Improving design process of the drivetrain components by MBD - CFD Multiphysics simulation using RecurDyn and Particleworks

UNIVANCE CORPORATION is a vertically integrated company which specializes in the development, manufacture and assembly of automotive parts and units. They have been pursuing their unique technologies based on business’ units including manual transmissions, 4-wheel drive units, automotive parts, and industrial and agricultural transmissions. We have had the pleasure to interview Mr. Naohiro Fujita and Ms. Kaori Sakai in Product Design Sec., Product Development Dept. at the headquarter’ factory in Kosai-city, Shizuoka to listen about the Particleworks simulation examples in the development of drivetrain components.

Please introduce your business.

Fujita: UNIVANCE started business in Nagoya city in 1937 and had produced parts for machine tools. Then the plant moved to Kosai City for production of aircraft parts in the time of war. In the postwar period, we worked on the manufacturing of shuttle body for sewing machines which had been booming those days, and gained about 40% market share in Japan. Then we introduced high-frequency quenching to metal parts through joint development with Shizuoka University School of Engineering, and this led us into the automotive industry. Now we deal with functional components such as one-way clutches, AT/CVT components, transmission and engine gears, EV/HEV gearboxes, manual transmissions, and 4WD transfer cases. In addition, we also produce transmissions and gearboxes for construction machines and agricultural tractors in North America.

How do you use CAD and CAE in the product development department?

Fujita: There are different groups depending on the products to deal with in the Product Development Dept. In our group, we use CAD and CAE to support design process of all products, which means that we’ve been performing simulation by CAE tools including Particleworks by importing CAD models created in CATIA V5, our standard CAD system. The purposes of the simulation are, for example, prediction during the concept design stage, design validation before prototype testing, and analysis for quality improvement. In contrast to the individual product groups where designers use “CAE for designers” for linear-structural analysis, we are in charge of further analysis which can’t be solved in design groups. Now Particleworks is used for CFD simulation and we also use MBD (Multi Body Dynamics) simulation software RecurDyn(1) for coupling analysis with CFD.
Sakai: I’d worked with CAD modeling for a few years after joining the company. At that time, I was also involved in CAE model creation work, and started doing simulation work using Particleworks since last year.

Fujita: Though it would be better to use CAD model directly for simulation, it is necessary to simplify CAD models before CAE simulation in most cases for memory reduction and efficient calculations, as our products have many components and tend to be very large. So we asked Sakai, who had been working with CAD modeling, to join us in dealing with simulation. It was realized soon thanks to the ease of operation use with Particleworks.

What was the main reason to start using Particleworks?

Fujita: Regarding CFD simulation, we tried to outsource a grid method CFD software vendor to perform oil sloshing simulation about 10 years ago. However, we couldn’t obtain the results we expected and couldn’t check if the simulation results were consistent with the experimental results, either. Though there was a requirement to confirm the real phenomena by simulation because it was too difficult to understand it only by experiment, it couldn’t be realized at that time. After a while, the request to visualize oil sloshing and lubrication for sufficient evaluation has increased and we started discussing the introduction of Particleworks.

While we were considering the software to use, there was another opinion that an entry version of grid method CFD software would be better. But we decided to try Particleworks because the result of the grid method software which we got from the outsourcing simulation in the past was not good and it was when MPS technology had begun to be widely known. Then, finally we started a benchmark test at the end of 2013 for the actual introduction, as we had a good impression for Particleworks during the research stage compared to another MPS software and thought that we could expect Prometech to provide sufficient technical support. In the benchmark test, we had evaluated if the simulation results corresponded to the experimental results for different analysis cases by cooperation with Prometech engineers, and this led us to the decision to introduce Particleworks. For the beginning, we rented the software to work on the simulation of the product before prototype testing, and found that the oil didn’t reach the necessary regions by the simulation. Then we repeated design changes and simulation more than 10 times and finally got to the actual prototype testing. As a result, we could accomplish certain result as the oil distribution was improved and spread enough in the real product, though it was not perfect. A half year later, we formally ordered the software and submitted a paper at the Prometech Simulation Conference in the following September. In addition to Particleworks, we also introduced RedurDyn which can be coupled with Particleworks, for co-simulation of the chain behavior and the oil lubrication in the transfer case. Transfer case is our key product and RecurDyn was necessary for such a chain simulation.

How was the impression after using Particleworks?

Sakai: Particleworks was the first CAE software tool for me, and I had thought CAE was more difficult to operate before using it. However, I was impressed to know that the Particleworks operation was very easy even if I didn’t have any CAE experience and knowledge, and soon I got motivated and was interested in simulation. Now I don’t have problems to get simulation results. If there is one thing which I pay attention to, it is to input the material properties precisely because there are many characteristics to define them. RecurDyn is used by another engineer and I work with him to exchange the data for coupling simulation between MPD and CFD.

Fujita: A decade ago, simulation had been thought to be used by specialists who devoted a lot of effort only to simulation. So there were sometimes communication problems between designers and simulation engineers. However, simulation has become much easier recently so that non-specialists can understand, and it has made our colleagues see simulation in a different way. Now the communication has improved in the environment where we can give our opinion to others and it’s much easier to work on our jobs. Additionally, the coupling simulation between Particleworks and RecurDyn is very easy to use.

What kind of impact has there been by introducing Particleworks?

Fujita: The situation around us has changed, because people in our company began to think that CFD simulation is possible and we can see what we have never seen before. Now we simulate the oil lubrication as soon as the layout is completed and we had done simulations for more than a dozen projects last year. Thanks to the excellent visualization capability of Particleworks, it’s easy to show the advantage of the simulation and is appreciated for the communication with business partners and explanation to other departments in the company. My presentation at the Prometech Simulation Conference was introduced in an internal newspaper in 2014 which featured CAE simulation and it’s been paid a great deal of attention.
Could you please give us your simulation examples using Particleworks?

Fujita: This is the simulation example applied to a transfer case. The transfer case is a device to distribute power from engine-transmission to front wheels and rear wheels of a 4WD vehicle by means of gears, sprockets and a chain. We used RecurDyn and Particleworks to simulate the mating of the chain and the sprocket and the oil lubrication.

Before, we had visually checked the oil lubrication created by the chain using resin clear case and endoscope. Such visual inspections have limitation, and it’s difficult to take measures because the inspection is after making real products and significant layout change is impossible even if there are big problems. However, oil lubrication is necessary for antifriction and cooling of the components and has the important role to improve the product quality. So we are glad that it can be visualized by simulation to evaluate how the oil circulates and how the oil flows after circulation. In this case, we used the model for which there is already an experimental data and evaluated how much the simulation result fits with the experimental result, because the case was for considering the introduction of RecurDyn and Particleworks. Though the calculation time was about 2 days at that time, now it became less than 1 day at most under the same conditions as Particleworks is of a new version and we improved the hardware setup. We can also use a smaller size of particle diameter compared to before and think that we can perform more accurate simulations.

Please tell us about the hardware setup.

Fujita: We use 8 core CPU and 4 board GPU in a desktop machine. It is needed to be able to use smaller particles to respond to the designers requirement and we think it’s necessary to add CPU as GPU has limitations for the number of particles.

How do you conduct the CAE training in the company?

Fujita: We have organized basic training mainly for software operation which is the same as software vendors provide. But it’s not sufficient and we started discussion about CAE training since last year. So we are planning to start training including material mechanics and real examples this year.
Could you tell us about what you feel is difficult in Particleworks and what you want to work on in the future?

Sakai: I have difficulty defining material properties. For example, it’s hard to know the material property if the oil is the oil maker specialized product. The unit conversion is not automatic in Particleworks, and I’m careful not to make mistakes on the unit. I also feel it’s not easy to find out the right definition of the simulation region and of the model simplification.

Fujita: It is required for the products to get all performance including not only lubrication but also strength and vibration. We do evaluation in parallel and change the layout if there is any lack for performance, and evaluate it again. As the measure for lubrication greatly influences how to change the model, I’d like to get the result as soon as possible and feedback. The size of the simulation model for our products tends to be large, and only the model geometry consumes a lot of computer memory. If the simulation is linear analysis, it can be thought to simulate only for a local area, but if we need to perform dynamics analysis, it’s necessary to evaluate the whole product and we feel difficulty to make a balance of simulation size, accuracy and speed. We’ve focused on fluid dynamics and would like to work on component cooling in the future. I hope to check the oil flow in earlier stage and consider the thermal behavior.

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

Sakai: We usually send e-mails when we need technical support and we are very satisfied with that the Prometech support team always responds quickly. Regarding the software capabilities, I hope the combination with CAD systems would be smoother in the future as the data exchange is complicated. Also, it would be appreciated if unit conversion capability was added.

Fujita: I think the responses to our technical questions are quick and it is appreciated that we can fully communicate in Japanese. We can’t use CAD geometry directly for simulation, which is something we feel difficult and it takes much time to prepare necessary models in the CAD system rather than the definition of the simulation. As we use large analysis models, it would be great if such CAD geometry usage became easier. In addition, we hope Prometech to develop capabilities for pump and cavitation which are not available now.

Thank you very much for your valuable feedback and information. Regarding the thermal fluid analysis, we’ve been developing it and planning to show the capability in sometime this year, as well as planning to present the cavitation handling in an academic conference this year. 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.

Reference
Presentation material of Prometech Simulation Conference 2014
Note:
(1) RecurDyn, developed and being sold by FunctionBay, Inc. (eng.functionbay.co.kr), is an advanced multibody dynamics software, which employs highly efficient solver based on Recursive formulation algorithm, geometry-based intuitive graphical user interface and abundant functionality which can model a variety of mechanical systems inside it.