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Certification Program for Computational Mechanics Engineers

Message from the President
Inaugural Address of the 91st President

JSME : Utilizing Our Knowledge and Wisdom in Working with the Society

Akira Yabe

President, JSME
Vice President of National Institute of Advanced
Industrial Science and Technology

I am Akira Yabe and am assuming the role of the 91st President of the Japan Society of Mechanical Engineers (JSME). Considering that JSME will celebrate its 116th birthday this year, I feel humbled in accepting the role of president of a society with such a long history and record of great achievements. JSME is now facing a number of important issues that affect our country and the world, such as how to lead the public in addressing environmental and energy issues and how to upgrade and innovate technologies in manufacturing and creating values. Also, JSME is expected to steadily address a bigger issue, namely, to gradually restore the public,s confidence in technology. Bringing together its knowledge, JSME will work with the public to realize such innovations. This year, we are planning to focus on the following three areas. Continued on page 2

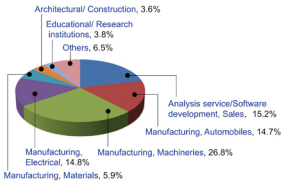
Certification Program for Computational Mechanics Engineers by JSME

Toshio Nagashima

Chair of JSME Certificate Committee of CM Engineer
Professor, Sophia University

BACKGROUND

Computational mechanics (CM) has become an essential technology for manufacturing in the modern period because CM is concerned with the virtual construction of a product being designed using a computer in order to investigate and evaluate deformation, vibration, thermal conduction fluid flow, and other mechanical behaviors to enhance the development efficiency and product performance. Structural and thermo-fluid analysis software, which is based on CM, has been widely used in industry, Continued on page 3



Types of Qualification, Levels of Certification, Standard of Target Persons And Fields of Examinations

Shinobu Yoshimura

Professor,
The University of Tokyo

Finite element analysis engineer in solid mechanics field has the following four grades, i.e. Basic Grade, Grade 2, Grade 1 and Senior Analyst Grade. Details of the grades are summarized as follows.

(1) Basic Grade

● Technical level of certification

Understands the basic procedure for linear stress analysis. Holds basic skills to use CAE software and is capable of conducting reliable analysis for basic linear elastic problems under proper supervision of a higher grade certified engineer.

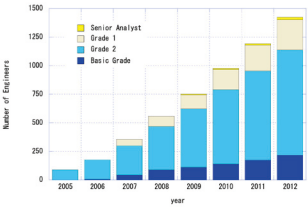
Continued on page 6

Certification Program of Computational Mechanics Engineer in Thermal-Fluid Mechanics Field

Mamoru Tanahashi

Professor,
Tokyo Institute of Technology

The Japan Society of Mechanical Engineers (JSME) has started the Certification Program of Computational Mechanics Engineer to qualify the levels of knowledge and skill of a computational mechanics engineer who can perform reliable and accurate computational mechanics analyses by oneself. Following to the pioneering certification for finite element analysis engineer in solid mechanics field in 2003, certification program for analysis engineer in thermal-fluid mechanics field has started in 2005 from Grade 2. In the thermal-fluid Continued on page 7



Message from the President
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JSME: Utilizing Our Knowledge and Wisdom in Working with the Society

Akira Yabe

President, JSME

Vice President of National Institute of Advanced Industrial Science and Technology

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<Utilizing JSME's knowledge and wisdom in actively working with the society>
-Strengthening internal and external partnerships and increasing the role of mechanical engineering by enhancing the exchange of technological needs and seeds-

1) Increasing opportunities to share information about social needs with JSME members

Current technologies appear to be characterized by a tendency to change dynamically and constant exposure to global competition. Under such circumstances, we would like to increase the opportunities to share with JSME members information on technological needs, namely, the key issues that should be addressed by research and development and what problems are desired to be solved. Also, review lectures on frontier topics in mechanical engineering are being planned to make the contents of annual meetings more attractive.

2) Promoting interdivisional collaborative projects and interdivisional cooperation

Lectures will become more attractive when two or more divisions cooperate with each other. Interdivisional cooperation will be promoted by providing support for divisions to engage in such interdivisional collaborative projects and to plan joint lectures.

3) Promoting projects based on the collection of knowledge from industry, academia, and government

Many specialists from various divisions will be brought together to compile knowledge from throughout JSME to the greatest possible extent without breach of confidentiality. They will summarize technological issues that should be addressed from the academic viewpoint, aiming to propose national projects and gain external research funding.

<Valuing human resources and activities for passing on experience and knowledge of manufacturing to the next generation>
-Creating opportunities for senior researchers to play active roles at JSME branches across Japan and clarifying their expected roles-

1) Encouraging senior researchers to participate in various activities as instructors

Senior researchers will contribute to the education of students, young engineers, and people who wish to acquire basic knowledge and specialized skills of mechanical engineering. Also, they can participate in workshops such as those for explaining technology to the general public in an easy-to-understand manner, to stop the trend of children losing interest in science, and to instruct people aiming to be professional engineers.

2) Providing solutions to technical issues

JSME will contribute to small- and medium-sized businesses by providing solutions to their technical issues. Also, our activities will be aimed at matching human resources to the needs of small- and medium-sized businesses, establishing manpower supply strategies, and providing solutions through a network of many specialists.

3) Promoting international standardization and activities related to certification of standards

JSME will promote international standardization activities and contribute to activities for accrediting and certification on the basis of international standards.

<Applying lessons from the Great East Japan Earthquake to the research and development of new technologies>
-Making concrete efforts based on the lessons from the Great East Japan Earthquake-

1) Promoting communication with the public to explain risk of technology with the aim of realizing the public acceptance while considering the risks involved

Considering the lessons learned from the Great East Japan Earthquake, we must restore the public's confidence in technology step by step. For that purpose, efforts will be made to explain the advantages and disadvantages of certain technologies in an easy-to-understand manner so that the public can accept those technologies. Because all technology is associated with risk, the promotion of risk communication, namely, active public relations activities in a broad sense, is

needed to make the public acceptance while considering the risks involved. We will promote discussions on software as well as hardware aspects of technology.

2) Providing information on the current status and issues of "law and technology" to the public through workshops

"Law and technology" involves discussion on the legal structure that is prepared to make technology more acceptable to the public. Members of the professional committee of law and technology will play central roles in providing information about the current status and issues of "law and technology" including the risks associated with technology.

3) Presenting a unified opinion of JSME to the public

Since the research committee on the Great East Japan Earthquake has carried out studies for a long time, efforts will be made to publish their conclusions to the public as a unified opinion of JSME in accordance with the specifications of JSME. By increasing the opportunities to present opinions to the public, JSME will establish its willingness to work with the public and foster a sense of unity among the Executive Board of Directors, divisional committees, and branch committees through discussions.

<Collecting the knowledge and wisdom of members for further innovation in JSME>

Besides the above three areas that should be focused on, there are many important issues to be addressed during this term. First, the publication of the newly reorganized JSME Journals written in English and Japanese will start this term. I hope that all JSME members will contribute to creating world-leading and attractive new JSME Journals that will attract more researchers and motivate them to submit their works.

In addition, a detailed analysis of the financial condition of JSME is required to improve the finances and to ensure a stable basis for JSME. In consideration of cost savings, clerical staff, directors, and related JSME members are encouraged to propose revisions and improvements in their activities.

Finally, I thank Dr. Shigehiko Kaneko, former President, and members of last term's Executive Board of Directors, branches, and divisions, as well as of the various committees, for their dedicated efforts. I will do my best to address the issues of JSME this year and sincerely appreciate your continued support and encouragement of JSME.

Certification Program for Computational Mechanics Engineers by JSME

Toshio Nagashima

Chair of JSME Certificate Committee of CM Engineer

Professor, Sophia University

Continued from page 1 design,and manufacturing, and these analytical results have enabled the development of products with high performance and safety. Such software is becoming popular and gaining high functionality due to remarkable improvements in digital computers. Therefore, CM software is becoming a black-box process. Ordinary engineers (non-expert CM engineers) use CM software in various engineering fields. Due to the graphical user interface (GUI) and robustness of commercial software, even beginners can achieve results that appear to be good, but that are in actuality completely erroneous. Furthermore, it is not an easy task to prove that the results are reliable. Miss-judgment, input data error, and selection of inappropriate algorithms in solving the analyzed models may provide completely ill-defined erroneous results. Design and manufacturing based on erroneous analyses results can lead to large losses, such as performance deficiencies and accidents. Using reliable CM software alone is not sufficient to obtain a reliable CM analysis. Ensuring the skill level of the CM engineer is critical. Therefore, guaranteeing the technological skill level of engineers who use CM software is important.

According to JSME, CM engineers are required to have knowledge on

(1)Mechanics (solid, fluid, etc.);
(2)Numerical techniques;
(3)Computer technology; and
(4)Domain knowledge regarding, for example, automobile, electronics, and nuclear engineering.

CERTIFICATION PROGRAM FOR CM ENGINEERS

Based on the above considerations and the demands placed on CM engineers, JSME has begun a certification program for Computational Mechanics Engineers starting from FY2003. Recently, certifications for three fields and nine classes, which include "Senior analyst grade," "Grade 1," "Grade 2," and "Basic Grade" CM engineers in solid mechanics and thermal

Fig. 1 Certification examinations are held in five sites including Tokyo, Nagoya, Osaka, Fukuoka, and Kanazawa in Japan

Table 1 JSME certification program results for computational mechanics engineers

		FEM, Solid （Grade）				Thermal-Fluid （Grade）				FEM, Vibration (Grade)				Total
		Elementary	2nd	1st	Analyst	Elementary	2nd	1st	Analyst	Elementary	2nd	1st	Analyst	
2003	Examinees		295											295
	Passed		166											166
	Pass Rate		56%											56%
2004	Examinees		391	128										519
	Passed		204	106										310
	Pass Rate		52%	83%										60%
2005	Examinees		468	141			109							718
	Passed		179	96			89							364
	Pass Rate		38%	68%			82%							51%
2006	Examinees	14	460	139		7	107							727
	Passed	14	123	96		7	79							319
	Pass Rate	100%	27%	69%		100%	74%							44%
2007	Examinees	28	435	109		37	123	59						791
	Passed	28	170	55		37	87	56						433
	Pass Rate	100%	39%	50%		100%	71%	95%						55%
2008	Examinees	82	477	128		45	160	49						941
	Passed	82	145	61		45	126	32						491
	Pass Rate	100%	30%	48%		100%	79%	65%						52%
2009	Examinees	80	534	129	19	23	165	62	8					1020
	Passed	80	160	81	12	23	130	34	7					527
	Pass Rate	100%	30%	63%	63%	100%	79%	55%	88%					52%
2010	Examinees	90	566	134	13	29	162	111	2					1107
	Passed	90	164	75	11	29	138	55	2					564
	Pass Rate	100%	29%	56%	85%	100%	85%	50%	100%					51%
2011	Examinees	89	596	173	7	34	149	112	3					1163
	Passed	89	215	78	6	34	131	49	3					605
	Pass Rate	100%	36%	45%	86%	100%	88%	44%	100%					52%
2012	Examinees	101	616	176	5	42	159	120	7		178			1404
	Passed	101	190	95	4	42	141	50	7		132			762
	Pass Rate	100%	31%	54%	80%	100%	89%	42%	100%		74%			100%
Total	Passed	484	1716	743	33	217	921	276	19		132			4,541

fluid fields, and Grade 2 CM engineer in vibration engineering, have been developed. Basic Grade certificates will be issued to applicants who are deemed to satisfy the certification requirements based on documentary examination. Applicant scoring prescribes scores for the respective grades in certification examination for Grades 1 and 2. Grade 1 applicants who are screened by application materials and pass an oral examination shall be certified as Senior Analysts.

Certification examinations for Grades 1 and 2 in the solid mechanics field are held at five sites, which are depicted in Fig. 1, including the Kanto (Tokyo), Tokai (Nagoya), Kansai (Osaka), Kyusyu (Fukuoka), and Hokuriku (Kanazawa) areas. On the other hand, certification examinations for Grades 1 and 2 in the thermal fluid field are held at four sites, including the Kanto, Tokai, Kansai, and Kyusyu areas. Moreover, certification examinations for Grade 2 in the vibration engineering

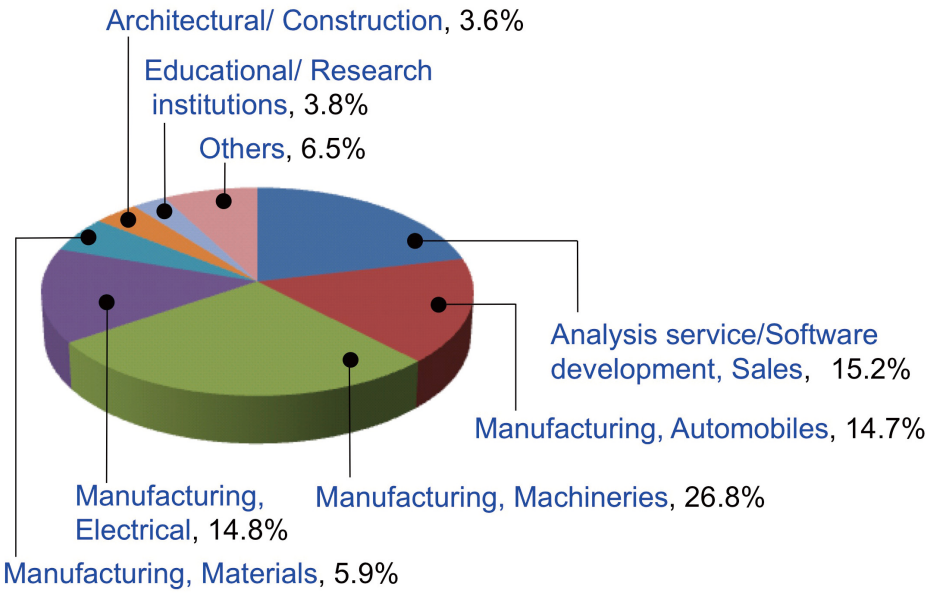

Fig. 2 Distribution of industrial affiliation of applicants in FY2011 for 1st and 2nd grades

field are held at two sites including the Kanto and Tokai areas. These examinations are carried out every December. Since FY2009, certification examinations for Senior Analyst grade have started and are carried out in Tokyo every September.

At present, the certification examinations are organized by the Innovation Center of JSME with the cooperation of seven related divisions and four branches of JSME, under co-sponsorship by 54 domestic associations related to computational mechanics, and with the support of the Japan Machinery Federation, the Japan Society of Industrial Machinery Manufacturers, and the Japan Electrical Manufactures'Association.

Table 1 shows the numbers of examinees/passing participants since FY2003. As shown in the table, a total of 4,541 participants passed the certification test in nine classes and are active in industry and educational/research institutions as CM engineers who have been certified by JSME. In addition, the industrial affiliation distribution of applicants in FY2011 for first and second grades is shown in Fig. 2. The CM engineer certification program has the following benefits:

(1)Reliable analysis results can be obtained using reliable computational mechanics software operated by certificated engineers.

(2)The certification makes engineer's own skill of technology and the range of responsibility clear, consequently the societal value improves.

(3)The CM certificated engineer can be expected to have a certain degree of knowledge and skill.

Currently, the certification program is operated by the Committee for Licensing Engineering Businesses/Specialized Committee for CM Engineering License Certification, which was established at the Innovation Center of JSME. The specialized committee has been chaired by Prof. Shinobu Yoshimura at the University of Tokyo since its establishment, and the current framework for the certification program has been completed as a result of his vigorous activity. The present author has held the chairmanship since FY2009. Since CM software is widely used throughout the world, such a certification is expected to spread globally in the future.

FUTURE PLAN

According to the current trend, internationalization is one of the most important issues in regards to the certification program. NAFEMS, which is an independent not-for-profit association focusing on the practical application of numerical engineering simulation techniques, such as the finite element method for structural analysis, computational fluid dynamics, and multi-body simulation, advances the quality certification of computer aided engineering (CAE) and has already provided the system of registered analyst. Recently, JSME has begun to consider mutual recognition between NAFEMS and JSME. Concretely, the equivalence of the JSME/CM Certificated Senior Analysis grade to a NAFEMS PSE license is currently under review.

Types of Qualification, Levels of Certification, Standard of Target Persons and Fields of Examinations

Shinobu Yoshimura

Professor, The University of Tokyo

Continued from page 1

(2) Grade 2

● Technical level of certification

Is capable of setting analysis problems correctly within the range of linear elasticity for basic problems of solid mechanics; holds knowledge on finite element analysis of linear elasticity; is capable of verifying reliability of analysis results on his / her own. Consequently, is capable of using reliable CAE software, selecting proper analysis functions, and solving basic linear elastic problems without obtaining a totally wrong solution.

● Standard of target persons

Engineer who holds mathematical / mechanical knowledge at the graduate level of mechanics course, and over 1 year practical experience in analysis.

● Fields of examination

1.Foundations of mathematics for computational mechanics
2.Foundations of solid mechanics
3.Foundations of heat conduction
4.Foundations of finite element analysis I
5.Foundations of finite element analysis II
6.Foundations of numerical methods
7.Selection of elements
8.Foundations of modeling
9.Foundations of usage of boundary conditions
10.Foundations of pre- and post-processing
11.Foundations of verification of results
12.Foundations of computers
13.Ethics for computational mechanics engineers

(1) Grade 1

● Technical level of certification

Holds knowledge to apply finite element analysis on various types of material and geometrical nonlinearities, and linear elastic fracture mechanics in a practical analysis of solid mechanics; is capable of setting analysis problems and conducting analysis properly; understands the process of verifying reliability of analysis results. Consequently, is capable of using reliable CAE software, selecting proper analysis functions, and conducting CAE analysis on various types of material and geometrical nonlinearities, and linear elastic fracture mechanics without obtaining a totally wrong solution.

● Standard of target persons

Engineer who holds mathematical / mechanical knowledge at the post graduate level of mechanics course, and over 3 year practical experience in analysis.

● Fields of examination

1.Stress and strain in nonlinear analysis
2.Material nonlinearity (elasto-plasticity, creep, viscoelasticity)
3.Geometrical nonlinearity
4.Boundary nonlinearity (contact)
5.Fracture mechanics / fatigue analysis
6.Dynamic analysis
7.Heat transfer analysis
8.Component technologies
9.Numerical methods
10.Verification of solutions and quality assurance
11.Information processing

(4) Senior Analyst Grade

● Technical level of certification

Holds analysis experience as well as extensive and in-depth knowledge of both theory and practice on finite element analysis of solid mechanics; is capable of planning and managing CAE analysis projects; holds high ethical standards and is capable of giving good presentations to clients and society.

● Application qualifications

Holds over 7 year practical experience in analysis and Grade 1 qualification for solid mechanics. Application for the examination of Grade 1 in the same year is not admitted.

● Examination method

Step 1: Documents to be submitted: Documents describing practical experience in analysis and experience in planning and managing CAE analysis projects.

① Description on over 7 year experience in analysis (time, period, outline, etc.)

② Essay describing one of typical practical analyses involved (time, period, contents, encountered problems, ingenuity points, etc.)

③ Essay describing one experience in planning and managing CAE analysis project (time, period, contents, encountered problems, ingenuity points, etc.)

Step 2 : Interview: 15 minutes presentation on practical experience in analysis / experience in planning and managing CAE analysis projects, 15 minutes interview based on application documents and the contents of the presentation.

Note 1: CAE analysis projects: Various CAE analysis-related tasks carried out in product design and development as well as investigations into the causes of product accidents when CAE analysis is used as the main method.

Note 2: Capability in planning and managing CAE analysis projects: In the CAE analysis project defined above, this is the ability to show real responsibility in the planning of various CAE analysis-related tasks, the guaranteeing of accuracy and reliability of obtained analysis, and the utilization of results.

(3) The companies will be able to collaborate with other company people, and also to improve the international sensibility through joint efforts. In the international standardization work, they will have an opportunity to exchange information with competitors and to be supported through the exchange with foreign countries. Additionally, their practical skill of English language is strengthened.

(4) It is necessary to establish the personnel training program from the long range perspective. Training program on the job is a powerful and efficient method in the improvement of personnel capability, the establishment of which needs understanding and support by the company itself.

Certification Program of Computational Mechanics Engineer in Thermal-Fluid Mechanics Field

Mamoru Tanahashi

Professor ,Tokyo Institute of Technology

Continued from page 1 mechanics field, the certification program consists of 5 grades: Basic Grade, Grade 2, Grade 1 and Senior Analyst. Computational method used in analysis of thermal-fluid mechanics problems strongly depend on purpose or target of the analysis, and lots of numerical methods such as finite element method, finite difference method, finite volume method, etc are widely used. Therefore, in the certification program in this field, specific numerical method is not determined.

In Table 1, levels of certification in the thermal-fluid mechanics field are summarized. In Basic Grade, an engineer is required to hold basic skills to use CAE software and is capable of conducting reliable analysis for thermal-fluid problems under proper supervision of a higher grade certified engineer. In Grade 2, an engineer is capable of setting analysis problems correctly within the range of single phase incompressible flow/compressible flow/laminar flow/turbulent flow for basic problems of fluid mechanics/thermodynamics (including heat transfer) and required to hold knowledge on analysis methods and has capability of verifying reliability of analysis results on his/her own. The engineer who will be certificated is capable of using reliable CAE software, selecting proper analysis functions, and solving basic thermal-fluid problems without obtaining a totally wrong solution. To obtain this grade, mathematical/mechanical knowledge at the graduate level of mechanics course, and over 1 year practical experience in analysis are required. The Grade 1 in thermal-fluid field is split into three sub-fields: single phase flow, multiphase flow and combustion. The engineer in this grade has knowledge to apply fluid mechanics analysis on either single phase flow or multiphase flow or combustion in a practical analysis of thermal-fluid

Table 1 Levels of certification in thermal-fluid mechanics field

Basic Grade	Understands the basic procedure for analysis in fluid mechanics / thermodynamics (including heat transfer).	
Grade 2	[Fields of examination]	
	1. Foundations of mathematics for computational mechanics 2. Foundations of fluid mechanics 3. Foundations of thermodynamics / heat transfer 4. Numerical methods 5. Mesh generation methods 6. Turbulence models	7. Boundary conditions 8. Foundations of post-processing 9. Foundations of verification methods of results 10. Foundations of computers 11. Ethics for computational mechanics engineers
Grade 1	[Fields of examination (one of the following fields)]	
	Field of single phase flow	
	1. Physics of incompressible fluid flow 2. Calculation methods for incompressible fluid flow 3. Physics of compressible fluid flow 4. Calculation methods for compressible fluid flow	5. Handling meshes 6. Physics of flow and modeling 7. Design application 8. Speed up and post-processing 9. Evaluation of results
	Field of multiphase flow 1. Foundations of multiphase 2. Bubble / droplet / particle 3. Wave and interface 4. Averaged model 5. Interface tracking / capturing method 6. Particle tracking model 7. Phase change 8. Verification of results	**Field of combustion flow** 1. Foundations of combustion 2. Combustion reactions 3. Laminar premixed flames 4. Laminar diffusion flames 5. Turbulent flames 6. Multiphase combustion 7. Verification of solutions
Senior Analyst	(1) Documents to be submitted: Documents describing practical experience in analysis and experience in planning and managing CAE analysis projects. a. Description on over 7 year experience in analysis (time, period, outline, etc.) b. Essay describing one of typical practical analyses involved (time, period, contents, encountered problems, ingenuity points, etc.) c. Essay describing one experience in planning and managing CAE analysis project (time, period, contents, encountered problems, ingenuity points, etc.) (2) Interview: 15 minutes presentation on practical experience in analysis / experience in planning and managing CAE analysis projects, 15 minutes interview based on application documents and the contents of the presentation.	

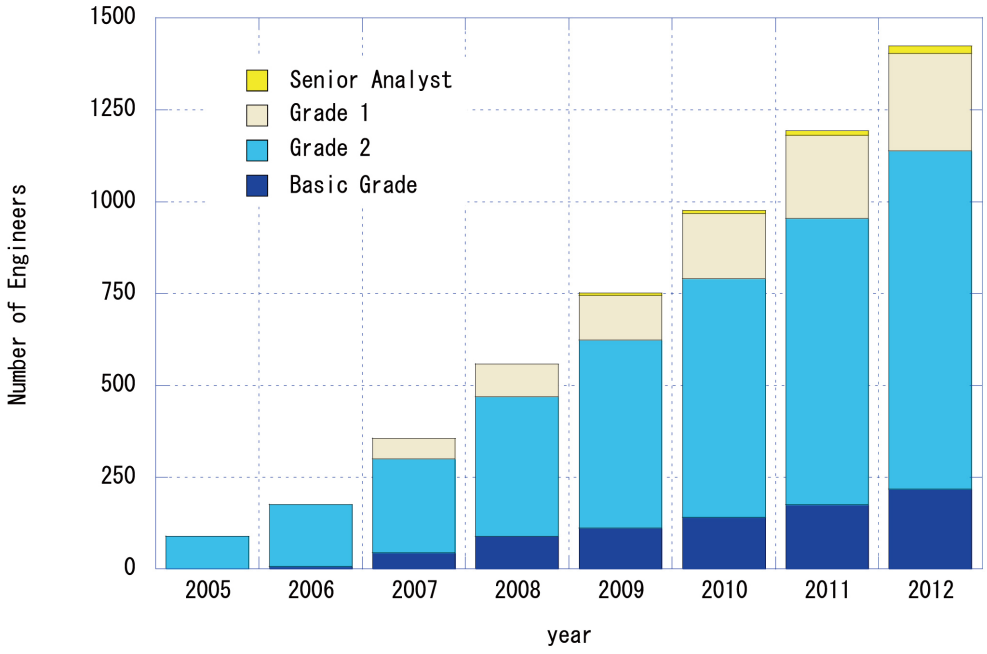

Figure 1 Number of certificated engineers in thermal-fluid mechanics field

mechanics; is capable of setting analysis problems and conducting analysis properly; understands the process of verifying reliability of analysis results. Consequently, the engineer is capable of using reliable CAE software, selecting proper analysis functions, and conducting CAE analysis on either single phase or multiphase or combustion flow without obtaining a totally wrong solution. The fields of single phase / multiphase / combustion flow are elective and one filed should be specified. Standard of target persons is an engineer who holds mathematical / mechanical knowledge at the post graduate level of mechanics course, and over 3 years practical experience in analysis. Technical level of certification for Senior

Analyst in thermal-fluid mechanics field is as follows: he / she holds analysis experience as well as extensive and in-depth knowledge of both theory and practice on analysis of thermal-fluid mechanics; is capable of planning and managing CAE analysis projects; holds high ethical standards and is capable of giving good presentations to clients and society. Application qualifications is conducted under the condition that applicant holds over 7 year practical experience in analysis and Grade 1 qualification for thermal-fluid mechanics, where application for the examination of Grade 1 in the same year is not admitted.

Total number of certificated engineer in the thermal-fluid mechanics field is shown in Figure 1. From 2005, certificated engineers are increasing steadily. In 5 grades, around 200 engineers are certificated every year recently. The total number of the certificated engineer is 1423 in last 8 years. The breakdown of the certificated engineers is 19 for Senior Analyst, 266 for Grade 1, 921 for Grade 2 and 217 for Basic Grade. Due to the target person for each grade, the average age of the certificated engineers depend on grades; over 40 for Senior Analyst, about 35 for Grade 1, about 33 for Grade 2 and about 30 for Basic Grade.

Nowadays, computational mechanics has important duty directly connected to performance as well as safety of products. Therefore, adopting a wrong result without understanding would cause a big economical and social loss. In such a situation, quality assurance of CAE engineers as well as that of CAE software is very important to guarantee the reliability of results of computational mechanics analyses. We believe that this certification program will contribute to improvements in computation mechanics in terms of CAE engineer's abilities.

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