Activities for TRIZ Penetration into Hitachi Group and Some Typical Application Cases

Setsuo Arita
Hitachi Research Laboratory
Hitachi, Ltd.
### Overview of Hitachi Group

#### Consolidated Basis (as of March 31, 2011)

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate Name</td>
<td>Hitachi, Ltd</td>
</tr>
<tr>
<td>Founded</td>
<td>1910 (Incorporated in 1920)</td>
</tr>
<tr>
<td>Revenues</td>
<td>¥9,315,807 million</td>
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<tr>
<td>Employees</td>
<td>361,745</td>
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<tr>
<td>Subsidiaries</td>
<td>913</td>
</tr>
</tbody>
</table>

#### Consolidated Revenues

- Information & Telecommunication Systems: 16%
- Power Systems: 8%
- Social Infrastructure & Industrial Systems: 11%
- Electronic Systems & Equipment: 10%
- Construction Machinery: 7%
- High Functional Materials & Components: 13%
- Components & Devices: 8%
- Digital Media & Consumer Products: 9%
- Automotive Systems: 7%
- Others: 7%
- Financial Services: 4%
Motivation of Innovative Engineering of Hitachi Group

In 1997, Hitachi, Ltd. decided to implement innovative engineering methods within all companies of the Hitachi Group to keep ahead of rapidly changing approaches in product development and design.

- The Hitachi Group is a multinational corporation and its products are in various fields.
- The Hitachi Group is involved in a multitude of technical fields.
- Implementing a Group-wide improvement program seemed impossible.
Strategy of Innovative Engineering

- Innovative engineering methods provide a strategy to understand and solve the essence of a problem by applying general solution techniques.
- Hitachi facilitated the introduction and penetration of these techniques.
- Hitachi promoted the development of more advanced methods based on them.
- All engineers should acquire these techniques as general knowledge and basic skills.

HiSPEED21
QFD, TRIZ, and the Taguchi method were judged to play a major role in the product development and design processes.

In 1999, the introduction and penetration of these techniques into the Hitachi Group was started.

The use of various general problem solving techniques by engineers to enhance their engineering abilities was facilitated.

Each division in the Hitachi Group was guided to promote the development of its leaders.
Competitiveness at Depth Layer

Competitiveness at Surface Layer *
(can be observed from outside)

Competitiveness at Depth Layer *
(can not be observed from outside)

Quality, Cost and Delivery etc.

Productivity, R&D and Engineering etc.

QFD, TRIZ and the Taguchi Method etc.

* Takahiro Fujimoto, Capability Building Competition, Chukoshinsho
Give a Route Map for Fact Finding & Front Loading

What to Develop

Bottle-neck Technology

Stabilization of Quality

Advanced Development of Technology

Customer Satisfaction & High Quality Products

VOC (Tangible & Intangible)

QFD

TRIZ

(Creation of New Concept)

Taguchi Method

(Pre-Evaluation)

“Product Development and Design Process Engineering Technologies” Proposed by T. Hayashi*

*Former Senior Chief Engineer in Hitachi, Present Chairman of the Board of Japan TRIZ Society
Penetration Activities of TRIZ

- Educational materials including applications of the TRIZ were developed and used to help management leaders and engineers understand the essence of TRIZ.
- Leaders were taught how to apply TRIZ and then, how to teach engineers to apply TRIZ.
- The aim was an increase in adoption and penetration of TRIZ by holding forums on engineering techniques focused mainly on applications of TRIZ, and by holding regular meetings with the TRIZ leaders at the divisions.
- Regular follow-ups were held every six months.
- Hitachi commended engineers who obtained excellent results in TRIZ applications.
Application Case

Automatic Judgment of Intensity Degradation of Airport Lights

This application case appeared in NIKKEI MECHANICAL in September 2000.
Group-wide Committee for TRIZ Penetration into Hitachi Group

Design and software technology committee

TRIZ penetration and development

- Technology Foresight-WG - Aim: study and application
- Failure Analysis -WG - Aim: merge with KT-method
- Inventive Creativity Strengthening-WG - Aim: merge with conventional tools
- Education Curriculum Preparation-WG - Aim: VOC-based curriculum
- Future Prediction-WG - Aim: study and application
- Effective Problem Solving-WG - Aim: merge with KT-method
- Equivalent Transfer Theory-WG - Aim: Study and Application

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Total number of TRIZ applications between 1997 and March 2011 was about 4530.
TRIZ Users by Position

- Senior Engineers: 38%
- Engineers: 33%
- Others: 22%
- Managers: 7%
<table>
<thead>
<tr>
<th>Sympo.</th>
<th>Presentation Title</th>
<th>Presenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Application of Matrix 2003 to Electrical System Development and Comprehensively Comparative Evaluation of Classical and Contemporary Contradiction Matrices</td>
<td>Setsuo Arita</td>
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<tr>
<td></td>
<td>Comparative Study of Two Contradiction Matrices Using Business Model Creating Method</td>
<td>Atsuko Ishida</td>
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<td>KT-PA in Failure Analysis Using Actual Product Accident Information</td>
<td>Fuminobu Takahashi</td>
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<tr>
<td>2nd</td>
<td>Proposal of Fault Analysis Method merging Kepner-Tregoe Method into TRIZ</td>
<td>Setsuo Arita</td>
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<tr>
<td>3rd</td>
<td>Application of a Contradiction Table to Computer Architecture – Sub-matrix and Invention Principles for Computer Problems –</td>
<td>Toru Shonai</td>
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<td></td>
<td>Introduction of the Activity to Promote TRIZ for Engineers and its Application Examples in Hitachi GST</td>
<td>Toshihiro Arisaka</td>
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<tr>
<td>4th</td>
<td>IT Trend Analysis by TRIZ Technological Forecasting – Using Altshuller’s Eight Patterns of Technological Evolution –</td>
<td>Toru Shonai</td>
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<td>Problems to be Solved and Technological Evolution of Magnetic Recording Media</td>
<td>Hiroyuki Suzuki</td>
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<td>Combined Use of the KT Method in Functional Modeling and the TRIZ Method in Idea Generation</td>
<td>Satoshi Okada</td>
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<td>Sympo.</td>
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<td>Pursuing the Essence of Innovation Through Applying TRIZ to Problem Solving in Business</td>
<td>Atsuko Ishida</td>
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<td>Survey on Thinking Methods for Invention and Discovery – A Step for Combining TRIZ With Non-TRIZ Methods –</td>
<td>Toru Shonai</td>
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<td>6th</td>
<td>How to Use TRIZ in Software and IT Problem Solving</td>
<td>Toru Shonai</td>
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<td>Evaluation of Methods for Creativity by Applying TRIZ-Based Business Idea Databases to Business Problem Solving</td>
<td>Atsuko Ishida</td>
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<td>7th</td>
<td>Activities for TRIZ Penetration into Hitachi Group and Some Typical Application Cases</td>
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<td>Reconstruction of a Business Solution by Abstracting a Current Problem Solving Result and Introducing a Service Oriented Mindset</td>
<td>Atsuko Ishida</td>
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<td>Introduction of the Collaborative Activity of the KT Method &amp; TRIZ to improve Hard Disk Drive Quality and Reliability</td>
<td>Kazush Tswako</td>
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</tbody>
</table>

Total Number of Hitachi Presentations is 16
Energy and Environmental Systems Laboratory (EERL)*

* EERL was merged into Hitachi Research Laboratory in April 2011.
R&D Fields of Power Systems at EERL

- Thermal Power
- Hydroelectric Power
- Nuclear Systems

- Advanced Medical Systems
- Power & Industrial Systems
R&D Fields of Industrial & Social Infrastructure Systems at EERL

Transportation Systems

Industrial & Social Infrastructure Systems
### Annual Schedule of Penetration Activities at EERL

- **Promotion by top-down and bottom-up**
- **High evaluation score as an incentive**

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<th>5</th>
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<td><strong>Application</strong></td>
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<td>Committee Meeting</td>
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<td>Commendation EERL Forum</td>
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Number of Applications at EERL

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Two Typical Application Cases

Case 1
- Problem Solving for Insulation Breakdown of Enamel Wire

Case 2
- Failure Analysis Merging TRIZ and Kepner-Tregoe® (KT)
Many failures occurred in motors recently.

Failures in the exchanged motors occurred again in a short time.

Partial Discharge ➔ Insulation Breakdown

Case 1: Problem of Enamel Wire

Phenomena

Output Voltage of Inverter

Partial Discharge Area
Application of Inventive Principle Based on Matrix 2003

**Improving Parameter**
- Improved immunity by blending in an inorganic insulation material
  - Improvement of reliability
  - Parameter 35 “Reliability/Robustness”

**Worsening Parameter**
- Worsened flexibility of wire
  - Parameter 34 “Ease of Operation”

**Inventive Principles**
- 28 Mechanics Substitution
- 1 Segmentation
- 40 Composite Materials
- 29 Pneumatics & Hydraulics

Selection of Inventive Principal 1
- Increase of Segmentation Ratio
Problem Solving for Enamel Wire

Increase of Segmentation Ratio → Fine Inorganic Particles

Improvement of flexibility while maintaining immunity to surge

Conductor

Enamel

Resin Coat Containing Fine Inorganic Particles

Result
Case 2: Failure Analysis Merging TRIZ and KT

Background

- TRIZ-FA (Problem resolution based on subversion analysis)
  - Extraction of failure cause candidates by analyzing elements and functions
  - Difficulty in evaluation of probable causes
- KT-PA
  - Evaluation of probable causes by describing four aspects of problem (What, Where, When, Extent)
  - Difficulty in establishment of probable causes

[ KT-PA : Kepner Tregoe Problem Analysis ]

Target

Proposal of an effective failure analysis method merging TRIZ-FA and KT-PA
Outline of KT-PA

(1) Description of the four aspects of problem (What, Where, When, Extent) about IS, ISNOT, Distinctions, and Changes

(2) Establishment of probable causes by Distinctions and Changes, or knowledge and experiences

(3) Evaluation of probable causes using IS/ISNOT pairs to find the Most Probable Cause (MPC)

IS: Observed event
IS NOT: Expected but unobserved event
Distinction: Feature of IS compared with IS NOT
Change:  • what is changed at Distinction
         • what is changed around Distinction
         • date/time of change
Comparison of Failure Analysis by TRIZ-FA and KT-PA

<table>
<thead>
<tr>
<th>Items</th>
<th>TRIZ-FA</th>
<th>KT-PA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merit</td>
<td>Rational cause extraction by functional diagram</td>
<td>Rational evaluation of probable cause by IS/IS NOT</td>
</tr>
<tr>
<td>Demerit</td>
<td>Difficulty in evaluation of probable causes</td>
<td>Difficulty in establishment of probable causes</td>
</tr>
</tbody>
</table>
Failure Analysis Merging TRIZ-FA and KT-PA

**Cause Extraction Approach**

To extract the true failure cause by TRIZ-FA, after finding the most probable cause by KT-PA

**Cause Presumption Approach**

To find the true failure cause by KT-PA, after extracting candidate failure causes by TRIZ-FA
Cause Extraction Approach

- Describing IS/IS NOT, Distinctions and Changes
- Establishment of probable causes by Distinctions and Changes
- Evaluation of probable causes by IS/IS NOT
- Drawing function diagram about the MPC
- Extraction of the true failure cause
Event: Sensor units A, B and D in same assembly intermittently output low values.
## Cause Evaluation by KT-PA

### Specific Problem Statement

**Output of the exchanged sensor declined.**

<table>
<thead>
<tr>
<th>Four aspects</th>
<th>IS</th>
<th>IS NOT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WHAT</strong></td>
<td>Exchanged specific sensors</td>
<td>Output decrease</td>
</tr>
<tr>
<td></td>
<td>①</td>
<td>①</td>
</tr>
<tr>
<td><strong>WHERE</strong></td>
<td>Specific sensor units A, B, D channels</td>
<td>③</td>
</tr>
<tr>
<td></td>
<td>⑤</td>
<td>⑤</td>
</tr>
<tr>
<td><strong>WHEN</strong></td>
<td>After start-up Plant output more than b% Burst A, B channels are stable in a few days</td>
<td>⑦</td>
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<td>⑨</td>
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<tr>
<td><strong>EXTENT</strong></td>
<td>Sensor output less than a% Intermittent output at plateau</td>
<td>⑪</td>
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</tbody>
</table>

### Evaluation of probable causes

#### “IS/IS NOT” tests

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<th>①</th>
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</thead>
<tbody>
<tr>
<td>1) Moisture invasion to connector</td>
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<td>2) Joint error of connector or sensor</td>
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<td>3) Leakage of gas</td>
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<td>4) Induced electric noise</td>
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<td>5) Amplifier anomaly</td>
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</table>

MPC: Most Probable Cause

MPC is analyzed by TRIZ-FA.
Visualization of Failure by TRIZ-FA

- Measurement of resistance of coaxial cable
- Measurement of resistances of coaxial cable and chamber

- Completion of coaxial cable assembly
- Joining coaxial cable to ion chamber

- Completion of sensor
- Vibration test and neutron source dose test

- Performance test
- Performance test after loading

- Shipment of sensor
- Sensor loading to reactor

- Sensor output corresponding to reactor output

- Connection failure caused by insufficient welding

MPC in detail

- Increased tension at joint
- Decrease of joint strength

Evaluation of countermeasure and reflection in product
This Method was presented at the second TRIZ symposium in Japan. The contents of the presentation appeared in October 2006 NIKKEI MONOZUKURI, a monthly magazine on design and manufacturing.
Summary

- TRIZ applications in actual work are promoted from the top-down and the bottom-up as Hitachi Group-wide Activities.

- Total number of TRIZ applications between 1997 and March 2011 was about 4530 in the Hitachi Group.

- Total Number of Hitachi Presentations at Japan TRIZ Symposium is 16.

- Merging of TRIZ with other methods is continuing to develop.

- TRIZ effectiveness is recognized in the Hitachi Group.

- TRIZ activities in the Hitachi Group are being continuously promoted.