Efficiency and Output of Energy Machines

(1) Aims

Material mechanics are applied to all fields of mechanical engineering as the fundamental technology. Evaluation technology related to design, manufacturing, maintenance, and operation must be provided to realize the actual structures as complicated, large-size and very small size mechanical products are made and the use conditions become severe. Especially, Accidents of machines supporting the social infrastructures and problems of complicated machines and components will cause significant losses in the society and economy.

The modern wants that the material mechanics must meet are as shown below:

(1) The material mechanics can evaluate the existing mechanical facilities and show the guidelines of replacement and repairs properly.
(2) The material mechanics can show the guidelines of supporting material and structure innovations for solving the energy problems.
(3) The material mechanics can show evaluation and countermeasures for ensuring the safety of mechanical facilities and equipment.
(4) The material mechanics can show the judgment means for enabling both the safety (reliability) and cost reduction.

We analyze the functions (skills) for fulfilling the above conditions, extract corresponding element technologies, and create a roadmap. Since material technologies apply to many fields, this roadmap shows the material mechanics necessary for improving the efficiencies and outputs of energy machines.

(2) Social and technical needs

- Efficiency improvement by increasing the temperature and pressures of thermal power plants and maintenance cost suppression by improving the reliability
- Increasing the power of nuclear power plants and ensuring the reliability
- Developing power generation systems suitable to energy diversification

(3) Key parameters

- The parameters for improving the power generation efficiency are the fluid temperature and pressure for the thermal facilities and the output for the nuclear facilities. The means for actualizing them in facilities are the material mechanics. The evaluation technologies applied according to the actualization levels of facilities have been established. This tendency will not change in the future. As a result of temperature rise, new materials will be developed, and simultaneously the structural strength evaluation technologies will be developed to suppress deterioration and damages.

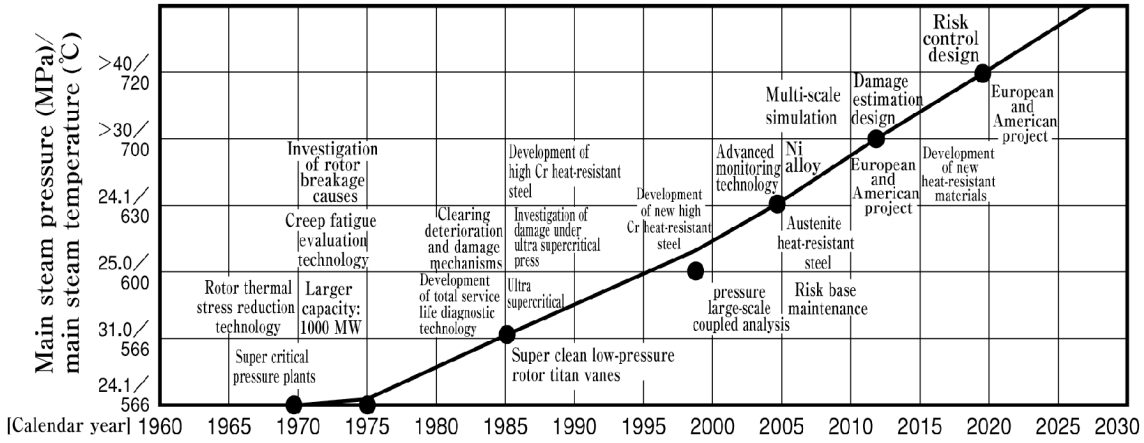
(4) Future directions for determining key mechanisms and parameters

- Developing the structural strength evaluation technology for heat-resistant materials to enable design for improving the steam temperature and pressures of steam power plants.
- Developing the structural strength evaluation technology for heat-resistant materials combined with cooling technology to improve the gas turbine combustion gas temperature of combined cycle power plants.
- Developing the environmental and structural strength evaluation technology to ensure the reliability of nuclear power plants and improve their outputs.

(5) Contributions to society

- Developing high-efficiency machines that may cope up with fuel diversification using strength design technology, since supply of fossil fuel may become unstable and remarkable price and quantity changes are expected.
- Developing the maintenance and reproduction technologies for utilizing the existing facilities efficiently to establish the energy machine industry structure not affected by reduction of resources and price variations.

(a) Main steam pressures and temperature of steam power plant facilities



Social & Technical Needs

1960～1970	・Increase of temperature and pressures (Boilers and steam turbines)
1970～1980	・Increase of capacity
1980～1990	・Frequent starting (DSS operation) ・Improvement and maintenance of existing facilities
1990～2000	・Reduction of maintenance costs
2000～2010	・Remarkable increase of temperature and pressures
2010～2020	・Development of 700 ℃ class machines ・Development of over-700℃ class machines
2020～2030	

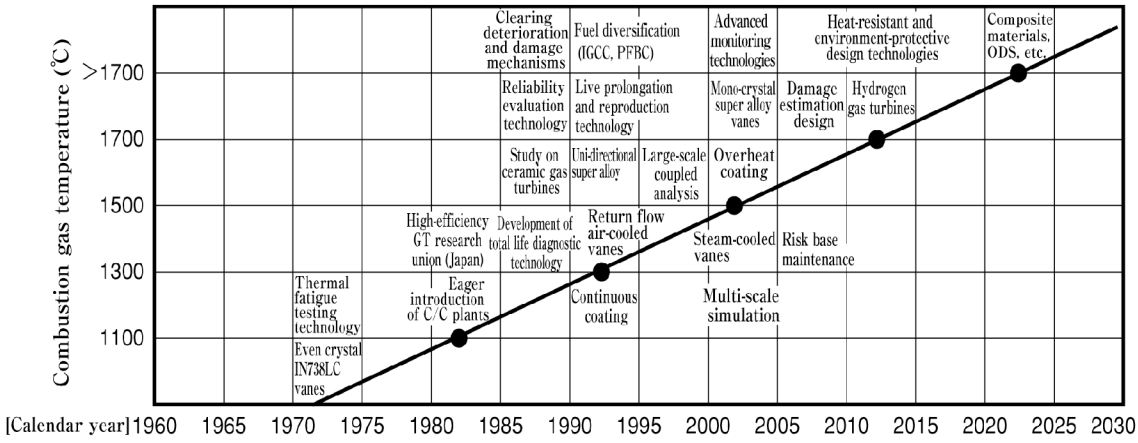
Economical Breakthrough

1960～1970	
1970～1980	
1980～1990	
1990～2000	
2000～2010	
2010～2020	・Development of 700 ℃ class machines ・Development of over-700℃ class machines
2020～2030	

Changes in Society and Markets

1960～1970	・High economic growth
1970～1980	・First oil shock
1980～1990	・Second oil shock ・Bubble economy
1990～2000	・Collapse of bubble economy ・Investment to economic recovery measures
2000～2010	・Suppression of new plants ・Electric power company in U.K. started combined gas thermal and wind power generation project. ・Global environmental problems ・Deadlock of oil supply and demand
2010～2020	・International oil demand will increase at rate of 2%/year. ・Wind power plants supply 3 million kW power. ・Oil-alternative fuels will be investigated in earnest. ・1 million kW class power plants will be put into practice. ・International bio-fuel market will grow to 52.5 billion dollars. ・Home-use fuel batteries will be released. ・Competition to acquire energy ・Coal gas will be used as fuel.
2020～2030	・Energy consumption will be reduced by 20% in the EU areas. ・Power generation independent of thermal plants? ・Coal demand will reach 7 billion tons in the world. ・Next-generation coal gas complex power generation for improving coal power generation efficiency (A-IGCC) will be put into practice. ・Nuclear power generation will share 30 to 40 % of total power generation in Japan.

(b) Combustion gas temperature of gas turbines for combined cycle power plants



Social & Technical Needs

1960～1970	・Increase of temperature and pressures (Gas turbines)
1970～1980	・Increase of capacity
1980～1990	・Frequent starting (DSS operation) ・Reduction of maintenance costs
1990～2000	・Fuel diversification
2000～2010	・Remarkable increase of temperature and pressures
2010～2020	・De-fossil fuel power generation
2020～2030	・Very high efficiency

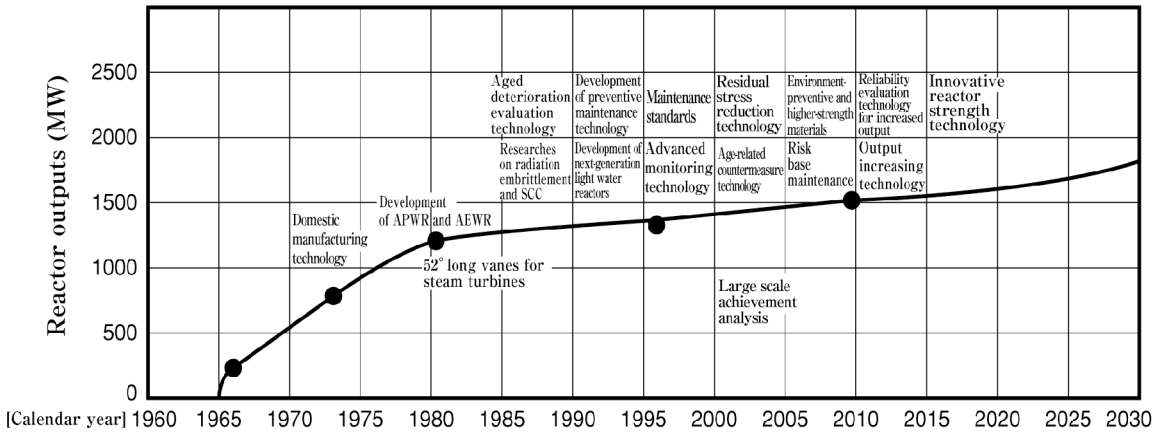
Economical Breakthrough

1960～1970	
1970～1980	
1980～1990	
1990～2000	
2000～2010	・Development of structural strength evaluation technology for heat-resistant materials combined with cooling technology
2010～2020	
2020～2030	

Changes in Society and Markets

1960～1970	・High economic growth
1970～1980	・First oil shock
1980～1990	・Second oil shock ・Bubble economy
1990～2000	・Collapse of bubble economy ・Investment to economic recovery measures
2000～2010	・Suppression of new plants ・Sempoku Natural Gas Power Plant of Osaka Gas started operation. ・Global environmental problems ・Deadlock of oil supply and demand
2010～2020	・Competition to acquire energy ・Large combined cycle power generation technology using large and high-efficient gas turbines will be established. ・Hydrogen fuel energy systems will expand market scale in Japan. ・Oil-alternative fuels will be investigated in earnest.
2020～2030	・Power generation independent of thermal plants? ・Energy consumption will be reduced by 20% in EU areas. ・Number of employees will reach 310 thousand. ・New energy industry market scale will reach about 3 trillion yen.

(c) Output power of nuclear power plants



Social & Technical Needs

1960～1970	· Energy best mix Light water reactors and steam turbines
1970～1980	· Increase of capacity
1980～1990	· Reliability improvement · Improvement and maintenance of existing facilities
1990～2000	· Advanced and rationalized maintenance
2000～2010	· Countermeasures against aged deterioration
2010～2020	· Output increase
2020～2030	

Economical Breakthrough

1960～1970	
1970～1980	
1980～1990	
1990～2000	
2000～2010	
2010～2020	· Development of environmental and structural strength evaluation technology
2020～2030	

Changes in Society and Markets

1960～1970	· High economic growth
1970～1980	· First oil shock
1980～1990	· Second oil shock · Bubble economy
1990～2000	· Collapse of bubble economy · Investment to economic recovery measures
2000～2010	· Suppression of new plants · Tsuruga Nuclear Power Plant Reactor No. 2 started pull-thermal operation. · Global environmental problems · Deadlock of oil supply and demand
2010～2020	· Competition to acquire energy · High-efficiency operation of small fuel batteries · Low-cost secondary batteries for stabilizing outputs of solar batteries (Approx. 100 thousand yen/kW) · Thermonuclear fusion reactors producing 8 tons oil worth of energy using 1 g fuel will start operation. · Full-scale search of oil-alternate fuel
2020～2030	· Power generation independent of thermal plants? · Energy consumption will be reduced by 20% in EU areas. · Over-50-year scale change of nuclear power plants into large light water reactors will start. · FBR (fast breeder reactor) systems including nuclear fuel cycles will be put into practical use. · Electric power networks with superconductive cables will be put into practical use.