Conference Paper

South Sea Pearl Shell Quality Inspection Using X–Ray Digital Radiography

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Abstract

South sea pearl from Indonesia has been prominent in the sea pearl world market. The south sea pearls are produced from shells, *Pinctada maxima* (Jameson, 1901). However, the quality of the south sea pearl of Indonesia commonly unspecified so that they are sold in bulk quantity to the world market. One of the problems is that due to lack of inspection technology access in order to define the sea pearl quality. The production of good quality sea pearls need a series of treatment for the shell. The process also takes a long time, about 2 yr to 3 yr. This paper presents in developing inspection technology using digital X-ray radiography and the way to define the dimension in correlation with its age. More specific is trying to distinguish the influence of culture period to the dimension of the sea pearl inside the shell. The existence of the sea pearl and its dimension are defined based on the digital radiography images. From the experiment, it is found the dimension of the sea pearl is dependent on the culture period.

Keywords: Digital radiography, Pearls, *Pinctada maxima* (Jameson, 1901), Quality control, X-ray inspection

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1. Introduction

South sea pearl product occupies half of the world market share. South sea pearl from Indonesia is considered very famous. Mostly, the south sea pearl is harvested from the *Pinctada maxima* (Jameson, 1901) [1]. Other type of pearls such as Akoya pearls may be produced from *Pinctada fucata* (Gould, 1850) [2]. In 2005, Indonesia was the biggest producer in the world at about 40 %. However, in 2011 the product of south sea pearls from Indonesia declined far after Australia. The decline is due to lack of science and technology in the way to enhance the quality and to increase the quantity of pearl production.

There are many technology and method can be used for quality inspection, such as X–ray luminescence [3], X–ray computed micro–tomography [4], ultraviolet–visible reflectance or fluorescence spectrum [4, 5] or using X–ray micro–radiography [6]. However, those needs financial capability and complicated technology operation.

Many research has been carried out in order to enhance the shell quality. Fouling organisms may affect to faulty of age and shell size [7]. The quality of pearl may be affected by the gender of the shell [8]. It may also be affected by the host and donor of certain oyster [9]. The round shape of the pearl may be affected by the culture method difference [10].

Understanding the access to the X–ray digital radioscopy is limited, we have developed another variant of an X–ray digital radiography system for shell inspection under UGM PUPT project scheme in 2014 to 2016. The schematic system is described in Fig. 1. It comprises an X–ray generator, a radioscopy unit along with a CCD camera, a control panel along with a display monitor and a cabinet that is encapsulated the X–ray generator and the radioscopy unit. In the control panel, there are interfaces for controlling X–ray exposure, capturing radiography images, controlling mechanics, and computer for handling all process and image processing. The cabinet of the system is covered by shielding of lead of 2 mm thickness surround. The X–ray can be operated at 60 kV to 7 kV, 30 mA to 50 mA, The research recommendation working is set up at low current Sample or shells can be loaded or unloaded on the object stage, close to the front end of the radioscopy unit. Once the sample is loaded, a radiography session can be performed and then the digital radiography image instantly appears on the monitor display. The user can do further processing and analysis following the protocols that we have developed.

This paper describes preliminary experience in developing an X–ray digital radiography system for shell inspection. The images are recorded in digital format. It can be presented in good contrast. The decision leads to the conclusion on pearls specification being harvested. Based on the study, it could be found on the relation between the diameter of the pearl within the shell and the period of cultivation in order to consider the appropriate harvest time.

2. Research Method

This research was conducted in the Department of Physics, Universitas Gadjah Mada. Samples have been obtained from Timor Otsuka Mutiara Co. Ltd. in Kupang, East Nusa Tenggara, Indonesia. Samples are identified based on the period of cultivation after it was injected with the nucleus. The radiograph images obtained from each shell, and then the findings based on image analysis were correlated to the physical data set.

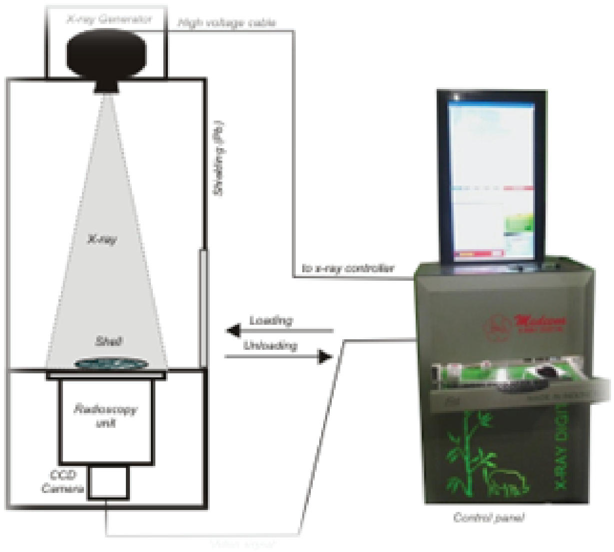

Figure 1: The X-ray digital radiography system for shell inspection. It comprises X-ray generator and radioscopy unit with CCD camera. All are encapsulated in cabinet with lead shielding to ensure the radiation safety. The system controlled digitally from computer panel remotely.

Figure 2: The samples harvested from the cultivation area.

All samples are obtained directly from the site based on the period of cultivation in Timor. The shells were cleaned to reduce corals upon its body as shown in Fig. 2a. Shells are collected in bins and check visually for any defects or dead shells as shown in Fig. 2b. The eligible shells are then checked using an analog radioscopy unit in order to see the presence of the pearls and its position within the shells as shown in Fig. 2c. Next, six samples are randomly selected based on the period of cultivation. Those are sent to the Universitas Gadjah Mada for laboratory testing.

The test used living six shells. The nucleus is about 2.3 mm of golden color. The diameter of the shell is about 8 cm. Following the cultivation, it have identified all shells based on its cultivation. The shell control (T.0) was at 11 mo, followed by 14.8 mo (T.1), 19 mo (T.2), 24.5 mo (T.3), 27.5 mo (T4) and 31.5 mo (T.5). Those are presented in Fig. 3.

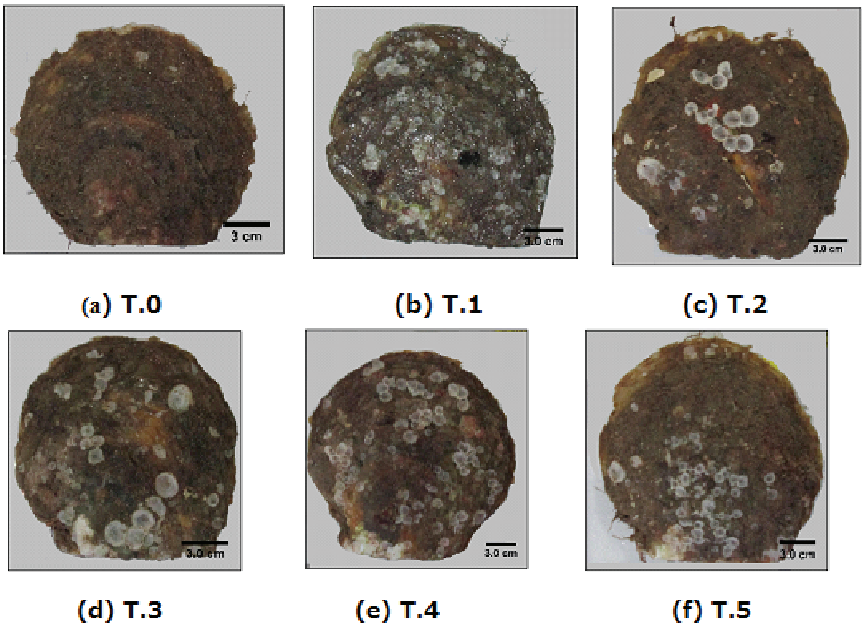

Figure 3: The shells of *Pinctada maxima* and their identification. Fouling organism may mislead the age and size shell.

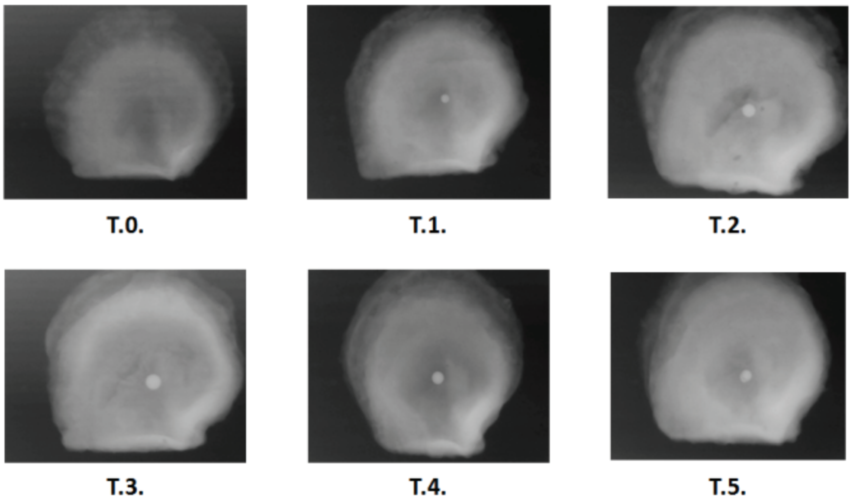

Figure 4: Radiographs of the shells of *Pinctada maxima* along with pearls inside. T.0. is the control (no pearl).

Once the arrived in Gadjah Mada University, the shell should be treated carefully to ensure the shell was still alive. Then, the shells were prepared for digital radiography session. The X–ray generator was set to the power of 60 kV/50 mA for 0.5 s of exposure. Software for image collection and image processing were developed customized for the specific purpose. Each shell collected up to four digital images per exposure. Then, image processing session is carried out to reduce noise and to enhance the image contrast. Analysis of the shell is carried out based on the diameter of pearls inside the shells and after it took out from the shell.

3. Results and Discussion

Digital radiography have images of the shells as shown in Fig. 4. As it is depicted, T.0 is the control with no pearl inside the shell. From the picture, it is shown that visually there is no significant correlation between the diameters of pearl inside with the diameter of the shells. It is also clearly shown that the T.5 has an irregular shape, which is considered to be rejected. It is expected that the pearls are growing in size as a function of the period of time cultivation. However, the T.4 looks smaller than T.3. This is considered to be an anomaly.

The grey level (or intensity) of the pearl inside are also inspected. Regardless the shell thickness, it is found that the intensity of the pearl tends to increase as the diameter of the pearl increases. This is due to the X-ray penetration is reduced as it passes through the bigger size of the pearl. The T.5 is barrock type so that it is excluded from some target analysis. Similar to T.4, it is clearly shown that is smaller than the T.3 so that it is also excluded. So, despite of the type of the pearl due to imperfectness, the assumption of the intensity increases as the diameter of pearl icrease is still valid.

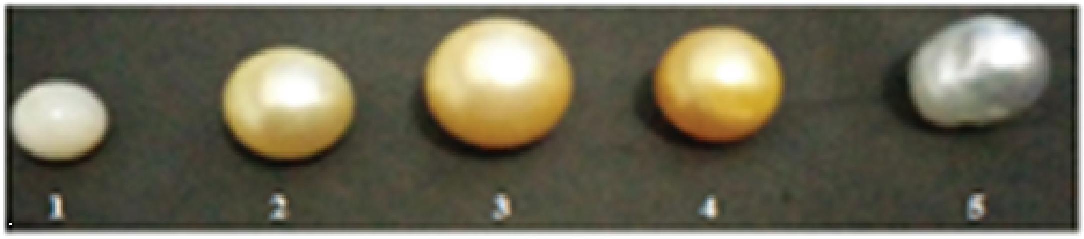

Figure 5: The actual pearl of T.0. – T.5, after they are harvested from the its shell.

Under visual inspection on the pearl, after it is harvested from the shell, it is clearly shown that the pearl size is consistent with its image in the shell as indicated in Fig. 5. Thus digital radiography is a good method to determining the size of the pearl inside the shell. The radiography images can be used to deduct the appropriate time for harvesting the pearl based on its diameter.

Table 1 presents tabulation of the relation of pearl size inside the shell, after outside and the type of the harvested pearl. For the time being, it is found that pearl diameter of 11.2 mm may be achieved for 24.5 mo time of cultivation. It can be expected that the harvest time may be saved about 6 mo earlier of 3 yr time of cultivation. The saving time of 1.5 yr may be deducted for 4 yr time of cultivation. Thus digital radiography can be used to monitor the pearl development so that eventually the harvest time can be deducted correctly.

Table 1: Relation of size of pearl inside and outside the shell, and the type of the harvested pearl.

ID No.	Diameter (pixels) (± 1)	Diameter (mm) (± 0.01)	Actual Diameter (mm) (± 0.01)	Intensity (greylevel) (± 2)	Type of pearl
T.0.	-	-	-	-	control
T.1.	11	9.6	6.4	118	normal
T.2.	19	9.8	9.4	134	normal
T.3.	22	11.4	8.4	142	normal
T.4.	17	8.7	9.6	128	anomaly
T.5.	18	9.5	11.2	131	barrock

4. Conclusions

From this preliminary experience, the X–ray digital radiography system that was developed in the department can be used for shell inspection in order to see the pearl inside the shell. From the radiography image, the size of pearl inside can be determined. There is a correlation between the sizes of the pearl to the period of cultivation.

The intensity (grey level) distribution in the image of the pearl may be used to deduct the type of the pearl. Any anomalies such as barrock form or smaller size than expected can be examined from the image. However, the size of the shell has no correlation with the size of the pearl inside the shell.

Through the study of its radiography images, the best time for harvesting the pearl upon a certain specification may be concluded. Upon certain conditions, the time of cultivation that leads to save the cost and meets to specific requirements may be determined.

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