"Develop New Material Replacing Steel"

Will to Develop Supersedes Advanced Age

Interviewer: Takamasu Kanji

Just before retiring at the age limit of 65 as a managing director of Daido Steel Co., a leading Japanese manufacturer of alloy steel, Watanabe Toshiyuki could not resist his desire to promote an unrealized research project. The regret overwhelmed his bright achievements during 42 years at the company. It was a project to develop a new industrial material replacing steel through a new method. Before reaching the day of retirement, Watanabe launched ISMAN J Corp. jointly with his current partner, Matsushita Masafumi. The "very youthful" 70-year-old Watanabe, who is leading a company of 10 people and a recipient of the Senior Award of the Japan Venture Awards for 2007, speaks of his dream in an interview with *Japan SPOTLIGHT.*

Photo: ISMAN J Corp.

ISMAN J CEO Watanabe Toshiyuki (right) and CFO Matsushita Masafumi

Development of New Material

Development of new industrial materials has been a major theme of research for the Japanese government for the past three decades. But no multipurpose materials replacing steel have been developed. What is the problem behind that?

Watanabe: An endless number of new industrial materials have been developed in the world. Steel and other metal alloys, ceramics, plastics, and composites, which are excellent for particular purposes such as strong in intensity but lighter than steel, strong in resistance against heat or acid, and so forth. Some of the new materials have already been used for special applications.

In reality, however, these new materials face a common problem – they are difficult to produce and require much higher production costs than conventional materials. They thus have stopped short of being used widely as multipurpose materials for various applications.

Our product, Meramix®, is composed of silicon, aluminum, nitrogen and oxygen, and produced by an entirely new "control-type combustion synthesis furnace." It is much lighter than alloy steel, and is also of high strength and excellent as an industrial material. In cost terms, I think Meramix® has reached a level where it can be fully competitive with alloy steel, which has long dominated the industrial material market. We have already begun marketing balls for ball bearings. I think Meramix® can be used widely for various machines and structural materials in the future.

Flexibility of Meramix®

Would you explain about the synthetic process, called the control-type combustion synthesis, developed by ISMAN J?

Watanabe: Combustion synthesis is a relatively new process to synthesize plural substances. It uses reaction heat from components to be synthesized. The process does not need input of outside energy in synthesizing materials, making it possible to sharply reduce production costs as a result. Synthesis of Meramix® involves a major onset of heat through the reaction between silicon and nitrogen.

Russia's state-run research institute ISMAN has taken the leadership in the research of the process. They call it "self-propagating high-temperature synthesis" and it is also called "combustion synthesis" in Europe and the United States.

Usual combustion synthesis carries with it the risk of explosion in the course of the process because of excessively high reaction temperatures. It had therefore been limited to the

laboratory level. Even Russia's ISMAN had limited output through this process to several kilograms.

We have developed a "control type" of furnace, which is filled with nitrogen for reaction with silicon while controlling temperature and pressure levels inside it. We originally tried to use this combustion synthesis process in the production of a substance called ßSiAlON which was developed in the early 1970s and is known to have various excellent properties. A composition analysis of the substance produced in the control-type combustion synthesis furnace showed that its composition was somewhat different from that of ßSiAlON. So, we gave it a new name, Meramix®.

By the way, we named our venture business firm ISMAN J Corp. expressing our respect to the Russian research institute ISMAN.

What are the properties of Meramix®?

Watanabe: Compared with alloy steel used for bearing balls, Meramix®'s density is 3.28 against the 7.9 for steel, meaning that its weight is 40% of steel. It is twice as hard as steel, its elasticity is almost equivalent to that of steel, and its fatigue property is four times bigger, and also it is not magnetic. In other words, Meramix® is lighter and stronger than alloy steel, and more superior in durability.

There can be many application fields where these characteristics of Meramix® may be effectively used as an industrial material. We currently produce Meramix® only for bearing balls. It is very suitable for fast-rotating parts of automobile engines, for example valves and cams. I think it can also be used as a structural material in other fields where light weight is desirable.

Meramix® is in the state of solid solution, as it is technically called. It is a state in which plural atoms form crystal. Alloys are such examples. Meramix® is a silicon alloy. To speak of possibilities, it must be possible to synthesize other metals and ceramics by the combustion synthesis to create new synthetic substances that would highly excel in properties such as resistance to heat or acid.

How do you process the substance produced by the control-type combustion synthesizer?

Watanabe: We have found that the level of strength goes up if the substance obtained from the furnace is cast into shapes according to applications after being ground into fine powder. We spent a year and a half to develop a new crushing machine. This device crushes the substance into ultra-minute particles each with a diameter of 500 nanometers, or one-2,000th the diameter of human hair. We were able to acquire particles of uniform size. I think we were the first in the world to succeed in processing a compound of silicon and aluminum into nanometer-level minute powder. We have given the name Meramix® to the substance in such minute powder form. We named it so because it is as hard as metals and weighs as little as ceramics.

Photo: ISMAN J Corp.

3.8-inch bearing balls used for fatigue test

Casting into Bearing Balls

How do you cast the powder as an industrial material?

Watanabe: Minute powder is put into a mold to be sintered. Various casting methods have been developed for the production of fine ceramic products. There are wet and dry types of casting. Under the wet type, moisture is added to fine powder before it is placed in a mold, while under the dry type powder is cast as it is. Other methods include one that puts a kind of "binder" into powder before it is placed into a mold to step up sintering. Another one does not use such a binder. In either case, there are various proper casting methods in accordance with products. In the case of Meramix®, the material is more easily cast into the targeted form after being moisturized. As a binder, we use a mixture of silicon and aluminum for 1% of the product.

Usually, a compound is used to cast a material after putting pressure on it and placing it into a mold. We improved a modernized pill-producing device based on Japan's traditional pharmaceutical technology for production of our first product – bearing balls. We were able to produce spherical products at a high speed with this device. Compared with conventional bearing balls made of alloy steel, we can cast at an amazingly fast pace – as many as 3,000 units per minute. So productivity went up and the cost of production was reduced.

Photo: ISMAN J Corp.

Rocks containing silicon, one of key raw materials for Meramix®, are imported from China.

Creating from Scratch

Did you develop new devices for almost all the series of processes you explained?

Watanabe: Yes, we did. First of all, we built a completely new control-type combustion synthesize furnace, and also built equipment to crush the substance from the furnace into minute powder. Then we built a modernized casting machine for the production of traditional pills. Next was a nondestructive inspection system to check spherical products. After founding the company in 2003, we completed a production line producing 3 tons per month in September 2006 to make plant-level production possible. A new production line with a monthly output of 10 tons is scheduled to be completed in June 2007.

We have placed the greatest emphasis on making the production line competitive enough with that of alloy steel products in terms of manufacturing cost. We were able to obtain much support from various parties such as the Kanagawa Industrial Technology Center, universities and business corporations at each stage of production processes, enabling ourselves to come thus far. We have promoted this project steadily, confirming each process one by one – checking the composition of the substance from the control-type combustion synthesis, uniformity of the size of particles, and the like.

We could lease a tract of land on the premises of JFE Steel Corp. in Kawasaki, Kanagawa Prefecture, to establish our production base. I feel some nostalgia for founding our business at the heart of Japan's time-honored coastal industrial region.

Utilizing Unused Resources

I feel you have a strong desire for development of new multipurpose materials replacing alloy steel. What is the reason?

Watanabe: Japan's steel industry has long taken the leadership in the world. But newly emerging economies, notably China and India, are fast catching up with Japan in recent years. In the field of specialty steel, where I had worked for a long time, the electric furnace business is said to be the king of dirty, dangerous and demanding industries and has lost much appeal among job-seeking young people.

As I mentioned earlier, a lot of new materials with excellent properties have been developed. But despite great efforts by various people in the development of multipurpose materials that provide a backbone to the manufacturing industry, we have seen no new epoch-making material exceeding alloy steel.

Iron accounts for only 7% of all natural substances on the Earth, compared with 24% for silicon. But only 200,000 tons of silicon are used annually in the world as an industrial material, mainly for electronic parts such as silicon wafers. I have long cherished an idea of using silicon as a multipurpose material for the manufacture of industrial products.

What are you doing to procure your main material silicon?

Watanabe: We need metal silicon. We currently use what is produced in China's Liaoning Province. We think the Sahara's white sand may be promising if it is refined into metal silicon using low-cost electric power from the Aswan High Dam. So we recently made an on-the-spot inspection. People there showed keen interest in our project to refine desert

sand into metal silicon. We received a positive response from them.

What is your consideration for environmental conservation?

Watanabe: Combustion synthesis uses reaction heat between components to produce alloys. So, there is no need to add outside energy, except for heating at the early stage of the process. It costs much less than production of other metals and ceramics. At the same time, it has little adverse effect on the environment because no carbon dioxide is emitted. I think it matches the US-originated movement to promote the idea of LOHAS (lifestyle of health and sustainability).

As I have often told my company colleagues, I hope they will take a stance of performing duties while enjoying, not solely devoting themselves to the company.

Cost Problem

Compared with alloy steel, what is the cost of producing bearing balls with the new material?

Watanabe: Our calculations show that we can ship at a cost twice that of alloy steel products if it is produced on our current production line. This takes into account the fact that Meramix® weighs much less than steel, with the former's specific gravity at 3.2 against 8 for the latter's. In addition, Meramix® is far superior to steel in terms of hardness and fatigue property. So, Meramix® is fully competitive against steel. An increase in output will further help reduce the price of Meramix® thanks to volume efficiency.

How much do you expect to boost production from the present level?

Watanabe: The monthly output will be 10 tons if production begins at the new production line that is scheduled to be launched in June 2007. This means commercial production is in sight. Under our present plan, we will expand output while seeking to widen the applications of Meramix®. We are envisaging an annual output of 100,000 tons in 2013 and 1 million tons in 2017.

Everybody is surprised to hear that our target is 1 million tons a year. Some people feel it is a fantastic story. But the annual output of alloy steel in Japan is 20 million tons and our target is simply to have Meramix® shoulder 5% of it. I am sure we can acquire such a level of demand.

We have provided samples of Meramix® to manufacturers both at home and abroad asking them to test its applications. Current demand for alloy steel comes mainly from the automobile industry. So we are pinning high hopes on its use for auto parts.

It is only four years since ISMAN J was launched. How have you financed the company's activities?

Watanabe: Several venture capital firms have thrown support behind us. Fortunately, our company's capital has reached ¥340 million. We are preparing to have ISMAN J listed on the Tokyo Stock Exchange's Mothers market for start-up firms two years later, in 2009. My business partner Mr. Matsushita, who is the vice president of our company, has taken the leadership of preparatory work for the listing. I have long maintained ties with Mr. Matsushita who used to manage a forging firm. He has a completely different viewpoint, unlike mine based on my career as an engineer. His arrangement of business management is perfect. I am very happy with him. In that sense, I think I was lucky enough to encounter my best business partner.

"Never Been Better"

You won the Senior Award of the Japan Venture Awards for 2007.

Watanabe: The Citizens' Forum on Startups and Ventures, the sponsor of the awards, is promoting a national campaign to support entrepreneurs, under the leadership of the Ministry of Economy, Trade and Industry. It urges every Japanese national to abandon the traditional notion "Select a big tree for your shelter" and instead display the spirit of challenge for self-reliance and for a dream of launching a new business. The forum annually gives the Japan Venture Awards as part of its activities. A fresh "Senior Award" category was added this year. I was one of the four winners of the award. I feel honored and encouraged very much. I said at the award ceremony, "Today, I feel I've never been better." I meant in the phrase that I feel my efforts so far were appreciated. I expect to strive toward tomorrow hoping to feel "never been better" again tomorrow.

It is only four years since ISMAN J was founded. We have been able to reach this point under JFE Steel's goodwill for us to use part of its premises and also thanks to support from a range of parties such as the Kanagawa Industrial Technology Center, the Kawasaki municipal government and university laboratories.

Strangely enough, I could gain support successively from people who extended helping hands when I sought engineers with specific techniques or when I consulted with acquaintances personally. What is most important is, probably, to take action first. In Japan, too, there are a variety of incubators who will help support entrepreneurs in the manufacturing sector. I think they are probably waiting for willing people.

When I said we will produce 1 million tons of Meramix® 10 years later, some people laughed at me, saying, "You are 80 years old then." But I expect to continue following my own path to my limit. JS

Takamasu Kanji is an editor and biographer. He is also a senior advisor to the Foreign News Editor of The New York Times.