Variable Speed Micro Hydropower System

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Abstract

We recently established a variable speed power generating system which combines a permanent-magnet generator and technologies related to power conversion and speed control.

The variable speed power generating system is composed mainly of a Permanent Magnet Generator (PMG) and a power converter unit. It features efficient operation, a simpler system configuration, and excellent maintainability. We expect that this product will contribute as a key product representing the innovation of a power generating system going forward.

1 Preface

We established product lineups of variable speed micro hydropower systems by combining a Permanent Magnet Generator (PMG) and power converters.

This paper introduces the system configuration, its features, and the result of a verification test using a model testing system.

2 Configuration and Features of the Variable Speed Micro Hydropower System

Fig. 1 shows a configuration diagram of the small variable speed micro hydropower system. For application to micro hydropower generation, this system employs a PMG, Meiden's standard industrial AC power converter THYFREC VT240S, and a converter unit: THYFREC 240S.

By using the speed control technology and PMG, we improved power generation efficiencies while there is a change in the drop range.

Fig. 2 shows a comparison of the configuration between the fixed-speed system and the variable speed system. Compared with a conventional fixed speed system, this system offers the following features:

(1) Generator output can be improved despite a head (drop) changing.

(2) Regardless of the source frequency and the number of poles of the generator, the revolving speed of the water turbine can be selected. Consequently, the generator can be directly coupled with the water turbine in a gearless mode. This construction is very helpful in saving system equipment and improving maintainability.

(3) By using a converter control, the AVR circuit of the generator can be eliminated.

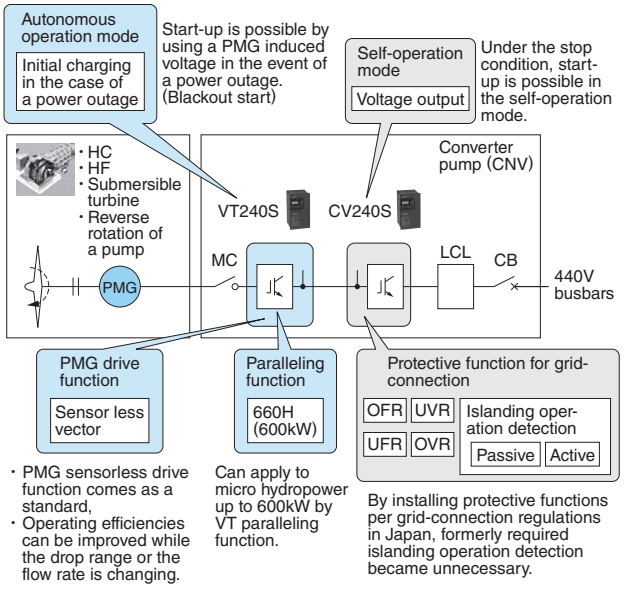


Fig. 1 Configuration Diagram of the Small Variable Speed Micro Hydropower System

This is a high-performance hydropower system that can improve its efficiencies under the changing drop range by using variable speed technologies.

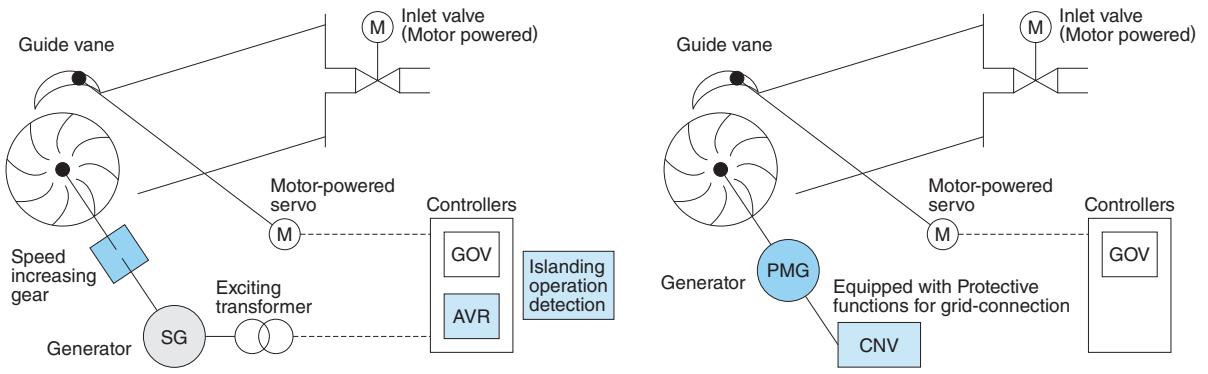
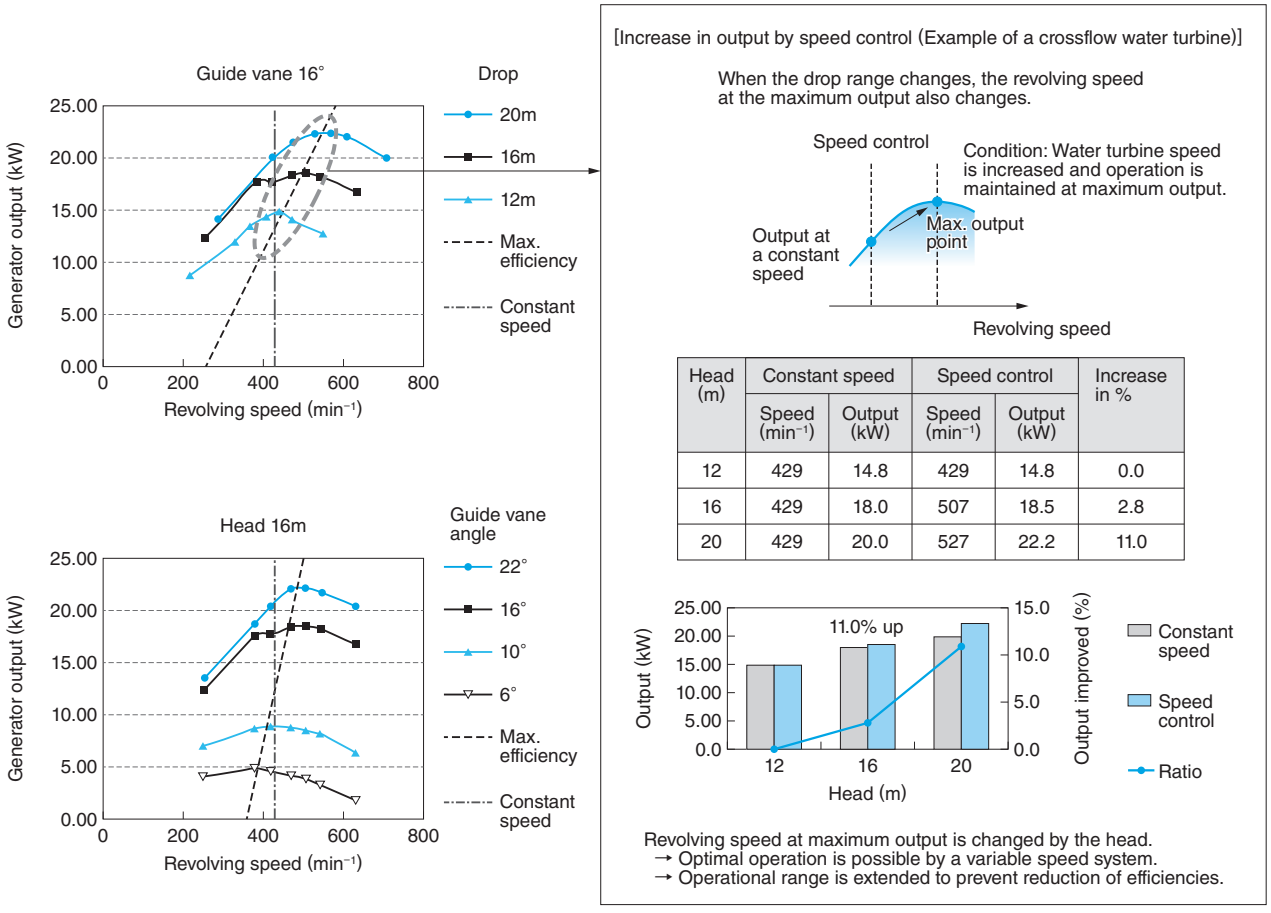


Fig. 2 **Comparison of the Configuration between the Fixed-Speed System and the Variable Speed System**

A variable speed system is adopted to improve output and save system equipment.



Head (m)	Constant speed		Speed control		Increase in %
	Speed (min^{-1})	Output (kW)	Speed (min^{-1})	Output (kW)	
12	429	14.8	429	14.8	0.0
16	429	18.0	507	18.5	2.8
20	429	20.0	527	22.2	11.0

Fig. 3 **Result of Verification Test on a 20kW Crossflow Water Turbine Model**

When the drop range changes, revolving speed at the maximum output also changes.

3 Verification Test by a Model Testing System

Fig. 3 shows the result of a verification test by using a model testing system performed on a 20kW crossflow type water turbine. **Fig. 4** shows an outline of the model testing system. We confirmed that optimal operation is possible even though the revolving speed at the maximum output is changed by the effect of a drop range. When the drop is 20 meters, the 20kW output at a constant speed of 429min^{-1} can be increased to 22.2kW by increasing

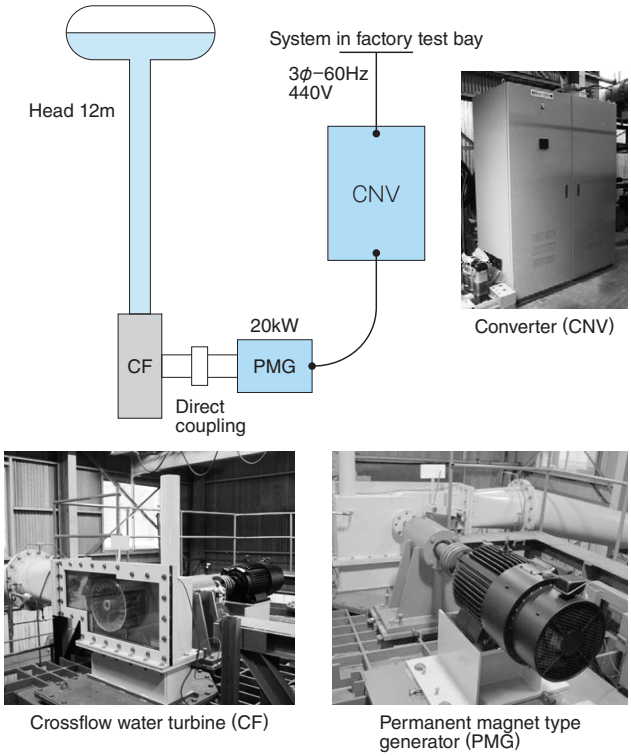


Fig. 4 Outline of Model Testing System

Testing outline is shown and it combines a combination of a 20kW PMG and a crossflow water turbine.

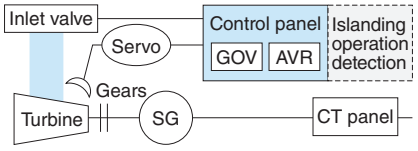
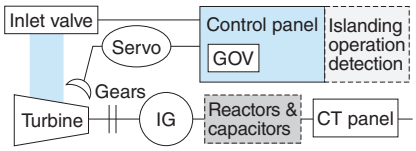
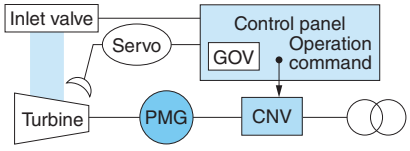
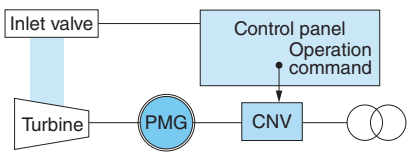
the speed to 527min^{-1}. This is equal to an 11% increase in output. Due to the aforementioned effect, we expanded operational range. In this manner, we were able to confirm that we could prevent the reduction of efficiencies on the generator output.

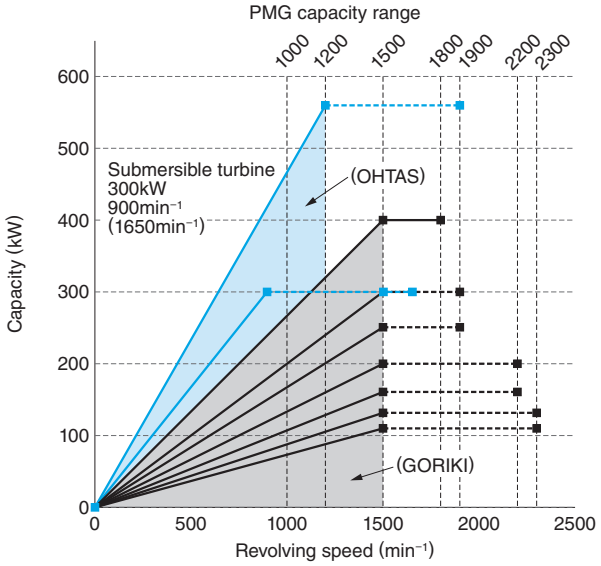
4 Product Lineups of Variable Speed Power Systems

Table 1 shows a list of product lineups. For the selection of the PMG capacity, the drop and flowrate are examined to determine the water turbine. The power generating system is selected and designed after defining the required specification for the generator. Fig. 5 shows the PMG capacity range for the variable speed power generating system. Converter lineups are included within the capacity range up to 600kW. An optimal capacity can be chosen according to the objective micro hydropower system. Fig. 6 shows the converter lineups of various speed power systems.

Table 1 Product Lineups of Micro Hydropower Systems

With additional variable speed power generating systems, we improved product lineups of micro hydropower systems.

No.	Water turbine	Generator	Operating system	System configuration	Applied products
1-1	Francis, crossflow	SG	Constant speed		[Conventional products]
1-2		IG			[Conventional products]
2-1	Francis, crossflow, pump reverse rotation	PMG	Variable speed		[Speed control system] ・Control panel ・Hydropower converter ・Hydropower PMG
2-2	Submersible turbine				[Speed control system] ・Control panel ・Hydropower converter ・Submersible turbine PMG



[Axis of the abscissas] For HF/CF (under planning)

Model	Capacity	Revolving speed	Runaway speed
K01	110	1500	2300
K02	132	1500	2300
K03	160	1500	2200
K04	200	1500	2200
K05	250	1500	1900
K06	300	1500	1900
K07	400	1500	1800
OH1	600	1200	1900

[Axis of ordinates] For submersible turbine

Model	Capacity	Revolving speed	Runaway speed
OHT	300	900	1650

Fig. 5 PMG Capacity Range for Variable Speed Power Generating Systems

Specifications of water turbine are selected according to the drop range and flowrate. The generator system is then determined and designed based on the generator design required conditions.

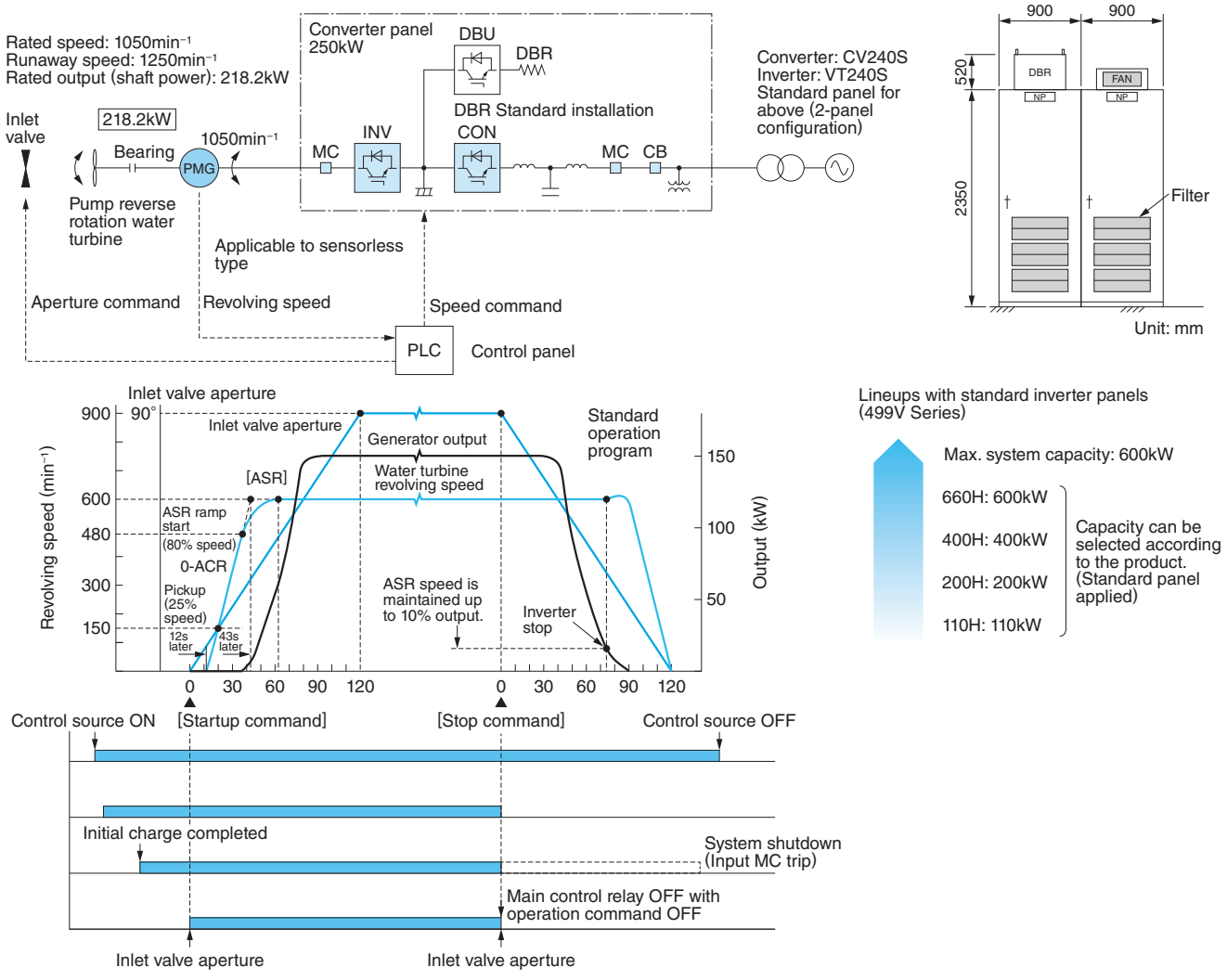


Fig. 6 Converter Lineups for Variable Speed Power Systems

Capacities that match the items are selected (Standard panel applied).

5 Postscript

This paper introduced our variable speed micro power systems with improved product line-ups. The variable speed power generating system is a system that can assure highly efficient operation. It can utilize the renewable energy resource to the maximum level. Going forward, we will continue to improve the performance of micro hydropower systems. For this purpose, we will make efforts to apply new innovations in technology and gain the technical know-hows from practical experiences.

Lastly, in implementing the model testing on system, we express our sincere gratitude to project members at EAML Engineering Co., Ltd. for their kind cooperation.