대한설비공학회 2006하계학술발표대회 논문집 pp.749~754

06-S-120

Numerical Analysis on the Flow Characteristics in Steam Ejector.

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Key words: driven ejector, Jet condenser, Aquafarm, Vacuum, Latent heat of evaporation

ABSTRACT: This study performed of a water cooling system by using a steam ejector and jet condenser to drop the temperature of the water in aquafarm by about 5℃ from 25℃ or higher. In this research, to replace the present water cooling system, we focused on a water cooling system operated by latent heat of evaporation, thus this system needs a vacuum pressure to evaporate the water in enclosed tank. The water cooling effects are dependent on the vacuum pressure in the enclosed tank, and the cooling water is generated by evaporation. As the experimental results, the absolute vacuum pressure obtained was about 5~8mmHg using a steam driven ejector with jet condenser in experiments. The obtained results are respectively ΔT=7℃, ΔT=5℃ and ΔT=5.5℃ at heat exchanger flow rate 4L/M. The obtained results are respectively ΔT=5.5℃, ΔT=5.5℃ and ΔT=5.5℃ at heat exchanger flow rate 4.5L/M.

Nomenclature

L_A : Air volume in enclosed tank [L]
L_w : Water volume in enclosed tank [L]
Q : Flow rate [L/min.]
T : Temperature [℃]

1. INTRODUCTION

In Korean aquaculture industry, flatfish and jacopever are preferred by fishermen on the ground that the former is characterized by the highly added value and better returns and the latter has advantage of raising the creatures. This implies that to help fries to quickly grow and to be strong enough to get over diseases needs to have much of melted oxygen, expecially to have a better control on temperature. Several investigations of aquaculture in sea water have been reported. Kim(1997)[3] examined the marine pollutions in view of biology. This biological treatment poses no problems to the aquaculture industry because the aquarium tank is separated from the water pollution. Partridge(1989)[6] and Sannomiya(1987)[5] examined the swimming structure and behavior of fish in an aquarium.

Takagi et al.(1993)[2]considered the effect of the aquarium tank size and shape. Generally, the aquaculture equipment has two types of closed

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and open flow systems. Jeong et al.(1998)[1] reported the flow characteristic by comparing a numerical analysis and flow visualization images. Hirashi et al. (1995)[7] examined the effect of water current in the aquaculture environments of the sea. The closed type is the system which the sea water is recirculated again in the aquarium tank. The water in the case of the open flow system is discharged into the sea. The first system needs more expensive equipment, but this system can save energy in heating the aquarium water during the winter season. Lee(1994)[4] carried out the experiment of a flow characteristics in the closed aquarium. In the design of the aquaculture tank, what need to be emphasized are the aquaculture environments. This means that the wrong design can cause mass mortality of breeding fish.

There are many important factors for breeding fish in an aquafarm. Some of these factors are biological others include sea water temperature and so on. What is especially important for good quality is the maintenance of the optimum aquaculture temperature. In summertime, when sea temperatures rise above 25℃ the growth condition is greater and diseases in fish spread.

Therefore, we performed a study of a sea water cooling system by using a steam ejector to drop the temperature of the water in the aquafarm by about 5℃ from 25℃ or higher. To replace the present water cooling system, we focused on a system operated by the latent heat of evaporation, using a vacuum pressure to evaporate the water in enclosed tank. The water cooling effects are dependent on the vacuum pressure in the enclosed tank, and the cooling water is generated by evaporation.

Much attention is given to dual-evaporator refrigeration cycles in these days.[4-8]

2. Experimental apparatus and description.

The cooling effects are dependent on the vacuum pressure, thus the vacuum pump has to achieve the pressure of evaporation. As the general vacuum pump is designed for high vacuuming in a small space, the ejector pump system is more suitable than the vacuum pump. In this paper, the steam driven ejector pump system is proposed for vacuuming in the enclosed tank.

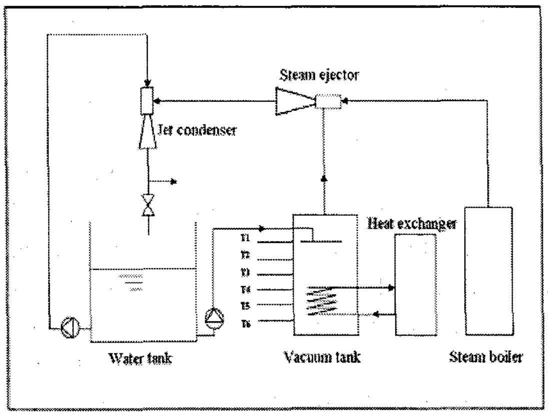


Fig. 1 Schematic diagram of the experimental apparatus.

Fig. 1 shows the experimental apparatus to measure the effect of vacuum levels in the enclosed tank. The designed vacuum chamber has a capacity of 200L and the inside air of the vacuum tank is evacuated by a steam driven ejector. One heat exchanger was installed in the experimental apparatus.

Fig. 1 shows the system generating cooling water by using latent heat of evaporation at low pressure. The low pressure generating system adopts vapor driven in this research. The vapor is created by a steam boiler and goes through a steam ejector. As the steam which passed the ejector goes through a jet condenser, it drops the pressure inside of the vacuum tank to a vaporable pressure.

The pressure transducer (PSHA0760HAAJ) was installed on the top of the vacuum tank. Six thermocouples(RTD PT100Ω) were installed inside vacuum tank at regular intervals. Thepressure signal is transmitted to a personal computer and data logger (DA100,

YOKO-GAWA).

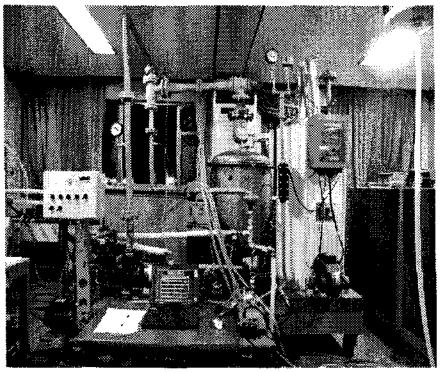


Fig. 2 Photography of experimental setup.

Fig. 2 shows photography of experimental setup of steam ejector. The pressure and temperature signal are transmitted to a personal computer and data logger.

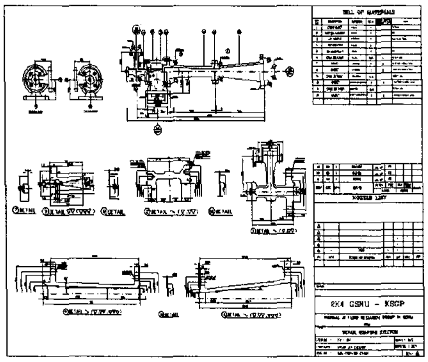


Fig. 3 Drawing of steam ejector.

Fig. 3 shows the drawing of a steam ejector. The steam ejector is constructed of three parts; a suction chamber, a motive nozzle and a diffuser. The high velocity jet stream of steam emitted by the motive nozzle creates a suction chamber, which draws the low pressure gases. The diffuser converts the kinetic energy of high velocity flow to pressure energy.

Table 1, 2 is processed as follow method. The steam ejector is operated after getting 60mmHg vacuum pressure by using a jet condenser, and then cooling efficiency is measured by experiments with each flow rate of heat exchanger.

Table. 1 Experimental parameters for water cooling efficiency of heat exchanger flow rate at 4L/M.

	Type1	Type2	Type3
Enclosed tank volume(Liter)	200	200	200
Filled water and air volume(Liter)	$50L_w$ $150L_a$	$100L_w$ $100L_a$	$150L_w$ $50L_a$
Steam pressure (kgf/cm^2)	4 ~ 5kgf/cm^2	4 ~ 5kgf/cm^2	4 ~ 5kgf/cm^2
Flow rate into heat exchanger Q(L/M)	4L/M	4L/M	4L/M

Table. 2 Experimental parameters for water cooling efficiency of heat exchanger flow rate at 4.5L/M.

	Type4	Type5	Type6
Enclosed tank volume(Liter)	200	200	200
Filled water and air volume(Liter)	$50L_w$ $150L_a$	$100L_w$ $100L_a$	$150L_w$ $50L_a$
Steam pressure (kgf/cm^2)	4 ~ 5kgf/cm^2	4 ~ 5kgf/cm^2	4 ~ 5kgf/cm^2
Flow rate into heat exchanger Q(L/M)	4.5 L/M	4.5 L/M	4.5 L/M

3. Results and discussion

To achieve cooling water, the water should be in an evaporating condition.

This condition can be achieved by vacuuming. Fig. 4 shows the vapor pressure and temperature curve. The pressure in the vacuum chamber has to search the vapor pressure to obtain the cooling effects by using the latent heat of evaporating.

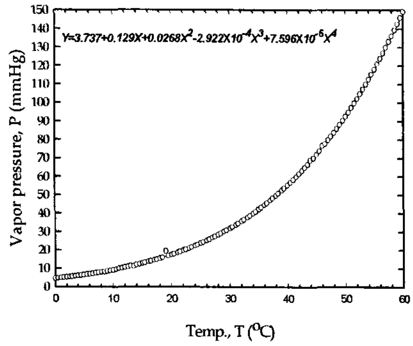


Fig. 4 Characteristics curve of vapor pressure by the variation of temperature at 0℃≤T≤60℃.

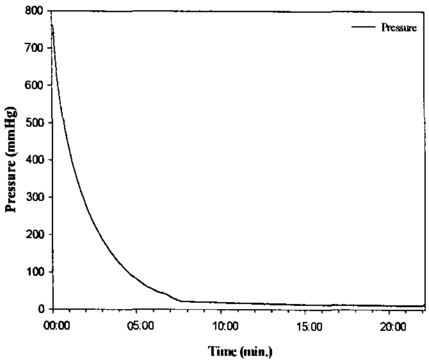


Fig. 5 Vacuum pressure of Type1 in table 1.

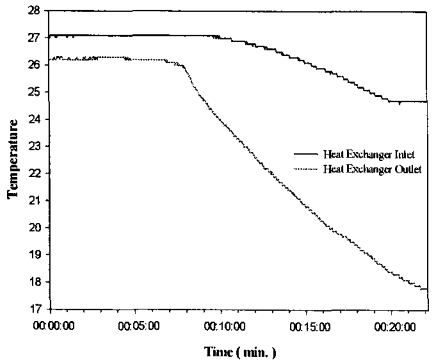


Fig. 6 Variation temperature of heat exchanger at Type1 in table 1.

Fig. 5, 7 and 9 show vacuum pressure of heat exchanger flow rate at 4L/M and the absolute vacuum pressure obtained was about 5~8mmHg at this point.

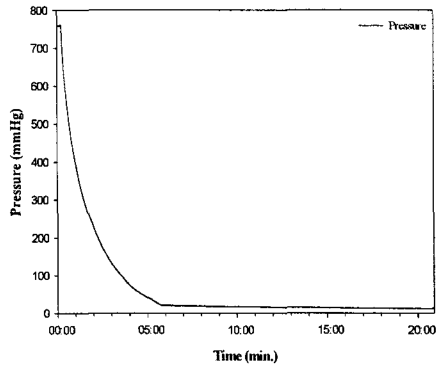


Fig. 7 Vacuum pressure of Type2 in table 1.

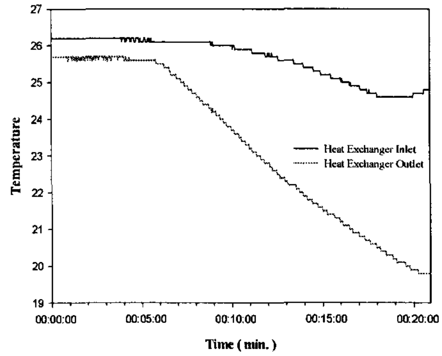


Fig. 8 Variation temperature of heat exchanger at Type2 in table 1.

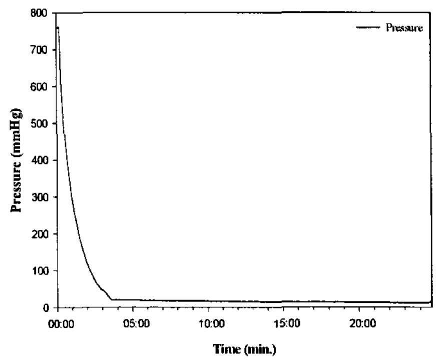


Fig. 9 Vacuum pressure of Type3 in table 1.

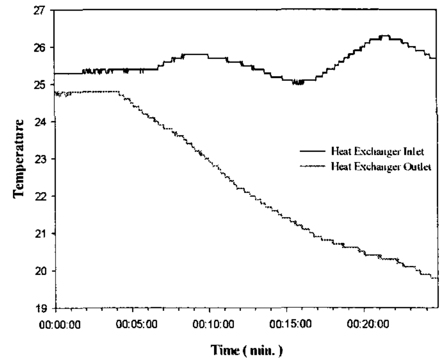


Fig. 10 Variation temperature of heat

exchanger at Type3 in table 1.

Fig. 6, 8 and 10 is the graphs of temperature difference of heat exchanger. The obtained results are respectively ΔT=7℃, ΔT=5℃ and ΔT=5.5℃.

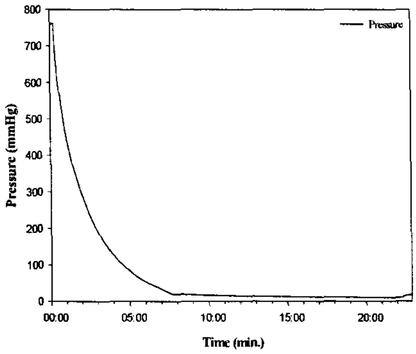


Fig. 11 Vcauum pressure of Type4 in table 2.

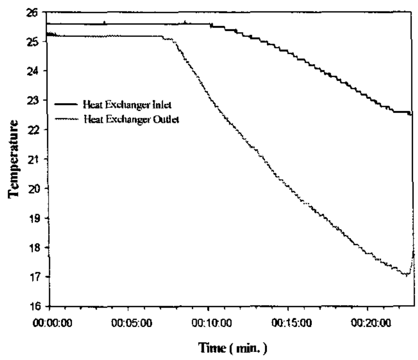
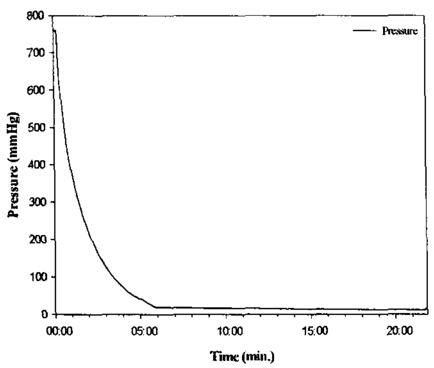
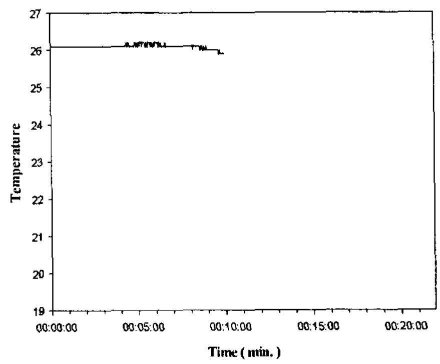


Fig. 12 Variation temperature of heat exchanger at Type4 in table 2.



. Fig. 13 Vacuum pressure of Type5 in table 2.



at 4L/M and 4.5L/M are compared bigger temperature difference can be obtained with lower flow rate.

4. CONCLUSIONS

In this research, we proposed a water cooling system by latent heat of evaporation. This system consists of the enclosed vacuum tank and steam driven ejector with jet condenser. From an experimental result, the conclusions are summarized as follows;

Water temperature proposed in this research is 25℃ and higher and the cooling system that temperature difference is about 5℃ was introduced.

As the experimental results, the absolute vacuum pressure obtained was about 5~8mmHg using a steam driven ejector with jet condenser in experiments.

The obtained results are respectively ΔT=7℃, ΔT=5℃ and ΔT=5.5℃ at heat exchanger flow rate 4L/M.

The obtained results are respectively ΔT=5.5℃, ΔT=5.5℃ and ΔT=5.5℃ at heat exchanger flow rate 4.5L/M.

The proper cooling effect needed in this research can be obtained by using heat exchanger.

ACKNOWLEDGEMENT

This work was supported by the Post BK21, Korea Sea grant Program by Ministry of Marine Affairs & Fisheries, the Program for the Training of Graduate Students in Regional Innovation which was conducted by the Ministry of Commerce, Industry and Energy of Korean Government, the authors gratefully appreciate for the support.

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