Particleworks™
Particle-based simulation software for CAE

users interview

Nippon Steel & Sumitomo Metal Corporation

The leading-edge Particleworks is one of our key technologies to maintain an advantage to be the world No.1 steel manufacturer

Nippon Steel & Sumitomo Metal Corporation (NSSMC) was established in 2012 by the merger of 2 leading companies in the steel industry in Japan, Nippon Steel Corporation and Sumitomo Metal Industries, Ltd. Since then, NSSMC has been setting a goal to be the world No.1 comprehensive steel manufacturer and aiming to gain a competitive advantage and enhancement of the company's value. One of those efforts is the strengthening of research and development capabilities and pursuing progressiveness by thinking outside the box. We have had the pleasure to interview Mr. Takao Taya, a Manager of Mechanical Engineering Div., Plant Engineering and Facility Management Center, which uses Particleworks as one of their advanced technologies, to hear the simulation examples for the cooling water behavior in the steel manufacturing processes.

Please introduce your business.

Taya: NSSMC supplies steel for a wide range of applications including automotive, building, bridge, shipment, and home appliances, and delivers those to local makers from our domestic and abroad factories. We globally provide high performance products with advanced technologies with high quality at low cost, for example high-strength steel plate "High-Ten" which realizes the permanent proposition "thin and strong steel" at the world's highest level. Our division is in charge of planning, design, and introduction of new production facilities for making steel, suggestion for remodeling of existing facilities, and stabilization and management of the manufacturing facilities including trouble shooting during the facility operations. In such responsibilities, I use CAE to evaluate the unclear physical behaviors and to reflect on the facility management.

How do you use CAE in the Plant Engineering and Facility Management Center?

Taya: We have engineers for CFD analysis and engineers for structural analysis such as elastic deformation, plasticity, and creep of the machine structures. In other departments, there are also CAE engineers, and we exchange CAE information with them. For CAE training, we organize not only software operation trainings, but also structural and CFD analysis technical courses for young engineers in the steel plant to learn basic knowledge. In such technical courses, the participants study with lectures at first, and then use CAE software for the actual problems in the plant and report the evaluation of the results. We organize such a full-scale CAE training because the engineers working in the plant have to judge the CAE results to reflect on them for the next action, and understand the simulation process and calculation logic for defining the right analysis conditions for each problem and evaluating the results correctly even if they are not in charge of CAE by themselves.

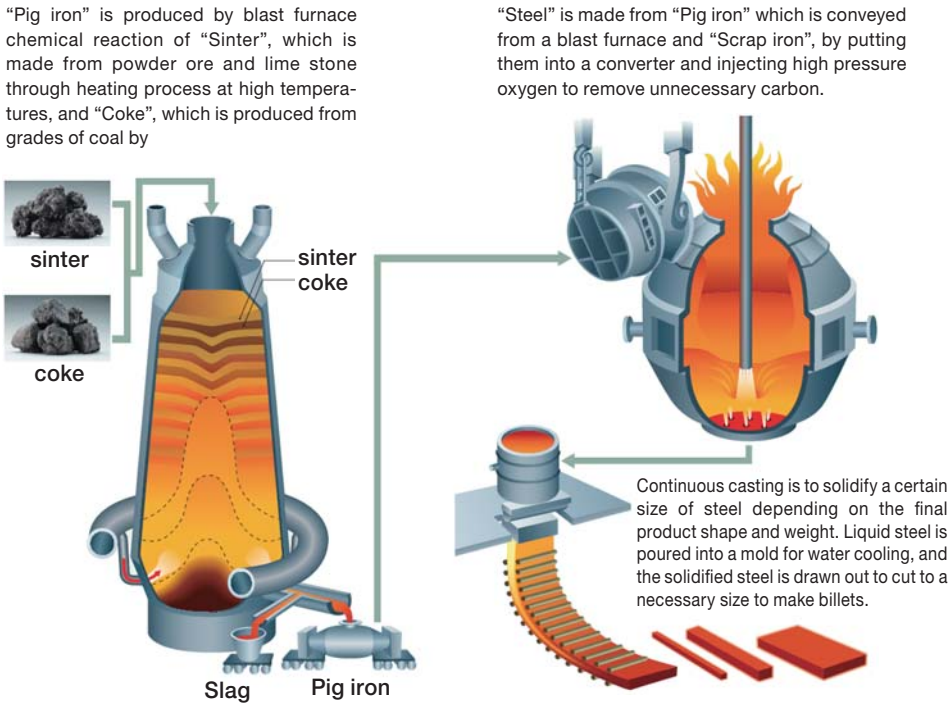


Fig1, Steel manufacturing process

What is the background and the main reason to start using Particleworks?

Taya: In steel manufacturing, while heating and cooling processes are repeated, cooling is especially important in terms of the quality and facility management. When the heated steel plate is cooled by many spray nozzles, the interference between water spray from different nozzles influences the product quality. In addition, the used water from cooling also contributes the following cooling process. To evaluate it, we had carried out experiments using real machine scale devices or performed simulations using a grid method CFD software. If using a grid method software, however, the calculation load was very large for the model with many nozzles and we couldn't get a result within our facility design period. It took a lot of time to create mesh to deal with the complicated free surface, and the simulation time was too long as it was necessary to calculate the air region, too. Furthermore, simulation didn't converge and we had to recreate mesh repeatedly and had to give up in the middle. Then, we found the Particleworks simulation using MPS method, which visualized the fluid flow of water spray on the car, and we decided to introduce Particleworks as it matched our problems. Since Particleworks doesn't require mesh creation, the time for consideration has become shorter. In contrast to a grid method, in which calculation tends to be large if repeating convergence calculation and result can't be expressed if the mesh size is not small enough, I felt that MPS is easy to use as it can realize phenomena without stopping calculation.

Mr. Takao Taya,
Manager of Mechanical Engineering Div.,
Plant Engineering and
Facility Management Center

I knew MPS since the time when it was a cutting-edge technology and still in the research stage. Then, commercial CAE tools using MPS appeared in the market and we decided to start using Particleworks because we had contact with Prof.Kosizuka, who developed MPS, in the JSCES activities. He visited our company for a lecture to the engineers here. We began the trial use of Particleworks in 2011, and found some points which should be improved. For example, as there was no default function to define the cooling water flow which spread by the oval nozzles, we asked Prometech to make it by customization. For others, we are satisfied with the standard capabilities, which are sufficient.

What was the effect and advantage after using Particleworks?

Taya: It is easy-to-use and the user interface is very good. It's convenient because we just need to input the coordinates and the flow volume when setting many nozzles. There are lots of problems which can be solved only by Particleworks, and we use it now very often. Regarding the calculation time, it has been drastically improved in these few years thanks to GPU support. Of course even faster is much better, because smaller particle sizes are more appropriate to simulate real phenomena correctly. As we usually need to get a final result for about 2 months, we consider adequate simulation size for 2-3 weeks and start case studies. Then we take 3-4 days for each case and totally 2 weeks for all case studies. So the total time duration to submit the facility spec is 2 months.

Until we introduced Particleworks, we had repeated hand calculations and experiments for the facility deign including cooling water, and changed the experimental device if there were design changes. It was extensive work and required a lot of cost and time. In case of experiment, we can only get rough data of outside flow volume and pressure, and can't evaluate the interference between water spray from different nozzles because the splashing water around it hides. If using Particleworks, we can see how the inside device gets water as there is a cutting plane result visualization capability. Such visualization helps us find an idea for which water spray will be good and leads the next action easily. As we simulate different cases at first and then conduct an experiment for the best case, we could reduce the design changes. Another good point of visualization is that our colleagues who are not using simulation can enter into discussion. It is very much appreciated because they can come up with new ideas such as that changing the arrangement of the spray for this way could lower the cost. If thinking only by the simulation engineers, we can't expect such an idea. So, Particleworks is a tool which can create such an opportunity where we can discuss together to have a first idea. The animation result is too real and some colleagues think it can simulate anything. However, we try to recreate the qualitative trend and focus on clarifying the physical phenomena behind it, because simulation results have some quantitative differences. We usually check the results by particles, but we sometimes use rendering results for special cases like showing it to customers outside the company. It's very convincing if we can show such a beautiful image. (Fig.2)

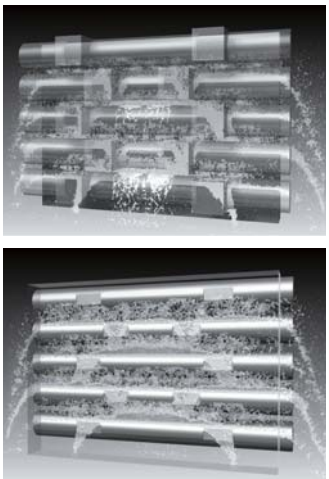


Fig2, Simulation result of water spray – rendering image
(Above: Roller side, Below: Slab side)

Could you please give us some simulation examples using Particleworks?

Taya: A main example is the simulation of spray cooling water behavior in the steel manufacturing process. By visualizing the behavior of the cooling water for continuous casting slab and heating steel plate, we evaluate how the cooling water flows smoothly and uniformly, and which arrangement of the cooling water nozzles and flow volume will be the best. In continuous casting process, liquid steel is casted in a mold as the first cooling and then it becomes solid by spraying water as the second cooling. This casting facility's height is about 10 m and it has a lot of pressure. Therefore, the steel which recently became solid is easy to deform and might expand like balloon, which is called "bulging". To prevent this, the steel plate is supported by short pitch rolls. The rolls are not used as it is remained long but divided into shorter ones to raise the stiffness. However, this divide creates water drip and puddles and it makes the solidification non-uniform and causes center segregation. As it is not good for quality, we try to arrange the spray nozzles to solidify the steel uniformly, but we can't evaluate how water splash and flow on the steel in detail by experiment. Although we have the results of the product quality and

hypothesis, we didn't know the primal mechanism for them. So we developed a model for the simulation of the spray water behavior by using Particleworks. Regarding the steel manufacturing facilities, we don't introduce the package product itself which is sold by facility makers, but present the necessary specs of the facility structure we need, to the makers. To evaluate the effectiveness of the facility introduction, we use simulation tools. (Fig.3, Fig.4, and Fig.5)

If a large volume of water is flown in the steel plate cooling facility, the water is not held back by the throating nozzles sometimes and it causes a line sensor failure. So, one of new simulation examples is the consideration of the facility spec, which doesn't flow the water in the direction to the line sensor, by using Particleworks. (Fig.6) We had done trial and error considerations only by experiments, and it was difficult to visualize the regions where spray interference by an experiment because of a large volume of water and we couldn't identify the major factor about why the water flowed in the direction of the sensor. Then we visualized this phenomenon by Particleworks and could identify the major factor. After then, we had a discussion with engineers in the factory, who are the client in this case, using the simulation result animation. This created lots of ideas such as changing shape of the side wall and changing cooling nozzles arrangement, and we could present the facility satisfying the necessary specs. Using Particleworks made it possible to narrow down the experimental level and it realized experimental cost reduction including making experimental facility and consideration in shorter construction time. The fact is, that we think we might not be able to present the facility structure satisfying the necessary spec only from the experimental trial and error and the consideration in short construction time.

In this way, introducing Particleworks, a simulation software using MPS, as one of the evaluation tools, our facility consideration process has been drastically improved. We think that the MPS simulation has an advantage for complicated free surface problems in terms of the speed and the ease, and its technology will spread in the world.

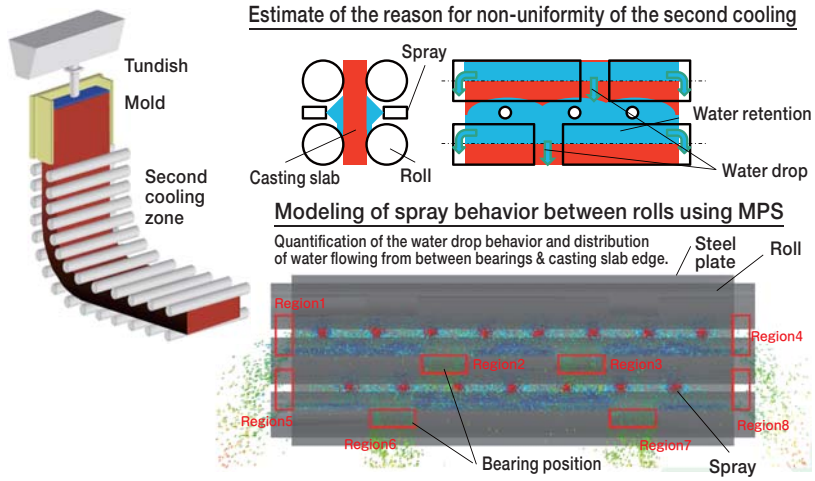


Fig3, Modeling of the water spray behavior

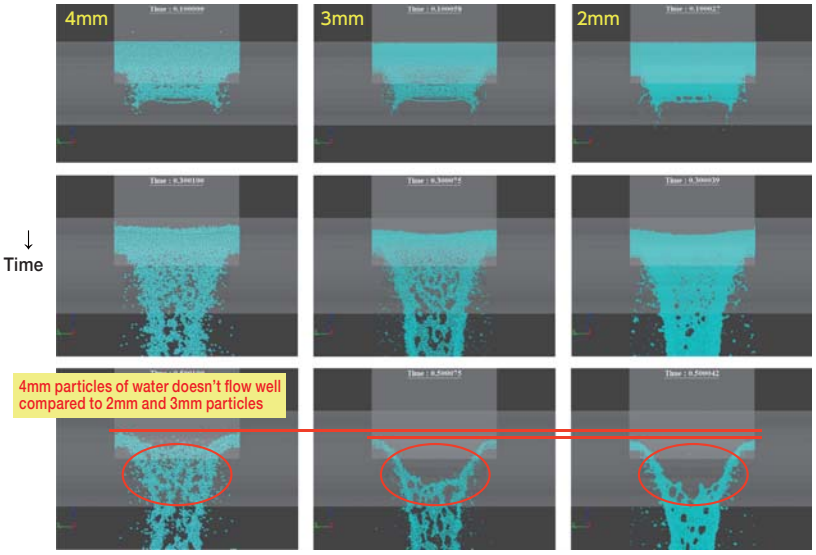


Fig4, Modeling of the water spray behavior – Influence of the particle size

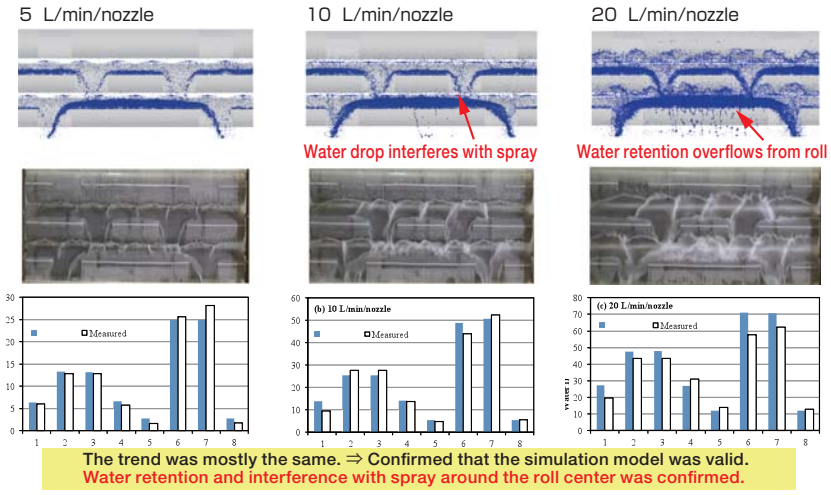
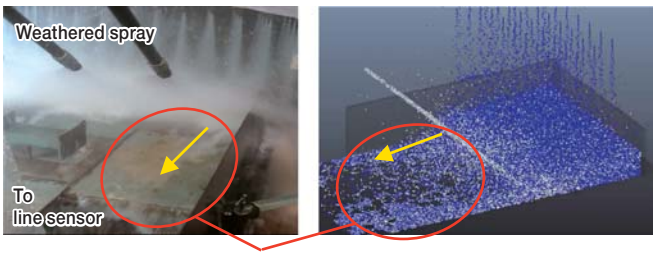


Fig5, Comparison between simulation results and experimental results for water spray by changing water flow volume



Water which can't be backed up.

Fig6, Backwater on the steel plate cooling device

You were quick to use Particleworks. Is this from your company culture?

Taya: We are aiming at the world No.1 comprehensive strength. So, as our company culture, the ideal situation which we are supposed to be for realizing the No.1 strength is to question all the time and we are always aware of how competitive companies are doing, to move a step ahead. Although a new technology like Particleworks has an anxiety about having only a short history, we would like to use it earlier than others to get necessary results, if it can solve problems that we have never solved. We are a large company having many employees who have special abilities in different fields, and it makes it possible to solve problems, which can't be dealt with alone, by cooperating with others in different departments. As we operate 24 hours a day and need to avoid stopping facilities, we also value the speed to obtain the results as soon as possible.

Are there any difficulties for learning CAE?

Taya: CAE is a tool for solving problems for the steel manufacturing process, so it makes no sense if we are unable to have a feasible measure supported by a simulation result based on principles. As most phenomena of the steel manufacturing process are phase transition and thermal fluid including chemical reaction, it's unreasonable to solve everything by CAE and the fact is to use the combination of experiment, hand calculation, and CAE. So, in addition to understanding their good points, it is required to have a skill to judge which part should be modeled in CAE, after considering each problem's cost and schedule. This skill includes understanding of the problem principle in the actual place and of the actual part, and communication with related people, so it is as important as CAE theory and I'm trying to consider it all the time.

Could you please tell the future expectations of Particleworks and Prometech?

Taya: I'm satisfied with the technical support of Prometech, as it is always quick and courteous. In case of the software developed in other countries, there are sometimes problems such as joint research doesn't proceed quickly, and it's difficult to know the core technology because the developer is on other side of the world. In contrast, we appreciate that it's easy to ask Prometech, a Japanese company, and they give us technical answers very quickly. Particleworks has an added value that there are phenomena which only Particleworks can solve. As our request, it would be great if making a model which can deal with a physical phenomenon for liquid drop. We also want to have the capability which can change the particle size locally. By using such capabilities, I'd like to solve complicated thermal phenomenon using Particleworks.

Thank you very much for your valuable feedback and information. Regarding the particles size change and the thermal fluid analysis, we've been considering the development and would like to promote the development so that we can provide it in the near future.
By valuing customer's opinions, we are focusing on the development so that our software will be much easier to use. Again thank you for cooperating with the interview despite your tight schedule. Prometech will continue to provide further support for better product development.

Reference
Presentation material of Prometech Simulation Conference 2014

NIPPON STEEL & SUMITOMO METAL CORPORATION

Head Office: Chiyoda-ku, Tokyo, JAPAN
Established: In October 2012 by the merger of Nippon Steel Corporation and Sumitomo Metal Industries, Ltd.
Activities: Steelmaking and steel fabrication / Engineering / Chemicals / New materials / System solutions
URL: http://www.nssmc.com

Interview: March 23, 2016
In front of the Plant Engineering and Facility Management Center of NIPPON STEEL & SUMITOMO METAL CORPORATION

Contact

PROMETECH.

Prometech Software, Inc.

Head Office
Hongo Dai-ichi Building, 8th Floor, 34-3,
Hongo 3-chome, Bunkyo-ku, Tokyo 113-0033, Japan
Tel: +81-3-5842-4082 Fax: +81-3-5842-4123
West Japan branch office
Asahi Kaikan, 7F, 3-3, Sakae 1-chome,
Naka-ku, Nagoya, Aichi 460-0008, Japan
Tel: +81-52-211-3900 Fax: +81-52-211-3901
URL: www.prometech.co.jp
E-mail: sales@prometech.co.jp