R&D SYMPOSIUM ROUNDTABLE
COOPERATION WITH TOHOKU UNIVERSITY "PROMOTION OF JOINT RESEARCH"

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Specialty: Mechanical engineering, fracture physicochemistry, long-term reliance in nuclear power

1975 DE, Graduated from doctoral course of Department of Mechanical Engineering, School of Engineering, Tohoku University

1988 Prof., School of Engineering, Tohoku University

1994 Guest Prof., Nuclear Science and Engineering, School of Engineering, MIT (Massachusetts Institute of Technology)

2004 Vice Dean, School of Engineering, Tohoku University

2005 Executive Vice President (for Research), Director, Office of Research Promotion and Intellectual Property

2006 Executive Director, Tohoku University Office of Cooperative Research and Development (also holding other posts), Executive Director, Tohoku University Center for Research Strategy and Support (also holding other posts)

2006 Executive Vice President (for Research and International Affairs) of Tohoku University, Director (Executive Director) of Tohoku University Center for International Exchange (also holding other posts)

Kotofusa Takagi

Director, Technical Center, Research and Development Center of JR East Group

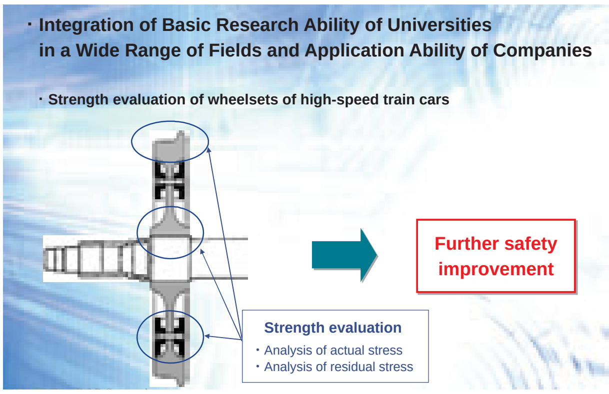
1 Purpose of Joint Research with University: by Takagi

Here I will give a brief explanation of the purpose of joint research with universities.

The JR East Group policies states that we "provide high quality and advanced services with station and railway businesses at its core," "support safe and punctual transportation and supply convenient and high-quality products and services," and "perform our social responsibility while ensuring profitability for the group's sustainable growth." We believe that our mission is to achieve these philosophy themes by research and development.

Our Technical Center has an organizational aim of establishing the top maintenance technology in the world based on this basic philosophy. For individual purposes such as the utmost in safety and cost reduction, we are making efforts to achieve those by utilizing universities' know-how through joint research and industry-academia cooperation.

We believe that the key of success is to integrate the basic research abilities universities hold in a wide range of fields with our applied technology as a railway operator and match those to each other. We are carrying out a variety of joint research with Tohoku University and here I will introduce one of those—strength evaluation of wheelsets for high-speed railway cars. Tohoku University has reliability evaluation technology based on fracture mechanics characteristics, and the know-how in this field is applied to structures of nuclear power stations.



We are now studying together to apply this know-how to strength evaluation of wheelsets for FASTECH 360 Shinkansen high-speed test train. As we can carry out reliability evaluation different from traditional methods, we expect to achieve higher safety than before.

Our other big aim in joint research with universities is development of human resources. In this joint research, some of our staff is sent to Tohoku University as researchers to study together with university personnel.

Separately from this joint research, we have accepted some students in a short-term internship program. The aim in that is to have them obtain a sense of corporate needs so that they are able to make valuable research after getting back to the university. We hope that could help in improvement of R&D ability of the university and our company.

Finally, I should say that matching of universities' seeds with corporate needs is still not organizationally done in joint research with universities. A system to utilize universities' abilities in companies is also far from completion. In this context, we still have many issues to overcome.

・Matching Universities' Seeds to Corporate Needs
(Current state) Through personal connection,
by papers at academic conference etc.,
coming across on the Internet by accident
→A system for organizational matching
Information transmission by universities,
Public invitation by companies,
Use of universities' contacts for industry-academia contact point and to clarification of companies' contact points
・A system to make full use of abilities of universities

Joint research with universities is one very effective measure for universities as well as for us since universities can bring their resources into the shape of contribution to society. This is set to be a major trend in future. In any case, I believe that it is important to establish a win-win system both for universities and us.

2 Coordination of Tohoku University and JR East: Mr. Shoji

I will introduce two subjects. First, I will explain our system and efforts in industry-academia cooperation, and then I will cover actual successes in research.

2.1 Industry-Academia Cooperation after Incorporation of National Universities

Industry-academia cooperation after incorporation of national universities has basically remained unchanged. But, I think that the diversity on the university side has been broadened in works and systems that universities can deal with. Our philosophy states that our base of such cooperation is independent ideas and actions by individual professors and expert researchers. Still, it is important to look a single direction as a university while respecting that philosophy. Thus, we have fundamental principles as a framework, which express our mission, policy and purpose of education to unify faculty members, administration staff, and students to achieve goals and purposes under these principles and objectives. And, what is important for industry-academia cooperation in particular is originality as a university and a financial foundation under a sense of independence.

Fundamental Principles and Objectives of Tohoku University

Mission: Contribute to the wellbeing and advancement of humanity through research activities as a research-intensive university.

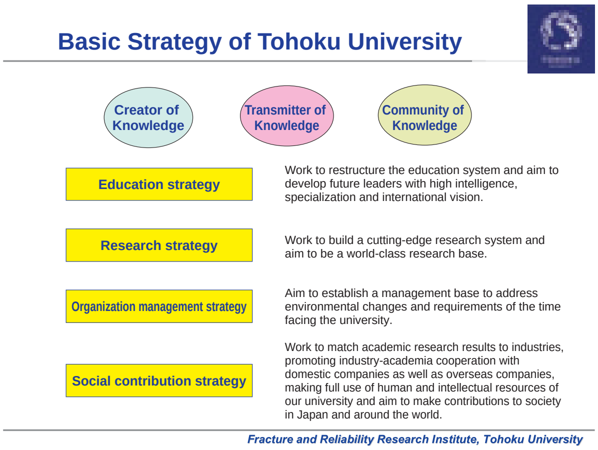
Policy: Contribute to freedom and rights of the people and prosperity and culture of the society as a university open to the world and the community.

Educational purpose: Develop future leaders and pillars of the society.

Bring together faculty members, administration staff, and students to achieve goals and purposes under these principles and objectives.
Enhance originality, independence, and financial foundation of the university

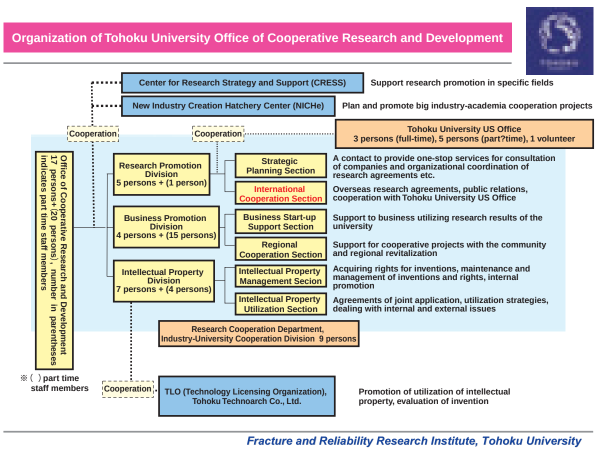
Fracture and Reliability Research Institute, Tohoku University

As basic strategies, we have an education strategy, a research strategy, an organization management strategy, and a social contribution strategy under the three directions of being a creator of knowledge, transmitter of knowledge, and community of knowledge.



These basic strategies include the words "international" and "world" since we have keen consciousness to internationalization and globalism to compete with the world more upon incorporation.

The next figure shows our present system to actually promote cooperation among industry, academia, and government.



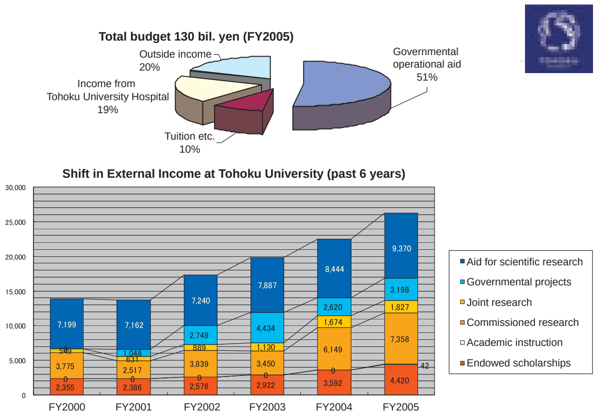
It may look much complicated, but basically we have an organization called the Office of Cooperative Research and Development of which I am Executive Director. This organization has three divisions; a Research Promotion Division to promote industry-academia research, a Business Promotion Division to provide the results of that research to society, and an Intellectual Property Division to manage and utilize our intellectual property. The Center for Research Strategy and Support (CRESS) supports research promotion in specific fields, and the New Industry Creation Hatchery Center (NICHe) carries out big projects. We also have the Tohoku University US Office staffed by three full-time members that develops international academia-academia and industry-academia cooperation in the USA. For actions concerning intellectual property, we have formed a TLO (Technology Licensing Organization), Tohoku Technoarch Co., Ltd., outside of the university that promotes actual use of intellectual property and evaluates inventions for realistic evaluation of our intellectual property and marketability research.

Speaking of current industry-university cooperation and internationalization, it is said that the linear innovation process from basic research to applied research, development and business won't work now. Non-linear innovation is attracting interest now, and industries have very high expectations for universities' basic research. In actuality, however, R&D expenditures by companies to universities are still much lower than in Europe and the USA.

What universities expect in innovation from industry-academia cooperation is the creation of new epoch-making concepts. We have great expectations for creation of new concepts by realizing corporate needs in addition to carrying out specific joint research. Generally Japanese are regarded not being good at creating concepts, and we have no particular courses on the subject. Creating new concepts and deploying them in the world are quite important and we hope we can achieve that in industry-academia cooperation. Accordingly, a venue for such brainstorming in industry-academia cooperation is needed, so we are providing the opportunity for that. In that, universities will be pivotal in enabling cooperation between companies in different fields and possibly bring about something very new.

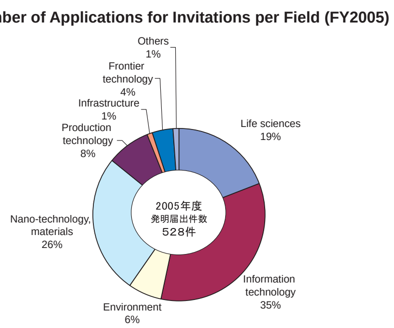
Tohoku University has purchased a golf course next to the School of Engineering using the university's budget to build a new campus there. We also have a plan to build a kind of Science Park along with that new campus. We hope for this science park to attract many companies and to be pivotal in achieving cooperation between such companies in diverse fields. We also hope that the science park allows us to secure budgets and space for research as well as diverse results both in the short and long term.

As for our finances, our total project expenditures in FY2005 were 130 billion yen. The budget from Ministry of Education, Culture, Sports, Science and Technology (MEXT) accounts for 51%, income from Tohoku University Hospital accounts for 19%, tuition and other own income accounts for 10% and income from outside including industry-academia cooperation accounts for 20% the total cost. That shows we still have high dependence on the national government. State universities in USA depend on states for approx. 20 - 30% of their budget and operate independently for the rest. Japanese national university incorporations may not necessarily follow such a way, but it is true that universities in Europe and USA are far beyond us in terms of financial independence. Of course, we should consider the existence of large foundations in Europe and USA as a separate issue.



Fracture and Reliability Research Institute, Tohoku University

Inventions by our university are roughly classified as 20% life sciences, 35% communication technology and 26% nano-technology and materials. Additionally, we have made inventions in production technology, infrastructure and environment. The number of applications for inventions is more than 500 a year, and this can be ranked as being high among universities. But this is just the number of applications because they cannot be developed into actual patents without financial support.

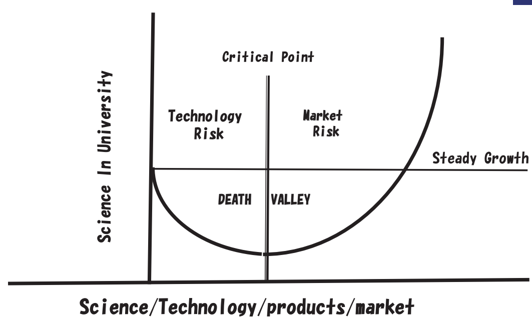


Fracture and Reliability Research Institute, Tohoku University

One of the aims of industry-academia cooperation is social contribution by using our intellectual property; and the number of such contributions is approx. 1,000 a year. Also we accept approx. 500 researchers from private companies to contribute to development of research human resources. We are also starting organizational cooperation—was once called collective cooperation—in the field of technical exchange. That means we bring seeds and needs together from organizations and put our heads together to create future concepts. Since such an approach requires efforts of a university as a whole, we are proceeding with organizational cooperation and setting actual themes through the contact point we have made. Companies favorably accept this and we are making special efforts on that. There have been some cases that cooperation was just a matter of form and further activities were not carried out, so we will make closer cooperation in this new system.

Next, I will introduce an instance how seeds of universities actually develop into business. Mr. George Hara, a former Japanese archaeologist and now venture capitalist in San Francisco, draws this figure. The figure shows that there is what is often called a "death valley" in the way of taking science in a university into an actual venture or a business. The area of this death valley is called "technology risk"—risk that emerges when science turns into technology. This risk occurs because excellent science is not always excellent technology. Then, there is "market risk"—risk in marketability of science even if it can stand on its own as technology. In other words, science in a university can develop into a business only when it can overcome technology risk and market risk. We have to remain conscious of that. Mr. Hara further said that venture businesses should offer more support, and we highly appreciate this comment.

From Industry-Academia Cooperation to Business

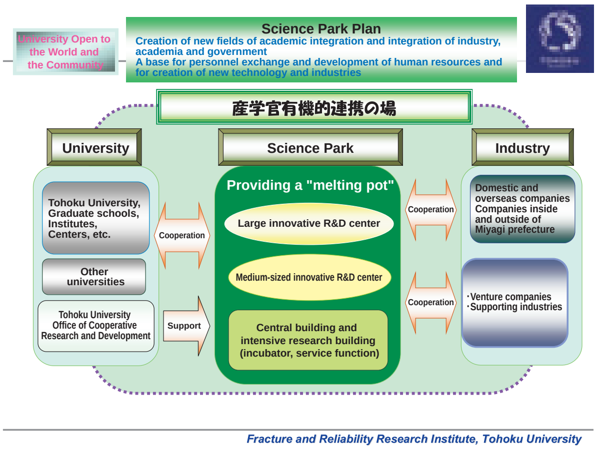


Drawn upon the data by Mr. George Hara

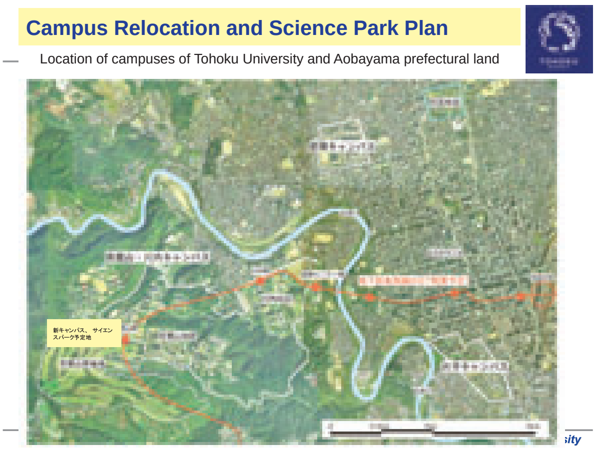
Fracture and Reliability Research Institute, Tohoku University

Internationalization of industry-academia cooperation is very important, but universities have little human resources that can handle that. While MEXT and Ministry of Economy, Trade and Industry (METI) take many budgetary steps to acquire such required staff, the number of staff members is still insufficient. We have invited international lawyers and patent attorneys to our International Cooperation Section for consultation, though the number is still small. The US Office is in contact with people such as lawyers on a daily basis on subjects such as intellectual property and joint research. This office is now functioning in a sense like a TLO to USA and Europe.

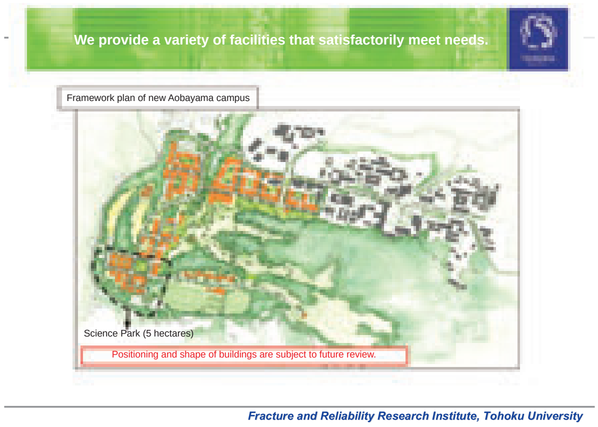
Next, I will introduce our science park that was mentioned earlier. The aim of the science park is to offer a place of industry-academia communication when returning the successes of the university has acquired to society. That is, to be pivotal for brainstorming and cooperation between different fields.



The central building of the science park will work as an incubator; so, we are going to build it with our own budget. It will be located within Sendai City across which four separate campuses are currently distributed. Half of Katahira Campus and Amamiya Campus including the Graduate School of Agricultural Science will move to this new park campus.



The black building in this map is the Graduate School of Engineering. There is a wide street in the middle of this campus, and the building faces that street. To be honest, this campus is quite unpopular, being just a highway with buildings on the both sides. Sasaki Associates Inc. in Boston, to which we have commissioned the design of our new campus, questioned why buildings have to face to each other in spite of such rich greenery; so we have taken the design concept where the new campus will have buildings facing to the green park. We are planning to start operation of the new campus in 2010 at latest.

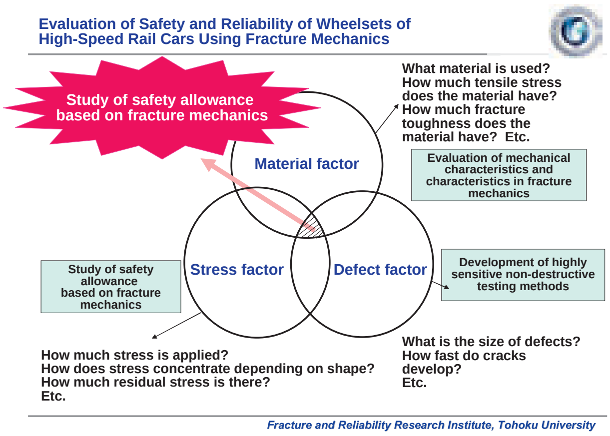


2.2 Joint Research of JR East and Tohoku University

Now, I will enter the main theme, our joint research. I used to work at the Graduate School of Engineering, but now I am conducting research at the Fracture and Reliability Research Institute. The institute is a total research center to ensure long-term reliability and safety of equipment and structures based on scientific rationality. It operates under two keywords; one is scientific rationality, which is a much-demanded theme. The other is long-term reliability. Just as society, and Japanese society more than anywhere else, is rapidly graying, nuclear plants are having the same aging problems; and reliability and safety are needed that take that aging element into account. It is the fundamental policy of this institute to build an academic base for serious study on these issues. For example, we are researching safety and reliability assurance for high-speed train cars there. We intrinsically feel safe and secure when riding trains thanks to past experiences; and the purpose of the research is to clarify the base of such safety and reliability. We thus evaluate that safety and reliability using fracture mechanics. In fracture mechanics, we do not make evaluations assuming that there is no flaw even when no flaws are found by inspections. We just think that applied inspection methods can find no flaws and are undecided as to whether or not there actually are any flaws. Thus, we make evaluations in fracture mechanics on the safe side, assuming there is a flaw that is beyond our ability to detect. Since we make safety evaluations assuming a flaw, higher safety is assured if there actually is no flaw.

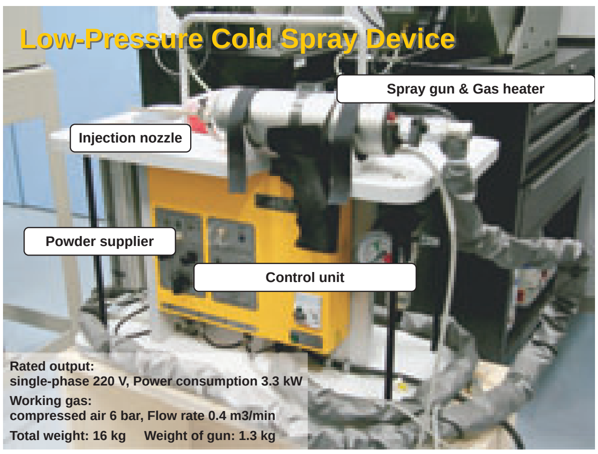
Based on this theory, we have carried out research on evaluation and analysis of reliability of wheelsets, measurement technology for reliability control of wheelsets, and evaluation of strength reliability of wheelsets of high-speed rail cars.

We have four actual themes in these studies. The first is evaluation of strength of wheelsets of high-speed rail cars. The second is application of cold spraying to railway maintenance. This is a method to grind a flaw on a component and fill the flaw instead of replacing a whole component, like grinding a flaw on clay and filling with a bit of new clay. The remaining issue of this application is whether it is really reliable. The third is a new non-destructive testing method using potential difference. The smaller the flaw we can find, the more reliable evaluation we can make. The fourth is evaluation of actual load of axles of E2 series Shinkansen cars. In order to achieve scientific rationality mentioned earlier, we have to know exact actual stress. There are many designed engineering products around us, but actual stress on those is often unknown. Design stress is lower in most cases, but when design stress is higher than actual stress, that might cause a serious problem. This is the reason why it is so important to determine actual load.

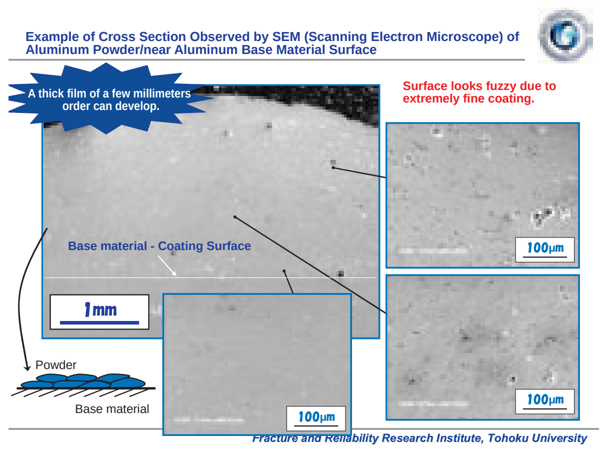


As for strength evaluation of wheelsets of high-speed rail cars, we make actual strength evaluation in our laboratory of material taken from treads, plates, bolt-fastened parts, bolts, and fitting of wheels and axles. We are confirming that the strength is satisfactorily higher than expected and investigating how a flaw develops by fatigue.

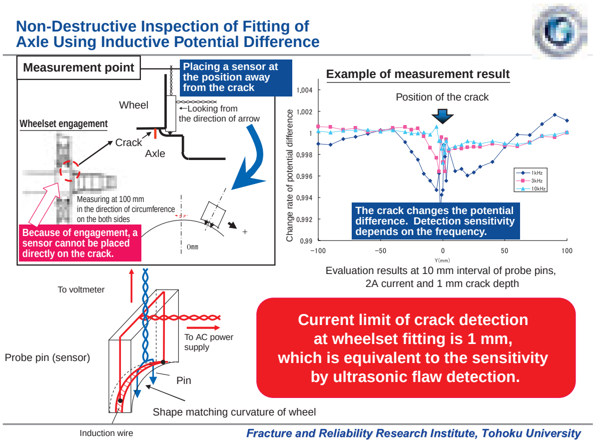
A low-pressure cold spray is in a sense a dream tool. It has a nozzle and uses powder. By supplying powder and striking those powder particles against a surface, the particles adhere to each other and accumulate. For example, it is like grinding and filling a hole or crack on something.



If the filled part has strength equivalent to or higher than before, this method can be adequately used in maintenance; so we are now verifying the possibility. Also, this needs no increase of temperature because it is a "low-pressure" cold spray. We have great expectations for this research in cold spraying that needs only spraying in the air at normal temperature. Now we are carrying out tensile tests of samples taken after spraying to compare the strength with the material before spraying. Current test samples are aluminum only, but if this method can be applied to iron, nickel, stainless steel, and other materials, it will be an epoch-making method of repair. Since particles accumulate in a short time, this can be a very effective repair method. After grinding and polishing the filled part, we cannot find the original flaw line at all. That means outstanding adhesion is achieved. Compared to traditional material, adhered material is far better at least in strength. By selecting the right material for powder, material with better characteristics can be developed. Tohoku University has experts in ultra-high purity metal; so we can make material of approx. 99.9989% purity that is difficult to make for other institutes. Such high purity material might look like ordinary material, but actually is different; and it has completely different characteristics. We have expectations that we can easily develop new materials that have been difficult to make by combining very high purity powder material with low-pressure cold spraying. We are planning to proceed with this project through internal cooperation.

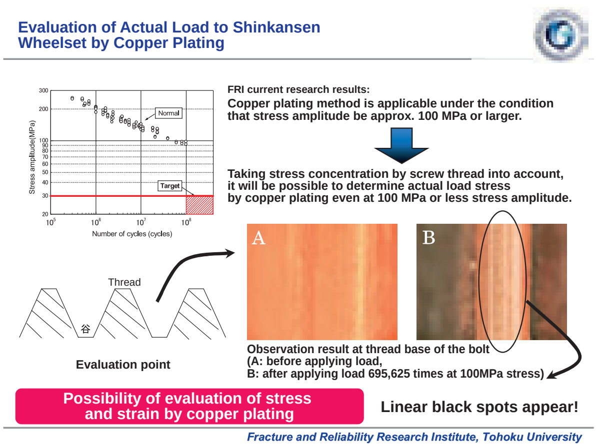


We are also particularly interested in fitting of wheelsets in finding a way to find such flaws or cracks. Traditionally, fitting has been inspected after disassembling; so we have developed a new non-destructive testing method using potential difference to enable inspection without disassembling. In this method, even a crack of 1 mm in depth and its position can be detected from outside as shown below. In this case, allowable flaw depth is specified approx. 5 cm or so in fracture mechanics. This means that material even with a crack of 5 cm depth can be used practically. Accordingly, I think that this new testing method is successfully applicable because it can detect a flaw of 1 mm depth.

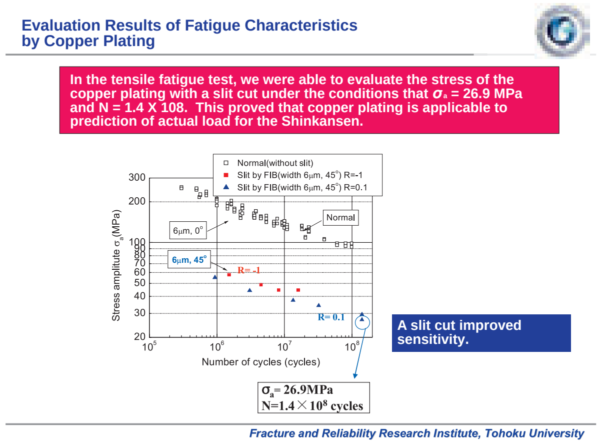


I will introduce one more subject. As I said earlier, it is difficult to determine actual stress. For example, when applying repeated fatigue to something plated with copper, copper-plating recrystallizes and black spots appear.

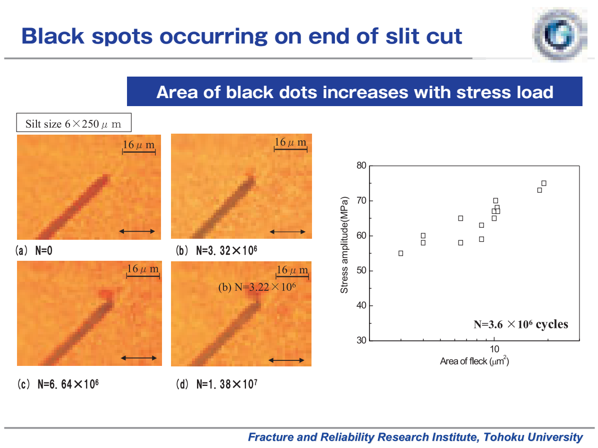
In order to identify actual stress to the bottom of the thread of a bolt, we applied actual loads to a copper-plated bolt using a testing machine. We found such black spots at the bottom of the bolt with 100 MPa applied approx. 700,000 times. We can identify the actual stress based on when and how these black spots appear. We have much expectation that actual stress can be determined by copper plating the bottom of the bolt of an actual operating part and then checking the bolt after operation.



Making a slight cut on the copper plating further enhances the sensitivity. In this way, we can now measure approx. 3 kg/mm^2 stress.



The advantage of this method is that we don't need wire or anything special. It works just by plating the part or attaching a small piece of plated film to the part and actually running it. We have tested this method in applications such as cars. It is a very convenient method because we can determine the actual stress by removing the plated part or the piece of film and checking with a microscope after driving the car for six months or a year. When concentrating stress on a part to improve the sensitivity, the black spots are detected there. We can determine the actual stress based on how the spots appear there.



This concludes an introduction to themes and the current status of our joint research. Thank you.