

Automatic Unloading System for Modernizing the Busan Cooperative Fish Market

Kyung-Chang Lee*, Young-Seok Jung**, Sung-Woo Kwak*, Jeong-Hyun Sohn**,#

*Department of Control and Measurement Engineering, PKNU,

**Department of Mechanical Design Engineering, PKNU

부산공동어시장 현대화를 위한 양륙자동화설비 구축 방안에 관한 연구

이경창*, 정영석**, 곽성우*, 손정현**,#

*부경대학교 제어계측공학과, **부경대학교 기계설계공학과

(Received 10 August 2020; received in revised form 12 October 2020; accepted 26 October 2020)

ABSTRACT

Currently, the Busan cooperative fish market follows a traditional market style. This study first investigates the current conditions and environment of the market, and to modernize the market, it proposes a new automatic unloading system based on the benchmark of Namhae Suhyup. In this system, a Korean-type suction fish vacuum pump is employed to increase the loading time. An automatic grader with an adjusting device for inclined angles and a weighing machine with an automatic alignment device are proposed. In addition, a folding machine is employed to prepare boxes. The specifications for each subsystem are provided. By implementing this system, the freshness of fish can be maintained and the sellers can earn more. This system can also be applied to the cooling system of the fish reservoir of littoral sea fishing boats.

Keywords : Unloading Automatic System(양륙자동화시스템), Automatic Grader(자동선별기), Automatic Packing System(자동포장시스템)

1. Introduction

In advanced countries such as Norway, Scotland, and Ireland, after the electronic auction of the fishery products is conducted instead of the consignment sale in the fish market, fish landing net carriers are berthed in front of the processing plant

to maintain the freshness of the fish by adopting a one-stop treatment from unloading to freezing. In the wholesale market in Hachinohe City, Japan, the automation of landing facilities has been realized by introducing fish pumps, fish transporters, packaging lines, and electronic bidding systems. In the Matsuura fish market in Japan, the landing process is divided into two stages. The first stage involves the processes from the dock to the landing net and through the sorter to the catcher. In the second

Corresponding Author : jhsohn@pknu.ac.kr

Tel: +82-051-629-6166, Fax: +82-051-629-6150

stage, after the auction is completed, the middle wholesalers use their own catcher cans to transport the products to the packaging processing plants and to the packaging machine through a conveyor before finally shipping them. Thus, the fishery products obtained from the landing until shipment do not touch the floor of the consignment sale center, thereby maintaining a hygienic process. The landing, sorting, packaging, second-packing, and shipping areas are all separated, unlike in the domestic consignment sale center. After the auction, the fishery products are washed with sterilized cold sea water, which maintains their freshness, and are re-packed in shipping boxes to complete shipment preparation. The increase in the quantity of landing and the possibility of standardization have led to increased overall sales. Moreover, the time for landing, packaging, and shipping has been shortened by the introduction of sanitary treatment facilities and automation of landing and sorting. In Norway, which commercializes fish pumps, large-scale ships, single-line fishing, and seawater cooling systems are used, thus realizing a well-developed automated system for landing large quantities of fish.

In advanced countries, as described above, the freshness of fish is maintained by rapid processing realized through the establishment of electronic auctions and automated lines. By contrast, the entire process of catching and processing of mackerel in Korea is as follows. After a large fishing trawler arrives in the port, it takes approximately 3 hours to land and sort the fish. Then, after the auction, approximately 2 hours of rework is done by intermediate wholesalers. Finally, about 4 hours are required to complete loading of the fish for delivery. Overall, the mackerels are exposed to room temperature for approximately 8 hours after landing, during which, an appropriate freshness management process is not adopted, thereby compromising on the freshness of the fish. According to a survey conducted by the Korea Institute of Maritime Affairs

and Fisheries on 289 fishery workers across the country regarding post-fishing treatment, only 21.6% of the consignment sales centers have a temperature-control system. In case of fish packing, most of the consignment sales centers rely on manual operation, with only 5.9% using automatic packaging machines^[1]. Due to the characteristics of marine products, freshness control is essential, and rapid and systematic landing and selection processes are required.

This study aims to analyze the current status of the Busan Cooperative Fish Market, and review the construction plan of facilities for realizing modernization of the facilities in the future.

2. Current Status of the Busan Cooperative Fish Market

The establishment of the Busan Cooperative Fish Market was approved in the 52nd Cabinet Council on August 21, 1959, and was opened as the Busan General Fish Market in November 1963. In January 1971, the name was changed to the Busan Cooperative Fish Market, and the current maximum consignment sales amount per day is 3200 tons, accounting to up to 30% of the domestic fishery product consignment sales. The mackerel consignment sales amount accounts for 70%–80% of the nation's stock. In February 2017, the cooperative joint business corporation was approved by the Ministry of Oceans and Fisheries. Fig. 1 shows an



Fig. 1 Busan cooperative fish market

Table 1 Main facilities

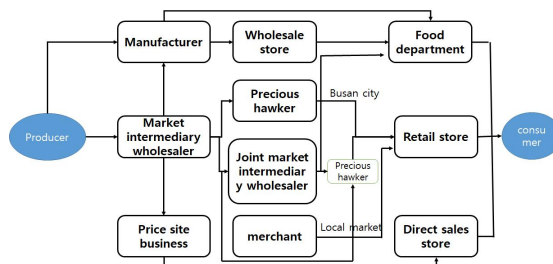
Item	Specifications
total areas	43,134m ²
alimony capacity	Max 3,200ton/day
come alongside pier	1,016m
live fish market	200m ²

Table 2 Other facilities

Item	Specifications
refrigeration factory	6,629m ²
office	16,316m ²
storage	1,445m ²
fisherman house	443m ²
parking lot	13,802m ²
marine product market	3,970m ²
waste water treatment	1,300m ² /day capacity
water treatment facility	1,000m ² /day capacity
water supply for fish ship	reservoir 1,000m ²

image of the cooperative fish market. Although it is the largest fish market for mackerel, there is scope for improvement as various facilities are aging and not sufficiently hygienic for the largest fish market in the country. The city of Busan aims to complete the modernization project by 2022, which involves establishment of the consignment sales center, refrigeration plant, wastewater treatment facility, and business parking facility. The plan is to realize the state-of-the-art consignment sales facility that provides automated logistics, distribution, processing, and packaging activities and to promote it as a seafood experience and tourism facility. Table 1 shows the consignment sales facilities of the Busan Cooperative Fish Market, and Table 2 shows the surrounding facilities.

Fig. 2 shows the process flow of the seafood supply chain. Consumers receive seafood from the producers through middle wholesalers at the source fish market, small-scale matchmakers, and retailers. The Busan Cooperative Fish Market handles coast fish, ocean fish, and imported fish, as shown in Table 3.

**Fig. 2 Flow chart of busan cooperative fish market****Table 3 Handling fisheries**

Item	Fish species
soft-grilled catch	mackerel, hairtail, squid, croaker, Japanes Spanish mackerel and 100 species, etc.
ocean catch	All fish species
imported marine product	All fish species

3. Plan for Constructing Modernized Facilities

The Busan Cooperative Fish Market covers a total area of 43,134 m² and has a consignment sales capacity of 3,200 tons per day. Auxiliary facilities, such as refrigeration plants, offices, and parking lots also need modernization. However, this study limits its scope to the modernization of the consignment sales center facilities. An example of the actual application of a landing automation facility that can be installed at the consignment sales center is the Mijo Port Suhyup consignment sales center in the South Sea, which has recently been installed and operated^[2-4]. It is reasonable to consider this center as a reference to plan the facility construction for modernizing the Busan Cooperative Fish Market, even though it has less number of installed lines owing to its smaller scale compared to the Busan market. Fig. 3 shows the facilities installed in the Mijo Port in the South Sea. It uses landing automation facilities for mackerel carriers and adopts



(a) Fish pump



(e) Packing system



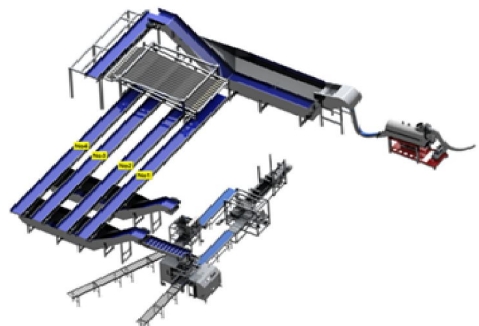
(b) Main hopper



(f) Boxing machine



(c) Automatic grader



(g) Total automatic unloading system



(d) Conveyor

Fig. 3 Site of automatic unloading system(Namhae Mizo Port)

the following landing and packing processes:

- (a) A suction pipe is inserted into the fish tank of the mackerel carrier and the mackerel is landed at the main hopper by using a fish pump.
- (b) The mackerel stored in the main hopper is transported to the entrance of the automatic sorting machine through a conveyor belt.

- (c) The mackerel input in the automatic sorting machine is sorted into four lines according to the size of the mackerel.
- (d) The sorted mackerel is transferred to the intermediate hopper or packaging line through a transfer conveyor.
- (e) In an integrated packaging system, a plastic covering is placed in a box, a certain amount of mackerel that has passed through a weighing machine is filled in the box, the packaging plastic is cut, and the box is transferred to the subsequent processing unit.
- (f) The boxes used in the integrated packaging system are prepared using a box manufacturing machine installed in a separate space and supplied through a conveyor belt.

The landing automation system installed in the Mijo Port is suitable for a relatively small consignment sales center. Nevertheless, on the basis of this automation system, in this study, the requirements of the facilities to be installed in the Busan Cooperative Fish Market are summarized as follows.

(1) Fish pump

The operation of the fish pump installed in the Mijo Port is monitored and turned on or off by the operator while pumping from the fish tank. For the Busan Cooperative Fish Market, it is necessary to control the operating speed of the pump according to the processing speed of the main hopper and sorter and the pump’s capacity must be expanded. Currently, in the Mijo Port, 40 tons per hour can be processed, but the Busan fish market is proposed to handle more than 60 tons per hour. In addition, the fish pump needs to be constructed in such a manner that it is movable according to the position of the berthing ship, and multiple fish pumps are required to supply catches to several sorters simultaneously.

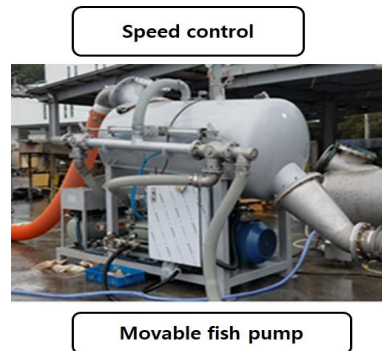


Fig. 4 Intelligent fish pump

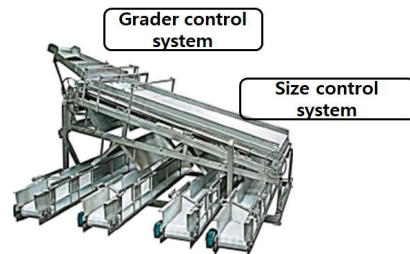


Fig. 5 Intelligent automatic grader

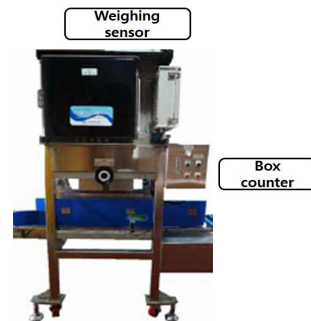


Fig. 6 Total packing system

(2) Automatic sorting machine

It is proposed to install an automatic sorting machine to effectively sort the fish transferred through the conveyor belt by weight or size. Fig. 5 shows an automatic sorter. The distance between the rollers in the automatic sorter can be individually controlled through which the transported fish can pass by size, and the space utilization of containers

can be improved by properly accommodating the sorted fish in them. It is proposed to install an automatic sorter that comprises a tilt angle control device and a sorting size control device.

(3) Integrated packaging system

Fig. 6 shows the integrated packaging system. A static weight meter weighs and transports fish sorted by size before final packaging. This essential post-treatment equipment must process large quantities quickly and accurately. For this purpose, the processes of weighing the sorted fish and inserting the plastic cover in the box must be completed quickly and accurately. In conventional metering devices, weight is measured with a capacity level sensor, which has a relatively large error rate; therefore, a more precise weighing sensor such as a load cell needs to be installed. In addition, durability of the plastic inserter must be ensured because it performs repetitive tasks within a short time. Furthermore, the number of boxes shipped needs to be monitored to determine the processing capacity immediately, and this must be linked with the integrated control operation system. The box manufacturing machine is a part of the automatic integrated packaging system; it automatically prepares boxes by detecting the location and shape of the corrugated cardboard. The weighed fish is packaged by placing it in a standard set of cardboard boxes with the plastic covering.

(4) Overall system configuration

The line arrangement of the entire system can be configured according to the installation area of the consignment sales center. The post-treatment process is the most important, and the integrated packaging system must be arranged for each line to be installed. In addition, although unmanned operation is crucial in the system, monitoring by personnel is required. By greatly reducing the time required for the processes performed at the consignment sales

Table 4 Total unloading system specifications

System	Requirements
Fish pump	5set
Automatic grader	5set, 40ton/hr
Conveyor belt	15set
Boxing machine	8set, 900box/hr
Packing system	15set, 720box/hr

center, it is possible to solve the problems related to maintaining freshness and hygiene in case of the conventional method of arranging or conducting auctions after loading or placing fish on the floor. Moreover, reducing the required manpower will greatly improve the process efficiency. Table 4 shows the specifications of the entire landing system.

The landing automation system is advantageous in maintaining freshness and improving hygiene for the general public, who are the final consumers of seafood, amid increasing interest in food safety in recent years. The landing automation system can cope with the reduction in the manual labor supply. Especially, the labor force required in the existing manual labor system for screening has its own capabilities, whereas the labor in the landing automation system is relatively standardized, allowing ordinary daily workers to sufficiently perform their roles. In this regard, both labor and recruitment costs can be reduced. Recruitment cost refers to the time and material cost required to obtain the right manpower in a timely manner, and some fish markets are currently spending considerable effort in recruitment. In the current situation of the modernization projects for the Busan Cooperative Fish Market, allocation of space for the landing automation system can be easily achieved and the cost burden can be reduced through government support projects.

4. Conclusion

In this study, the present situation of the Busan Cooperative Fish Market was analyzed and the construction plan of facilities required for modernization in the future was examined. By building landing automation facilities that integrate the fourth industrial revolution technologies such as Internet of Things, the efficiency of the management system and the reliability of the distribution environment can be further improved. In addition, the landing automation facility is expected to greatly contribute to the improvement of the aging consignment sales centers in Korea and to generate significant profits on the income from fisheries-related activities.

M., Kim, P. H., Heo, J. H., “Development and test of the automatic unloading system including fish pump, Proceedings of KSMPE fall conference, pp. 1, 2019.

Acknowledgement

This thesis was supported by the National University Promotion Program Supporting Fund for Pukyong National University in 2020.

References

1. Kim, D. Y., Kang, J. H., “Comparison of distribution competitiveness of the mackerel industry between Korea and Norway”, *Journal of Fisheries and Marine Sciences Education*, Vol. 27, No. 6, pp. 1685~1692, 2015.
2. Jun, C. W., Sohn, J. H., Choi, M. G., “Analysis of mackerel sorting performance for development of automatic mackerel grader”, *Journal of the Korean Society of Manufacturing Process Engineers*, Vol. 15, No. 3, pp. 115~121, 2016.
3. Jung, S. H., Jun, C. W., Sohn, J. H., “A Study on the development of automatic unloading system including fish pump”, *Proceedings of KSMPE spring conference*, pp. 172, 2019.
4. Jung, S. H., Jun, C. W., Sohn, J. H., Bae, S.