this and suggested making some prototypes. They made speakers out of standard white oak and also out of wood previously used in whiskey barrels. In a blind test, 100 percent of listeners could easily hear the difference. I asked a friend of mine who is an acoustics expert for an explanation, but he just smiled and said, 'It's the same situation as with making whiskey.'"

What is the attraction of furniture made from the wood of whiskey barrels? Before examining this, I decided to just enjoy the feel of such a table and sit down and relax in such a chair.

Advantages of autonomous distribution
The cellular storehouse

Outside the Research into Artifacts, Center for Engineering at The University of Tokyo the cicadas are so noisy, we're worried about getting a good recording of our interview with Dr. Tetsuo Tomiyama on new theories of production.

"When we promote recycling for environmental reasons, we usually take an engineering point of view and focus on



■Figure 1 Changes to a Barrel During Fermentation

Mr. Kato performs research on the effects of wood on whiskey, even investigating differences between wood pieces taken from different sections of the same tree.

Over 1,000 chemical elements are said to be contained in whiskey and even with multiple tests and statistical analysis, you can only confirm things such as its age. We cannot determine the quality of a whiskey through such tests.

*1 Working with the various elements contained in barrels, water can contain alcohol molecules to prevent a strong smell.

*2 The acids created while whiskey sits in a barrel facilitate a reaction with fatty acids contained in "new pot" whiskey, which creates a pleasing fragrance (fatty acid ester).

Several hundred years of life remain ..... the rebirth of barrel material

how to break down waste products quickly and efficiently. In contrast to the major efforts we put into creating products that decompose easily, however, recycling centers typically do not take full advantage of changes made possible by modern technology. For example, nonvaluable items are still usually just destroyed with a shredder and buried in waste sites."

Even if we encourage consumers to repair and reuse older products, in the final analysis, this kind of plan is unrealistic. Even if a product can be repaired successfully, consumers are often unsatisfied because, though it functions perfectly, it is several years old. Add to this the high cost of stocking parts and the smarter business strategy for manufacturers has been to forget about old products and concentrate on selling new ones. Still, if we did want to end the "disposable era" and appeal to consumers to continue using older products, what kind of first step could we possibly take?

"I think it's time to reconsider the entire system, which includes economic issues for manufacturers and the psychological issues of consumers."

Today's engineering research is usually tightly connected to a practical application, however, Dr. Tomiyama thinks we can return to a more fundamental kind of engineering research. One of the responsibilities of a national research organization is to do research with a view towards the longer term and toward this end, one goal has been to investigate "soft synthetic products," the antithesis of most of today's products. Soft synthetic products have the unique ability to flexibly respond to both outer changes (i.e., user needs, environmental issues) and inner changes (i.e., wear and tear, parts failure). Such characteristics apply to all phases of their life cycle: design, production, usage, maintenance and recycling.

How can we turn this into reality? Dr. Tomiyama is investigating a cellular machine that has an autonomous distribution intelligent system that consist of independently functioning intelligent cells. This is getting pretty abstract... Let's look at a series of systems Dr. Tomiyama has been working on called "Demonstration of an idea." First let's consider his "cellular automated warehouse," comprised of rectangular-shaped boxes in close contact, each having a pallet on top. (See the photograph on page 6.)

■ Warehouse cell (See figure 2.)

Accumulated pallets can be moved into one of four adjacent warehouse cells using a turntable and roller. Communication between adjacent cells is achieved using an RS-232C interface, while an infrared rays communicates with the pallet itself. The warehouse cell is equipped with a 16-bit CPU.

■ Pallet

Pallets include local data storage and carry goods into the warehouse for storage. It is possible to transfer this information as required downward into the warehouse cell. The pallet is equipped with a 16-bit CPU and independent power supply.

"The most interesting aspect of this system is not the hardware, but the concept behind an autonomous distribution intelligent system."

There is no centralized control system that brings all data together into one location. Each cell makes independent decisions and movements while staying in contact with nearby cells. So how can they work together as an integrated unit?

- **A user can designate goods to be sent to an exit cell (a warehouse cell) connected to a computer.**
- **Exit cells transfer their data to adjacent warehouse cells, which pass it on to other warehouse cells. This process continues until all parts of the system contain the same data.**
- **Each warehouse cell monitors the pallet above it to see if it contains goods matching the goods designated by the user. If it does, it sends the pallet in the direction of an exit cell.**
- **Every cell on the way to an exit functions independently, but acts cooperatively to pass a designated pallet from cell to cell until it reaches the exit.**
- **Once the designated goods arrive at an exit cell, the pallet erases the commands it originally received.**

Even if you alter the overall picture by shuffling the location of various modules (represented by squares, rectangles and other shapes), the system should still

function properly (See figure 3, Verification of Structural Reconfigurability). If you switch off certain warehouse cells, the goods will simply go around nonfunctioning areas to reach their final destination, and without any centralized control system (See figure 4, Verification of Fault-Tolerance).

"In any production system, we work to avoid situations where the failure of one part would stop the entire system. And since each part in the cellular automated warehouse functions independently, if one cell breaks down, the system will still function. The only anomaly will be the goods left on top of the cell that failed."

By extrapolation, we can conceive of products that could function for an extremely long time. Even as parts get old and fail, the overall function could still be preserved.

The technology of longevity

Functions that can be abandoned

Based on the cellular automated warehouse model, Dr. Tomiyama developed a "cellular assembly system" that includes a "manipulator cell" as a key element. Originally designed to meet certain specific requirements from a customer, this system is equipped with a communication interface, vision system and control computer. (See figure 5.)

Manipulator cells utilize a communication interface and facilitate data exchange between source and target warehouse cells. And during assembly, a vision system is deployed to pick up parts from source cell pallets and transfer them to target cell pallets.

The method for transferring goods (parts) from cell to cell is virtually the same as with the cellular automated warehouse, the only difference being a fixed order for parts to arrive at a source cell, a function necessitating an assembly graph.

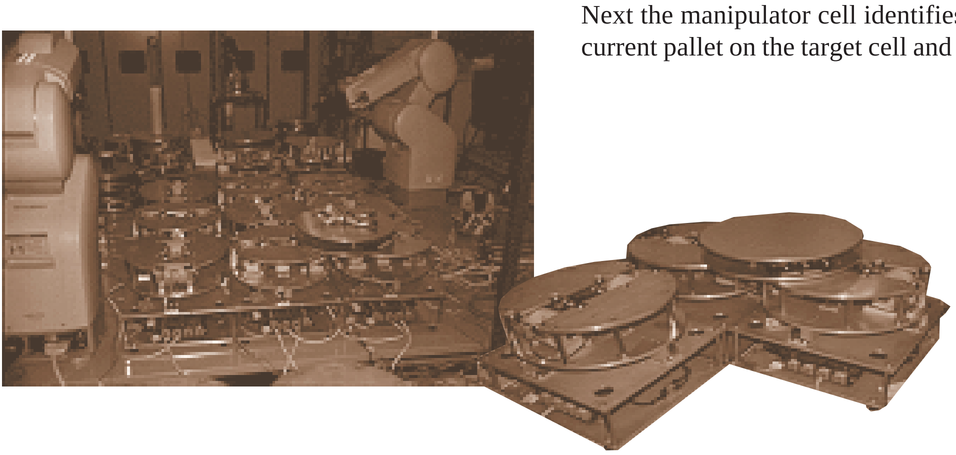
If the final goal is a 3-piece stack of items with A on bottom, B in the middle and C on top, the manipulator cell begins by communicating this to the target cell. Then it tells the target cell to accept pallets having a B-A combination (A on bottom), pallets with only A, or empty pallets. The first stage of assembly is complete when one of these pallets arrives at the target cell.

Next the manipulator cell identifies the current pallet on the target cell and asks source cells to bring whatever pallet is needed for the next stage of assembly. If the target cell pallet contains B-A, it would look for C. If it has A, it would look for C-B or B. If empty, it would look for C-B-A, B-A or just A. This continues until the C-B-A combination (A on bottom) is assembled. (See figure 6.)

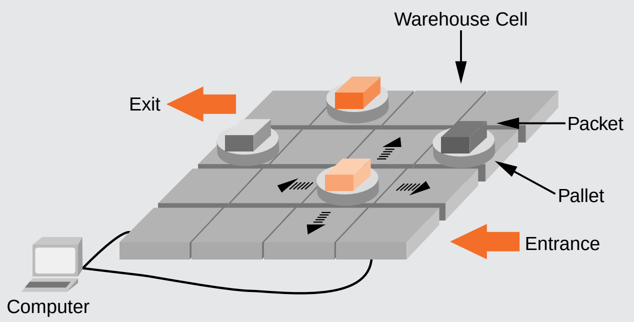
It is important to note that the original cellular automated warehouse system remains intact. A new cell was simply added to expand the functionality beyond warehousing to create an assembly system (functional reconfiguration). This represents a tremendous improvement in "positive maintenance" compared with previous systems primarily concerned with fixing problems to get the system "back to zero" (original condition). By applying these methods to creating easy product upgrades, Dr. Tomiyama hopes to give manufacturers business opportunities that go beyond new product sales.

Several concrete successes show Dr. Tomiyama's vision becoming a reality. These include adding a manufacturing function to create a "cellular production system". By adding a "cleaning cell", he created a "cellular reproduction system". I told him his cell systems look like those 16-tile sliding puzzles enjoyed by children, and he replied that they are already thinking about how to combine cellular systems with other algorithms. Because of their flexibility, cellular systems are able to handle a wide range of new applications.

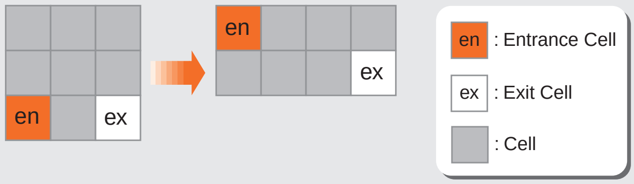
"I would never deny that cellular systems are less efficient than traditional production methods that utilize centralized control. But in our modern era, do we really need to continue producing exactly the same kind of car or appliance forever?



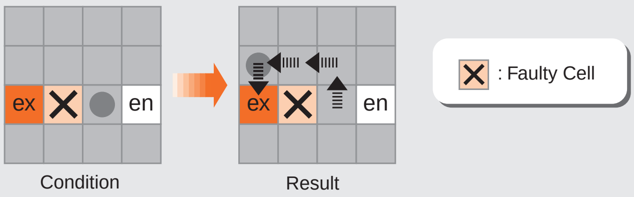
■Figure 2 Cellular Automated Warehouse



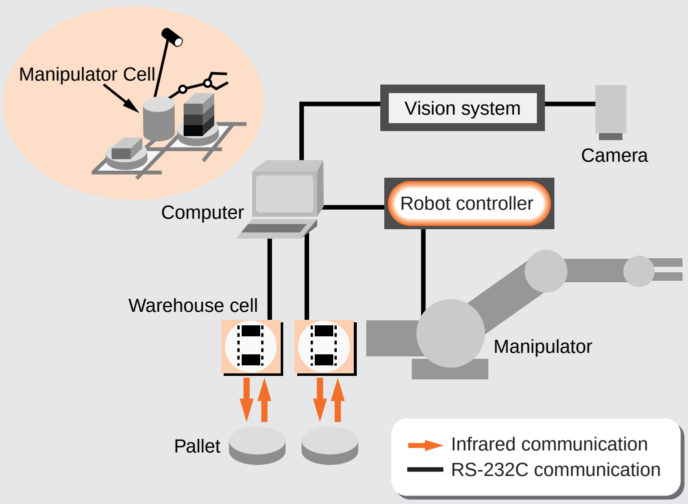
■Figure 3 Verification of Structural Reconfigurability



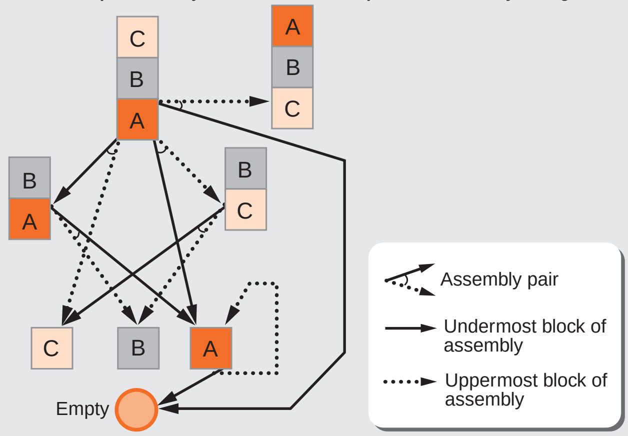
■Figure 4 Verification of Fault-Tolerance



■Figure 5 Structure of a Manipulator Cell (from cellular automated warehouse to cellular assembly system)



■Figure 6 Assembly Graph (To create the target configuration of goods on the pallet, the system enumerates all possible assembly configurations.)



Dr. Tetsuo Tomiyama is a professor at RACE (Research into Artifacts Center for Engineering) of the Tokyo University and a visiting professor at Hoso University. Born in 1957, he received his undergraduate and doctorate degrees from Tokyo University's Department of Precision Machine Engineering. He has also done research for CWI in Amsterdam, Holland.

Products should evolve according to our needs, and this requires the product creation system to change often. If you consider total cost and time required, perhaps it's time to give cellular production a try."

Even if a product's function changes rapidly, certain core elements survive. Conceiving of products from this point of view is radically different from simply trying to make them last longer. There's also the feeling of familiarity you get from using a product for a long time and Dr. Tomiyama shared his final thoughts on just such an affection.

"Just like the feeling we might have toward a refrigerator we purchased when a child was born, we feel affection for certain products because of memories we associate with them. In fact, I actually doubt consumers have any real affection for the products themselves. In the end, though, I think affection falls into the category of culture, not technology. But beyond simply making products last longer, technology can also affect and create a foundation for culture."