【Technical Report】

Micro Hydroelectricity Using Irrigation Ponds

Aiming for local production for local consumption of natural energy

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Picture 1 Water level survey of an Irrigation Pond

Introduction

While natural energy development such as solar and wind power generation is ongoing in various places, small-scale hydropower is receiving much attention as one of the options. Mountainous Tottori prefecture, where small-sized rivers and irrigation ponds are found in various places, is an area with high potential for micro hydroelectricity. Above all, irrigation ponds which are used as irrigation for paddy rice fields are especially suitable facilities for micro hydroelectricity since the water can easily generate the gravitational drop. Under the circumstances where the aging problem is making the management of irrigation ponds difficult, using the power generated by micro hydroelectricity for labor saving for irrigation ponds management represents local production for local consumption of energy, which is introduced a unique way of the modern age.

Advantages of Siphon Intake

Siphon intake was invented as low-cost and labor saving equipment as a means to let water flow over the bank between an irrigation pond and beneficiary paddy fields and to lead it to the generator. Water intake is started by a pump which pours water into the siphon tube and will not be used afterwards. Even though an electric bulb for problem handling and air ventilation is necessary, the equipment composition is quite simple as a method of water intake from an irrigation pond.

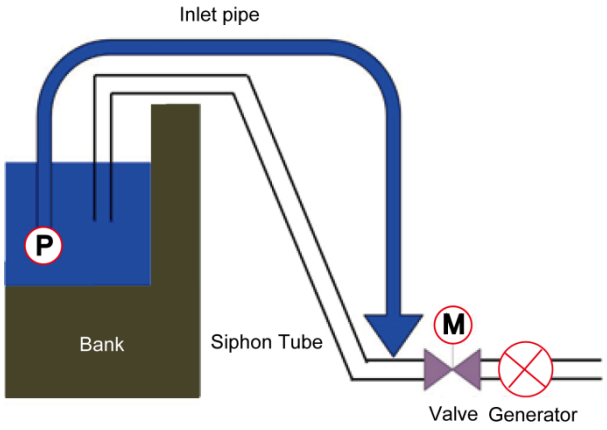
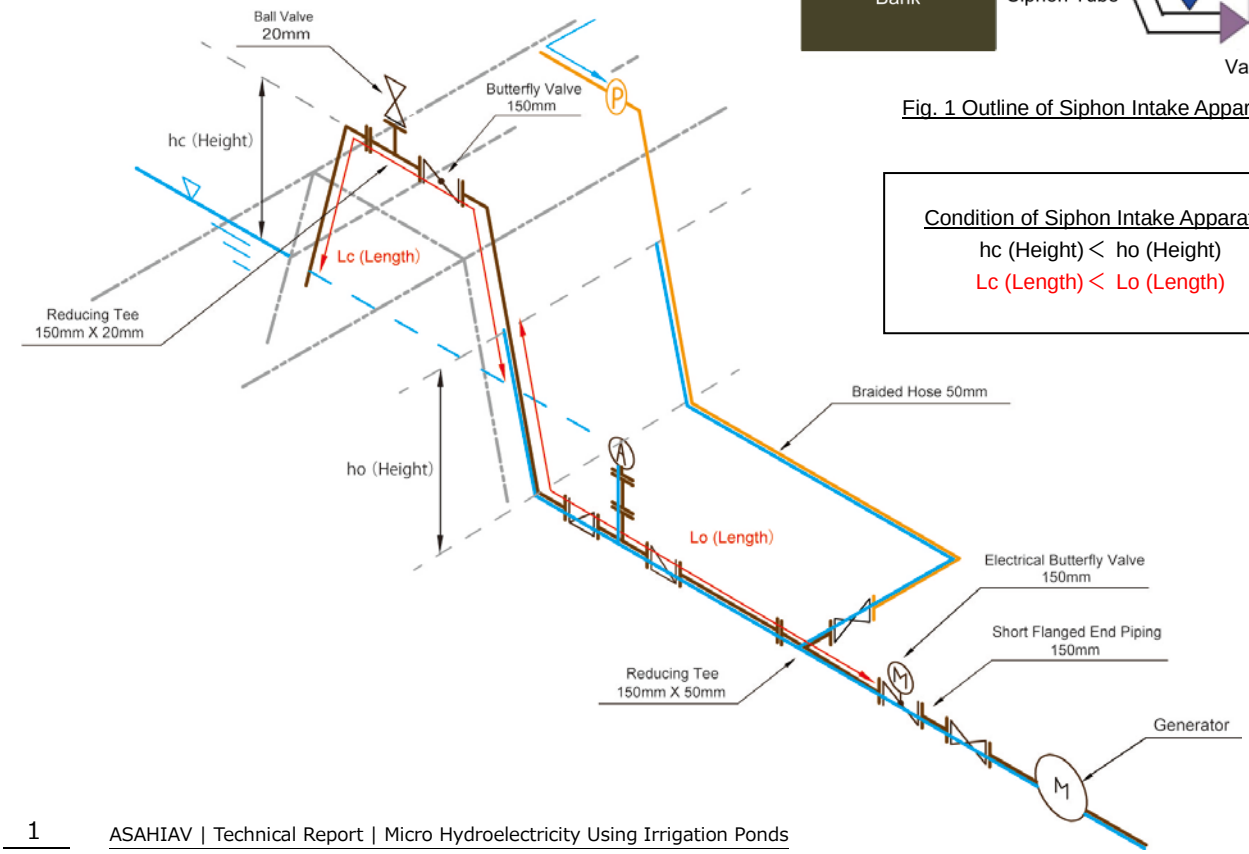


Fig. 1 Outline of Siphon Intake Apparatus



Condition of Siphon Intake Apparatus

hc (Height) < ho (Height)

Lc (Length) < Lo (Length)

Estimated Power Output [1)]

To estimate the power output, Nanatani pond and Matsutani pond in Tottori prefecture were selected. General information on the two irrigation ponds is summarized in Table 1. Since they are the irrigation ponds with relatively big water storage capacities in Tottori prefecture (Japan), stable power generation can be expected.

Table 1 General information on the Irrigation Ponds

Irrigation Pond	Nanatani Pond	Matsutani Pond
Storage Capacity ($x10^3m^3$)	210	259.2
Dam Height	12	16.5
Beneficiary Area of Paddy Fields	44.5	13
Catchment Area	0.3	0.62

Picture 2 Whole picture of siphon intake apparatus

Picture 3 Connection part of inlet pipe of Siphon Intake

As a monitoring survey, power output was estimated by measuring the following items.
Monitoring period: Mid-June to mid-September of 2010, 2011 and 2012

* Water level of the irrigation ponds
* Water level of the irrigation canals
* Precipitation
* H-V curve of the irrigation ponds
* H-Q curve of the irrigation canals

Fig. 2 Estimation results of power output for Nanatani Pond

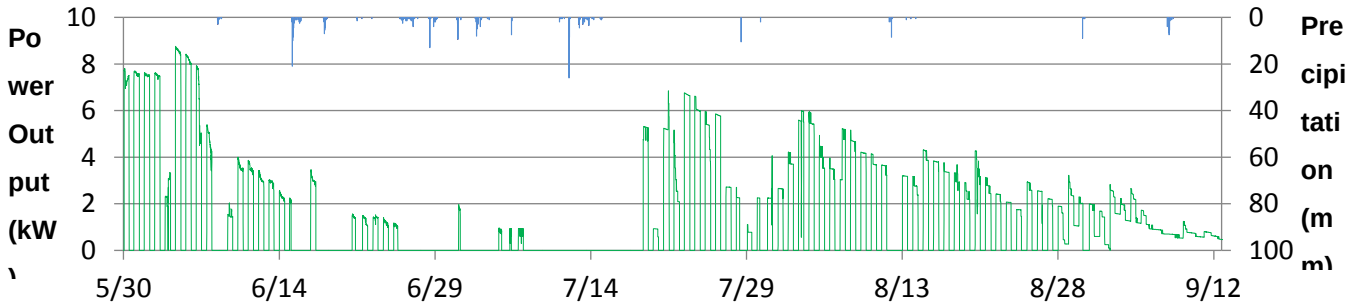


Fig. 3 Estimation results of power output for Matsutani Pond

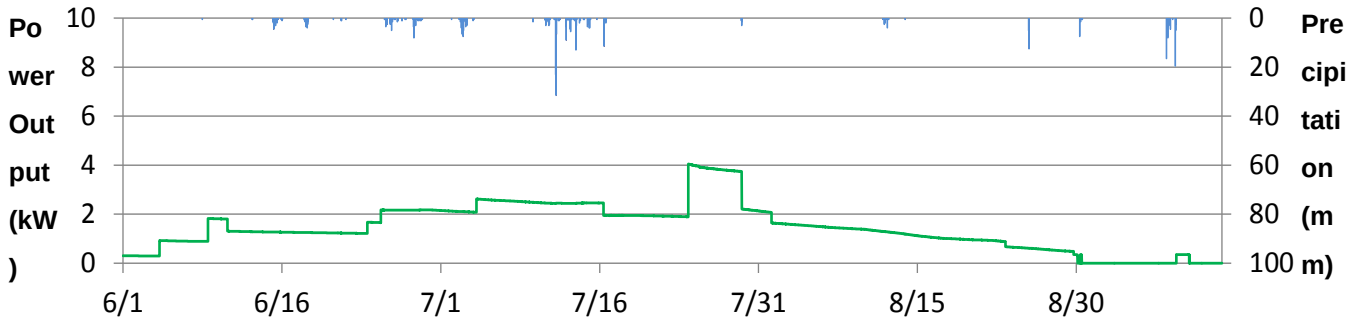


Table 2 Estimation results of power output

	Nanatani Pond	Nanatani Pond
Gross Generation (kWh)	1821	3443
Total Discharge (m^3)	199735	265182
Maximum Output (kW)	4.99	3.6
Average Output (kW)	1.69	1.32
Monitoring Time (h)	2538	2610
Discharge Time (h)	1080	2610
Generating Time (h)	1080	2610
CO_2 Conversion (kg・CO_2)	1011	1911
Oil Conversion (L)	463	875

Estimation results of power output are shown in Fig. 2, Fig. 3 and Table 2. The gross generation differs between Nanatani pond and Matsutani pond because water discharge takes place basically in the daytime at Nanatani pond. Like this, understanding of the managing method of an irrigation pond is the important factor for hydraulic power generation. In any event, the estimation results revealed the high potential of irrigation ponds.

Picture 4 Monitoring System
(Water Level and Temperature Sensor)

Picture 5 Monitoring through Smartphone

Conclusion

By estimating the power output in this occasion, we became aware of the high hydroelectricity potential of irrigation ponds. In the future, by means of the field experiments of power generation with siphon intake, accuracy improvement of the estimation results can be expected.

In addition, though it is not mentioned here, this siphon intake is also considered to be used without the generator part. As an approach to disaster prevention and mitigation for irrigation ponds at the time of heavy rain, it is expected to play an active role as emergency discharge equipment which is easy to operate and maintain as well as inexpensive. 2)

Acknowledgements

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References

1) Katsuyuki Shimizu, Yasuyuki Kusaka, Yoshinobu Kitamura, Koji Inosako,“Micro hydroelectricity using irrigation ponds for better water management”,22nd International Congress on Irrigation and Drainage & 65th IEC Meeting (2014)

2) Yuki Fukuda, Katsuyuki Shimizu, Yumi Yoshioka, Osamu Kinoshita, Yoshihide Tsumura and Koji Yamauchi: “Approach to Disaster Prevention and Mitigation of Yutani Irrigation Pond in Tottori Prefecture”, Water, Land and Environmental Engineering, 85 (1), Pages 37 - 40 (2017)