7. Task 7 Development of Hydrogen Refueling Station

7.1 R&D Target

R&D target of hydrogen refueling station in the WE-NET phase II program is “to develop and demonstrate a small scale of test system with hydrogen supply capacity of 30Nm^3/h, equivalent to about one tenth of actual scale, in order to establish the element technology and system technology of stand alone type of hydrogen refueling station for the purpose of fuel supply to hydrogen fuel cell vehicles”.

In the fiscal year of 2001, we designed in detail and manufactured the remaining composing equipments for two types of hydrogen refueling systems (Natural gas reforming type and PEM water electrolysis type), as in the fiscal year of 2000. We did construction work for components equipments of these hydrogen refueling stations including utility facilities. A trial operation and tuning of the system were performed. In addition, through an operation combined with a test tank, the system of hydrogen refueling station was verified and filling technology was developed. We also investigated and examined these systems to prepare the technical guidelines for several kinds of hydrogen refueling stations.

7.2 The result of R&D in 2001

7.2.1 Natural gas reforming type hydrogen refueling station

In fiscal year of 2001, we manufactured the remaining component equipments according as detailed design done in the last fiscal year and built the hydrogen refueling station. After completion of the station, we tuned up component equipments by combined operation and carried out filling test using model tanks.

(1) Total system

We installed all component equipments, constructed the whole system of hydrogen refueling station including utility facilities and finished tuning operation for main component equipments.

As a result of safety study for hydrogen refueling station, we install one earthquake sensor and three fire alarms as additional safety devices. An automatic information system activated by alarm was incorporated in the centralized control system as a safety measure in the operator’s absence. .

(2) Reforming type of hydrogen production equipment

As for the reforming type of hydrogen production equipment, the design and manufacturing of PSA equipment were performed and an investigation for packaging the equipment was made from the viewpoint of safety. It was ascertained in a confirmation test that its performance satisfied with original designed value. After that, this equipment supplied hydrogen satisfactorily both in tuning operation for the metal hydride type storage equipment and high pressure hydrogen storage equipment

and in operation experiments. The running time of 700 hours and hydrogen supply of 7,600Nm^3 was achieved.

(3) Metal hydride type of storage equipment

Following the detailed design specification in the last fiscal year, we manufactured the metal hydride (MH) type of storage equipment with an absorption rate more than 30Nm^3/h and a supply rate more than 150Nm^3/h. Its performance was verified by tests both in single operation and in combined operation with the hydrogen production equipment and MH filling system.

(4) MH filling system

As for MH filling system, we installed the MH dispenser unit and cooling unit manufactured in the last year and carried out performance test both in unit operation and in coupled operation together with the MH storage equipment and MH model tank. It was ascertained that this system satisfied basic performance of filling hydrogen of 25Nm^3 in ten minutes, the target value.

(5) High pressure filling system

As for high pressure filling system, we installed the high pressure compressor manufactured in the last year. The gas storage unit and high pressure dispenser unit designed in the last year were manufactured and installed.

This system passed the inspection according to the High Pressure Gas Safety Law after its completion. Consequently, it became legally possible to fill hydrogen of 35MpaG to hydrogen vehicles in this station.

(6) Results of operation test

In fiscal year of 2001, operation tests on MH filling system using metal hydride type of storage equipment and high pressure filling system were carried out.In the test for MH filling system using metal hydride type of storage equipment, a rapid filling test to MH model tank (separated chamber type) designed and manufactured in Task 5 was conducted. It was ascertained that the target performance of filling hydrogen of 25Nm^3 in ten minutes was satisfied. Figure 7.2.1-1 shows the change in flow rate and pressure of hydrogen with time. Though there was some variation in hydrogen flow rate, integrating flow increased linearly till hydrogen of 20Nm^3 was filled, because pressure difference (P) between the MH storage and the MH model tank was held to be more than fixed value necessary to control flow. We obtained data enable us to optimize the rapid filling condition, such as supply condition both for heat medium in the MH storage equipment and for coolant in the MH model tank.

In the test for high pressure filling system, we adjusted flow control of high pressure dispenser using high pressure model tank. We filled hydrogen up to the

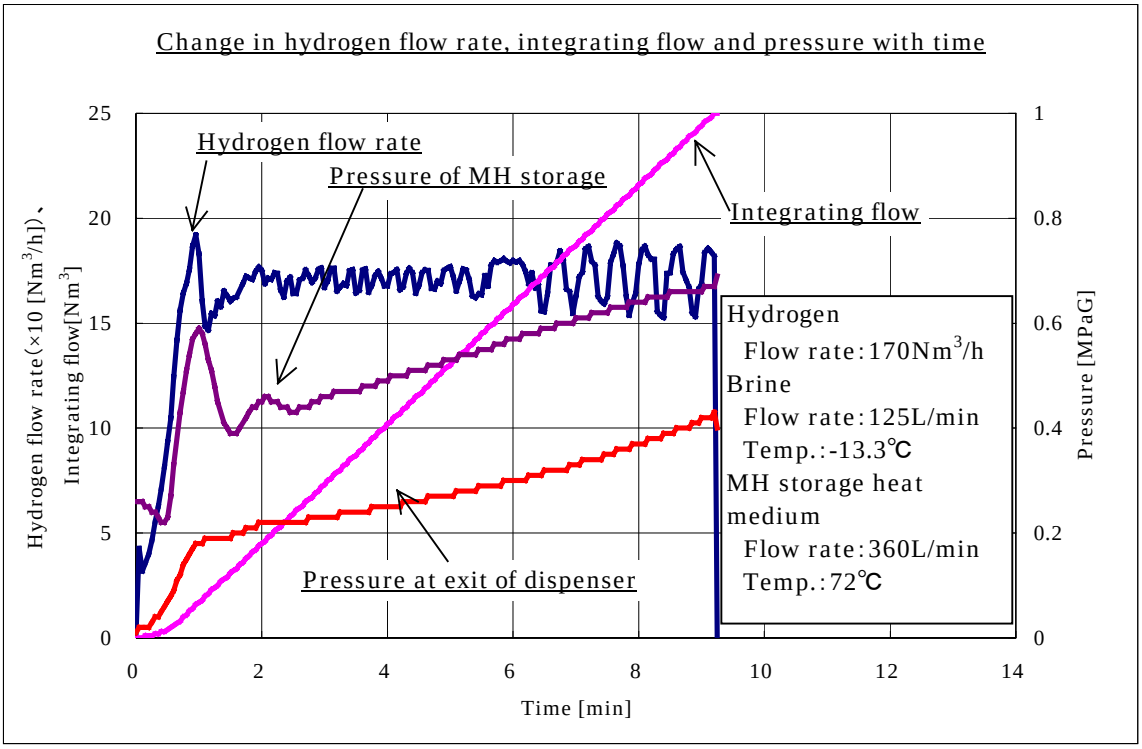

Fig.7.2.1-1 Rapid filling experiment of MH filling system

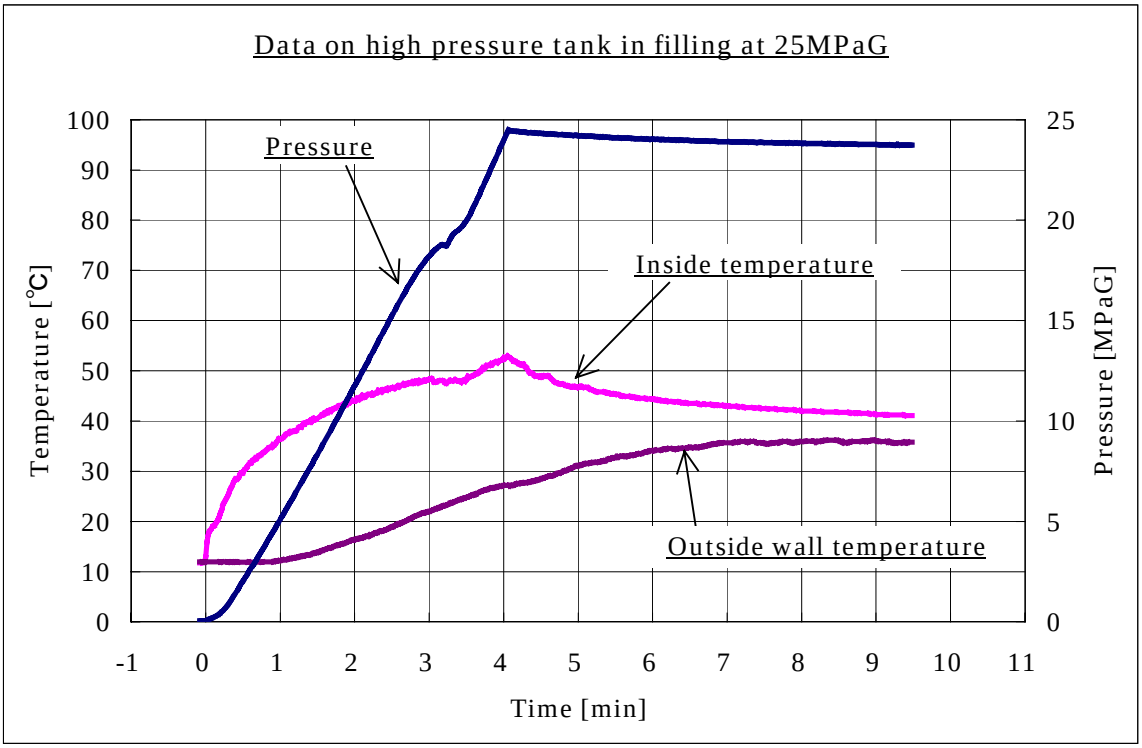

Fig.7.2.1-2 Rapid filling experiment of high pressure filling system

pressure of 25MPaG in four minutes by cascade system to study temperature change of high pressure model tank. Figure 7.2.1-2 shows the behavior of temperature and pressure of the tank in filling up to 25MPaG. It was ascertained that the heating characteristics of the tank due to adiabatic compression did not exceed beyond the safe level.

7.2.2 PEM water electrolysis type hydrogen refueling station

The research in the fiscal year of 2000 was followed by detailed design and manufacture of remaining component equipments, construction of PEM water electrolysis type hydrogen refueling station and operation test combined with model tanks.

(1) PEM water electrolysis type hydrogen production equipment

We manufactured the main body of the equipment, control board, DC power supply and finished to install on the refueling station site. A trial operation of the equipment at the station site was conducted. It was confirmed that the performance satisfied with a required specification value (pressure/ production volume/ purity).

(2) High pressure type filling system

The detailed design and manufacture of the compressor had been finished. Also, the trial operation at 40MPaG by nitrogen and helium was carried out in the manufacturing factory. It was confirmed that the performance satisfied with a required specification value (discharge pressure/ processing quantity). This system passed the completion inspection based on the general rule of the High Pressure Gas Safety Law in Japan and was permitted as the high pressure production equipment. After that, the combination test of the compressor and the gas storage facilities was carried out using hydrogen at the station site. It was confirmed that the performance satisfied with a required specification value (discharge pressure/ processing quantity). We also conducted an experiment of filling hydrogen to the model tank.

(3) Metal hydride filling system

The brine chiller was permitted as the production apparatus after submission of its notification report, according to the refrigeration rule of the High Pressure Gas Safety Law in Japan. On the refueling station site, the absorption and supply test of metal hydride type storage equipment were carried out to confirm that the performance satisfied with a required specification value (absorption time, supply pressure/time). After that, using the model tank designed and manufactured in Task 5, we also carried out the filling test of hydrogen.

(4) Remote watching system

We built a remote watching system that the station operation data was transmitted from the central control board inside the station yard with wireless LAN, because

buildings could not be constructed inside the yard according to the Building Standards Act in Japan. This system enabled us to watch the status of operation of the station and to collect the operation data.

(5) Operation test

As for the high pressure filling system, rapid filling test of hydrogen of 30Nm3 at pressure of 25MPaG and 35MPaG by combination of gas storage facilities and dispenser using high pressure test tank. As a result, it was confirmed that hydrogen was filled into the tank safely within 5 minutes(Figs.7.2.2-1 and 7.2.2-2). As for the metal hydride filling system, rapid filling test of hydrogen of 30Nm^3 was conducted by combination of the metal hydride storage equipment, the brine chiller, and the MH dispenser using the model tank(plate-fin type) designed and manufactured in Task 5. As a result, it was confirmed that hydrogen was filled into the tank safely within 9 minutes, just as the high pressure filling system.

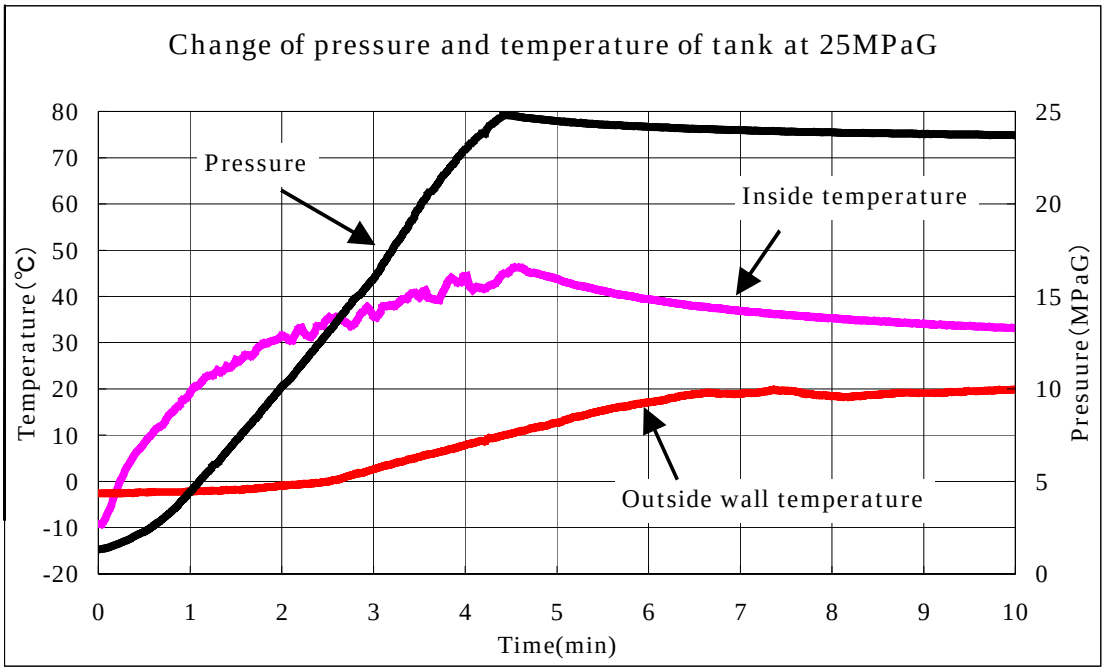

Figure 7.2.2-1 Rapid filling experiment of high pressure filling system(25MpaG)

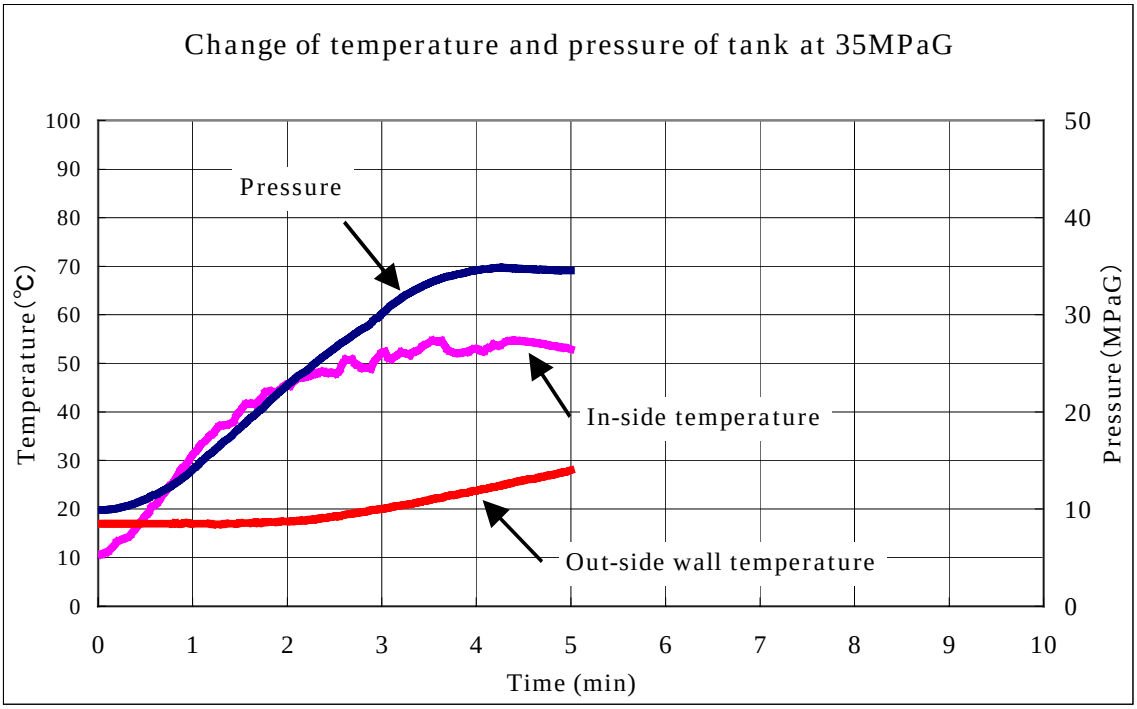

Figure 7.2.2-2 Rapid filling experiment of high pressure filling system(35MpaG)

7.2.3 Examination of technical guidelines for Hydrogen Refueling Station

With a policy that easing of official restrictions is not our aim, we examined safety issues closely about two types of the hydrogen refueling stations built in this year, holding working groups of production, storage and filling. For safety measures adopted for these hydrogen refueling stations, fundamental philosophy for safety and mounting locations for sensing devices were investigated.

This work was conducted in cooperation with Task 2 taking charge of safety in general of WE-NET Project. Task 2 reviewed safety measures adopted hydrogen refueling stations to confirm that these hydrogen refueling stations were safely constructed; design review on July 17 and on-site review for reformer type of hydrogen station on Oct. 31, water electrolysis type of hydrogen station on Feb. 1. It is necessary to know the extent of disaster by explosion in order to secure safety of hydrogen refueling stations. Task 2 took charge of hydrogen explosion experiment. In fiscal year of 2001, explosion experiments on (a) semi-open system and (b) duct system were carried out.

7.3 Research and Development Subject in the Future

(1) Optimization of rapid filling to test tank

1) Metal hydride filling system

・Control of hydrogen filling and brine flowing

・Optimization of rapid filling and sensing full charging

2) High pressure filling system

・Control of hydrogen filling

・Optimization of rapid filling and sensing full charging

(2) Optimization of total system of hydrogen refueling station and safety estimation

・Optimization of total system of hydrogen refueling station combining component equipments

・Verification of basic performance by periodic self inspection

・Legal safety inspection for high pressure equipments

(3) Examination of technical guidelines for hydrogen refueling station

・Safety evaluation of component equipments as well as total system

・Clarify the point of improvement on safety

・Documentation of safety guideline for hydrogen refueling station based on results obtained from evaluation mentioned above and experiments on hydrogen diffusion and explosion conducted by the Task 2 program