■ Research Details ■

1. Social background for the development of this software

To cut down on CO_2 emissions and make other considerations for the environment while answering the needs of the consumers for more sophisticated technology, manufacturers are in need of new technologies being constantly developed to be quickly incorporated into industrial products. In addition, the emergence of BRICS and other emerging countries into the international marketplace is creating a need for better cost competitiveness, achieved through cost reductions and streamlining. However, every year society takes a greater interest in—and makes more demands for—better safety and quality, which is making quality and safety assurance, an important issue alongside the development and implementation of new technologies and stronger cost competitiveness.

2. Research history

By employing the Fault Tree Analysis (FTA*[1]) method to guarantee product quality and by creating fault tree diagrams (FT diagrams), Jatco's engineers performed fault factor analyses at the product design stage and analyzed factors behind product malfunctions. Creating FT diagrams has required extensive knowledge and expertise, making it difficult for novices. Even veteran engineers can become too reliant on past experience and make omissions and other errors on FT diagrams. At JATCO, the fact that engineers were putting a lot of time and effort into creating FT diagrams for everyday business made improving the efficiency and quality of FT diagram creation as a major challenge.

At the University of Tokyo, researchers are working on "quantity dimension indexing*[2]", a knowledge management technology wherein knowledge descriptions concerning physical phenomena are indexed as vectors in a seven-dimensional space composed of the seven SI base units, the exponent*[3] of namely length (m), mass (kg), time (s), electric current (A), thermodynamic temperature (K), amount of substance (mol), and luminous intensity (cd). AIST has, through the development of, and activities to popularize, its "MZ Platform*[4]" software development platform, developed a high level of experience and knowledge concerning the creation and operation of systems for operational analysis and IT for the production floor.

Now, JATCO has signed joint research agreements with the University of Tokyo and AIST, and has developed FTA support software to both lessen engineers' workloads and improve analytical quality.

3. Research details

FTA is a method of analyzing failure factors by arranging the sub events that are the factors behind the failure event in a sequential tree structure. Properly identifying sub events thus becomes the most important task in any FTA, and the University of Tokyo's quantity dimension indexing technology was adopted to properly identify sub events. Using this technology, all failure events can be expressed as combinations of quantities, comprised of vectors in a seven-dimensional space expressed in the seven base units, and their large/small relationships with the normal values for those quantities. For example, a "high stress" failure event can be expressed as "$[N/m^2]+$". Based on this expression, an engineer can determine whether or not the quantity of a failure event can be configured with multiplication/division/exponent multiplication or add-subtract calculations for sub-event quantities, and can verify the suitability of an arrived-at sub event.

Pathing using quantity dimension indexing
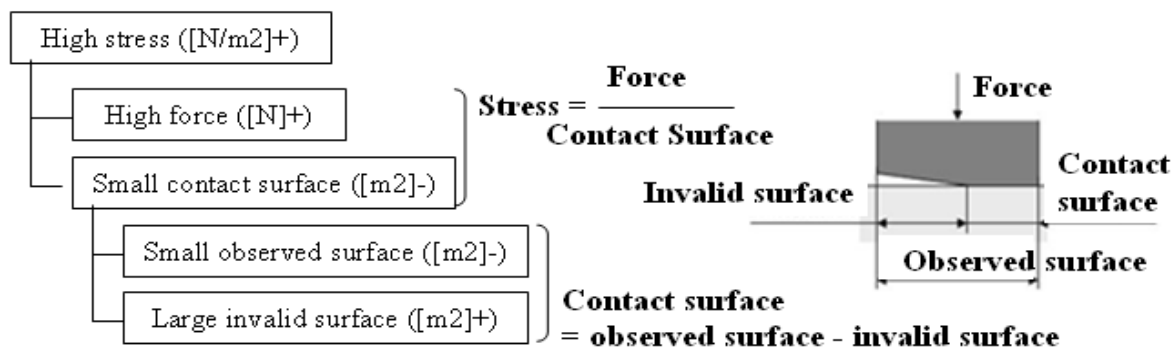
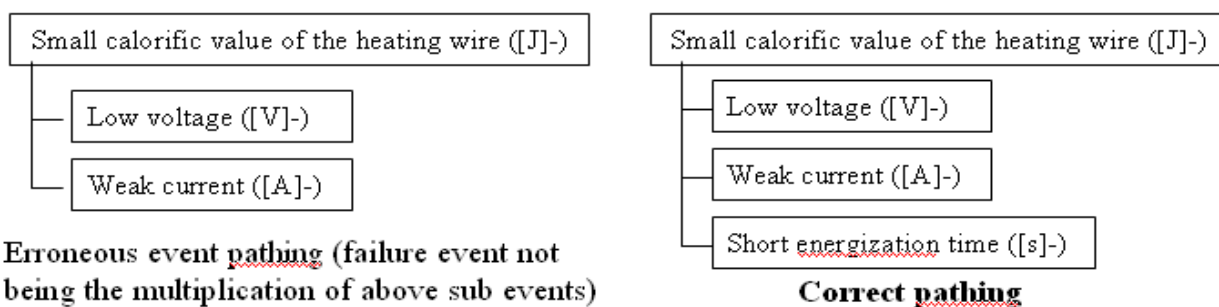## Verification of suitability

Figure 1: Verifying suitability of failure event pathing using quantity dimension indexing

To assist engineers with data entry, there have been improvements made to dictionary functions to convert technical terms like "stress" into units such as "N/m^2", and to search functions that enable searching public pathing pattern examples found in textbooks and resource books as well as FTA pathing pattern examples created in-house in the past. The FT diagrams that went through pathing verification were entered sequentially into a previously-created FTA database. This software can

thus store technical knowledge on a company's servers and make efficient use of it.

AIST's MZ Platform was used to develop the software. Based on interviews with on-site engineers and on FTA activity objectives, a focus was placed on system usability, with development prerequisites being the ability to reduce workloads and use FT diagrams created in the past. Figure 2 shows this newly-developed software.
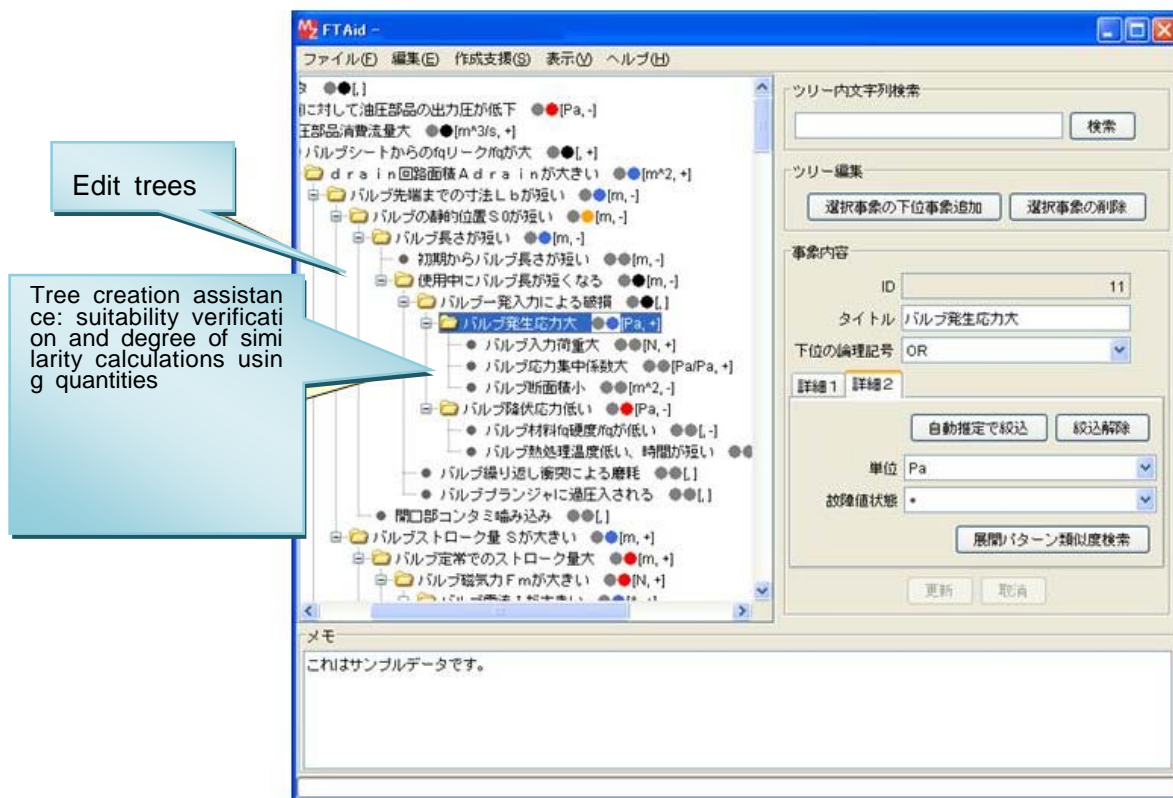

Figure 2: FTA Support Software

Results of a trial run of the FTA support software at JATCO showed a 50% decrease in engineer workload compared to the traditional manual method. Moreover, pathing was performed without error by referencing public pathing pattern examples found in textbooks and resource books as well as FTA pathing pattern examples created in-house in the past. Consequently, both workload reduction and improvement of analytical quality was achieved.

4. Plans going forward

Trial versions of the FTA support software will be distributed to JATCO-affiliated automotive part manufacturers, and the software's functions and impact on quality improvement activities will be evaluated and verified. There are currently no concrete plans for the sale of the software.

■ **Guide to Technical Terms** ■

◆*[1]: **Fault Tree Analysis (FTA)**

FTA was developed at Bell Laboratories in the 1960s, and is a failure analysis method that uses fault tree diagrams on which failure events are arranged in a tree structure. In Japan, FTA has become a Japan Industrial Standard (JIS) used widely by companies for root cause analysis for system and product failures. An important quality tool, FTA is also a method to assist planning at the design stage and is effective at retaining design knowledge as a part of knowledge management.

◆*[2]: **Quantity dimension indexing**

With quantities there are always units, and quantities can be expressed by combining exponents for the seven SI base units. Indexing descriptions for physical events using quantity units introduces comprehensiveness, objectivity and universality of the SI unit system into the act of organizing and searching these descriptions while enabling those descriptions to be applied as design knowledge management. This is what is referred to as quantity dimension indexing.

◆*[3]: **Exponents**

A integer expressing the power of a number. For example, for force [N], expressed as [kg m/s^2], the exponents for length [m], mass [kg], and time [s] are 1, 1, and -2, respectively.

◆*[4]: **MZ Platform**

MZ Platform is a software development tool developed by AIST in order to advance IT systems in the manufacturing industry. A feature of the platform is that it allows IT systems to be created and managed more easily without having to write any programs by combining software parts called components. It has been released to the public via "MZ Platform Consortium", one of the consortiums of AIST