Initiatives Biomass Combustion Technology for Steam Power Plants to Achieve Carbon Neutrality

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For achieving carbon neutrality, Mitsubishi Heavy Industries, Ltd. (MHI) has accumulated experience in biomass co-firing and 100% biomass firing for pulverized coal-fired steam power plants of various types and output ranges in Japan as well as overseas. As the latest example, large (1,000-MW-class) ultra-supercritical steam power plants in which pulverized coal is fired have started biomass co-firing operation at the ratio of 10% or more (calorie basis).

1. Introduction

In order to fulfill our national goal of reducing carbon dioxide (CO_2) emissions by 46% from the 2013 baseline by 2030 and achieving carbon neutrality by 2050, the electric power companies and business operators with independent electric power generation facilities are employing various measures to cut CO_2 emissions. The steam power plants, which especially emit CO_2 in large quantities, are strongly required to decrease the usage of fossil fuel. The use of biomass as an alternative fuel is expanding because of its good availability and economic advantage. Being characterized by their large capacity as a power source and high load-following capability, the pulverized coal-fired steam power plants serve as a power source to balance power supply and demand. If the fuel is switched from coal to biomass, or high ratio biomass co-firing or 100% biomass firing is introduced, CO_2 emissions can be substantially reduced while retaining the advantages of pulverized coal-fired steam power plants. Furthermore, as the 100% biomass firing technology has already been established in Europe, it is also the center of attention mainly among the Japanese business entities aiming to reduce CO_2 emissions from their steam power plants as soon as possible (by 2030).

This report presents the characteristics of biomass firing technology for steam power plants and the latest application examples.

2. Our biomass pulverization/combustion system

In terms of burning biomass in pulverized coal-fired steam power plants, either of the following technologies is applied: (1) a mixed pulverization/combustion system (with the use of wood chips or pellets) in which biomass is fed into the same mill as coal and is pulverized together before being fired in the same burner as coal, or (2) a dedicated pulverization/combustion system (with wood pellets), which is equipped with a mill and a burner dedicated to pulverizing and firing biomass. In the mixed pulverization/combustion system, biomass has to be pulverized as finely as coal to ensure the flammability of coal, whereas the dedicated pulverization/combustion system allows biomass to be pulverized more coarsely than coal owing to the high flammability of biomass. Being less bound by the mill's operational restrictions, the latter system can process more biomass, and therefore can increase the co-firing ratio more easily. **Table 1** summarizes the characteristics of both systems.

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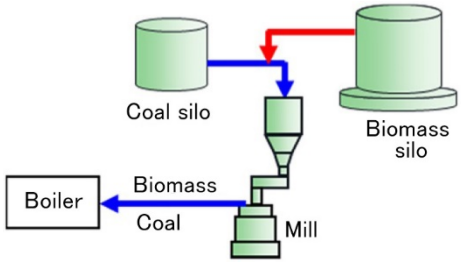
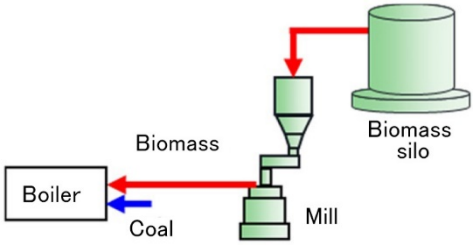
Table 1 Biomass pulverization/combustion system (per burner)

Pulverization/ combustion system	Co-firing ratio*	System configuration
(1) Mixed pulverization and combustion	Up to several % (calorie basis)	
(2) Dedicated pulverization and combustion	Approx. 10 to 20% (calorie basis) × number of mills	

*: Biomass co-firing ratio in boiler, not per burner

In the dedicated pulverization/combustion system, the biomass co-firing ratio can be further increased by adding a minimum set of devices/equipment suitable for the use of biomass without performing substantial specification changes or remodeling the existing facilities of pulverized coal-fired steam power plants. In this system, the vertical mill with many proven records for application in pulverized coal-fired steam power plants and the low-NOx burner with superior ignition stability are incorporated in the combustion equipment. By optimizing the vertical mill and the low-NOx burner for biomass application, the reliability of the equipment can be enhanced. Our combustion equipment, i.e., the mill and the burner, has been developed/designed, considering separately the situations in which the fired fuel is 100% biomass, or either coal or biomass.

Biomass is higher in volatile matter content than coal and, as wood pellets, has a lower fuel moisture content than other solid fuels. The minimum ignition energy is lower than coal. In the dedicated pulverization/combustion system, in which the concentration of biomass in the mill becomes especially high, concerns are mainly raised about spontaneous ignition in the mill and rapid combustion. As such, the mill and the pulverized fuel chute are equipped with a rapid combustion protection system (consisting of a container fille pressure vessel at an early stage. With biomass having a low minimum ignition energy a d with fire extinguishing media, pressure sensors, etc.) to detect and stop an excess s mentioned above, sparks generated by contact with metals, etc., may serve as a source of ignition. So, it is also important that safety measures should be taken upstream of the combustion equipment including removal of foreign matter such as metals in the fuel handling system.

3. Biomass co-firing technology application examples

3.1 Taketoyo Thermal Power Station Unit 5

This is the boiler delivered to JERA Power Taketoyo LLC. Coal and wood pellets are co-fired in this boiler. The biomass co-firing ratio is about 17% (calorie basis) (at a power output of 1,070 MW). The feed rate of wood pellets is approximately 90 t/h. Of its six mills, one is for exclusive use of biomass. The pellets pulverized by this mill are fired in six burners that are used only for biomass (a mill and single-stage burners). The power output from this plant is one of the largest in Japan. The scale of biomass combustion is also one of the largest among the units we have delivered. **Table 2** shows the boiler specifications of the Taketoyo Thermal Power Station Unit 5 and **Figure 1** gives the exterior of this boiler plant.

The combustion system is two-stage combustion with the opposed firing system, using MPS mills and HT-NR3B burners (**Figure 2**). It is characteristically equipped with a specialized large-capacity mill and burners for exclusive use of biomass (wood pellets). This mill and burners for biomass use have been optimized from the perspectives of operational management and

structure. Specifically, consideration is given to the facilitation of pulverized biomass discharge for the former and the realization of stable ignition over a wide range of burner loads for the latter.

Table 2 Boiler design specifications (Taketoyo Unit 5)

Output	1,070 MW
Maximum evaporation capacity	3,210 t/h
Turbine inlet main steam pressure / temperature	26.4 MPa (g) / 600°C
Fuel	Coal, wood pellets
Co-firing ratio	≈17% (calorie basis)
Vertical mill model	MPS-280BH
Burner model	HT- NR3B

Figure 1 Exterior view of boiler plant (Taketoyo Unit 5)

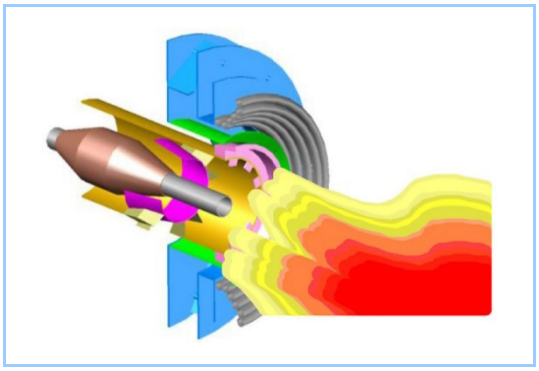


Figure 2 Dedicated biomass burner (Taketoyo Unit 5)

3.2 Misumi Power Station Unit 2 of Chugoku Electric Power Co., Inc.

This is the boiler delivered to Chugoku Electric Power Co., Inc., in which wood pellets and coal are co-fired. The biomass co-firing ratio is about 10% (calorie basis) (with a power output of 1,000 MW). The feed rate of wood pellets is approximately 50 t/h. The power output from this plant is one of the largest in Japan. The scale of biomass firing is also one of the largest among the units we have delivered. **Table 3** shows the boiler specifications of the Misumi Power Station Unit 2 and **Figure 3** gives the exterior of this boiler plant.

Table 3 Boiler design specifications (Misumi Unit 2)

Output	1,000 MW
Maximum evaporation capacity	2,900 t/h
Turbine inlet main steam pressure / temperature	24.5 MPa (g) / 600°C
Fuel	Coal, wood pellets
Co-firing ratio	≈10% (calorie basis)
Vertical mill model	MVM32RL
Burner model	M-PM burner

Figure 3 Exterior view of boiler plant (Misumi Unit 2)

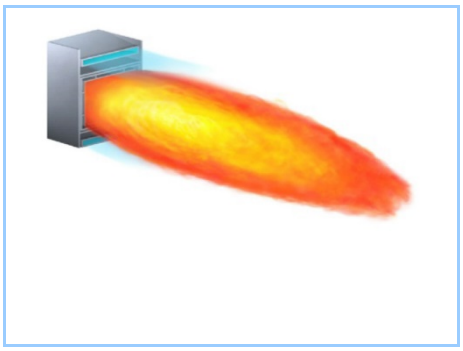


Figure 4 Burner usable for either biomass or coal (Misumi Unit 2)

The combustion system is two-stage combustion with the circular firing system, using MV mills and Multiple Pollution Minimum (M-PM) burners (**Figure 4**). It is characteristically equipped with a total of six mills, of which two can be switched between coal and biomass for exclusive

pulverization. These two mills are connected with 16 burners (two mills and two-stage burners), which can be used for combustion of either coal or wood pellets.

4. Conclusion

We have accumulated experience in biomass co-firing since the start of commercial operation of the 110 MW class pulverized coal and biomass co-fired steam power plants in Japan, which we delivered between 2018 and 2019. The 1,000 MW class pulverized coal-fired steam power plants have started using the country's first dedicated pulverization/combustion system for biomass, which is suitable for the operation at a high biomass co-firing ratio. This dedicated pulverization/combustion system has been in operation at the two units which are Taketoyo Thermal Power Station Unit 5, and Misumi Power Station Unit 2. Their capacities are one of the largest among the facilities we have delivered. Augmented by this experience with the two units, our product line-up for steam power plants is now available over a wide plant output range of 110 MW to 1,070 MW (**Figure 5**).

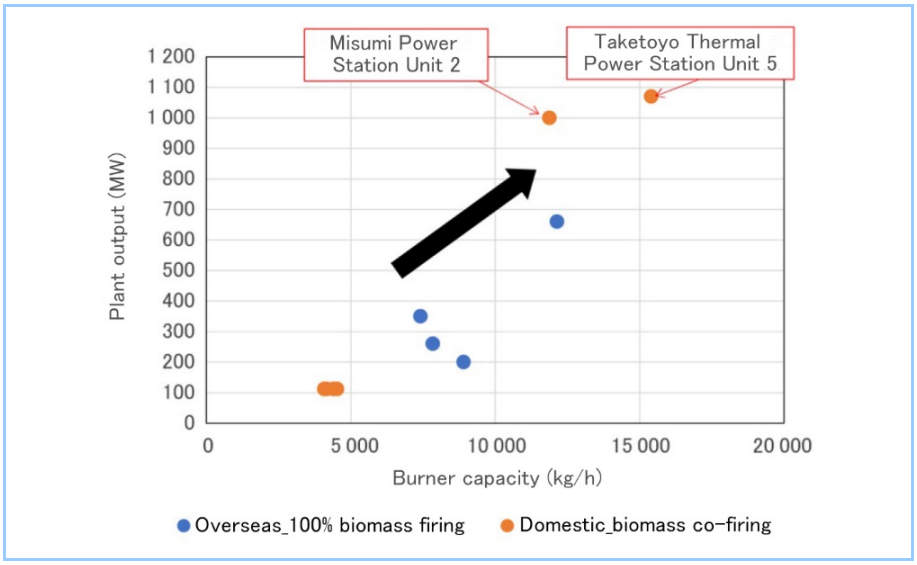


Figure 5 Our delivery record of biomass plant/100% biomass-fired burners

Moving forward, we will introduce the use of biomass, expand the co-firing ratio, and work out a plan for eventual 100% biomass firing by applying the design and test-operation results shown in this report to other existing plants (**Figure 6**). While meeting the needs of electric power companies and business operators with independent power generation facilities, we will contribute to the achievement of a carbon-neutral society.

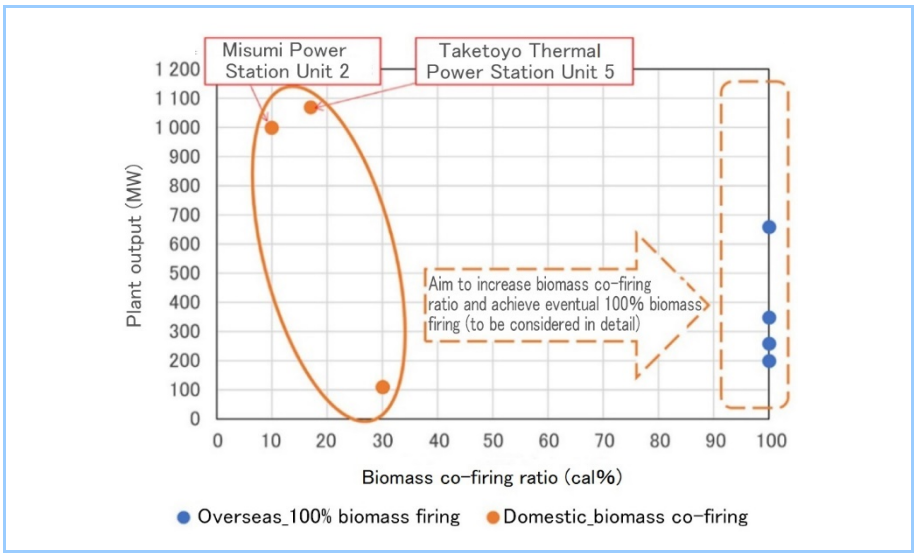


Figure 6 Our biomass plant/co-firing ratio data and prospect of development

References

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