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Stress Distribution Analysis of Two Aluminium Hook Models by Photoelasticity Method

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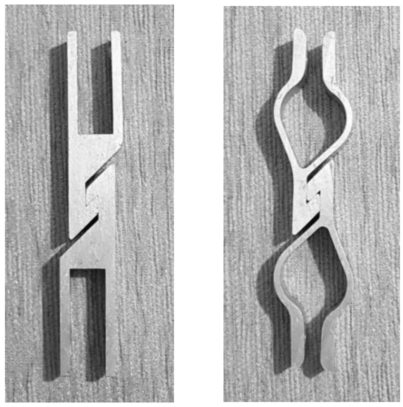
Abstract

There are two profile models that serves as a hook. These models were made from 6061 series aluminium materials, working on the load of 3 – 10 kg and these hooks area is corrosive. Two hook models have geometric resemblance but work the same. Therefore, these two hook models would like to be comparable with one another, in order to figure out which model is better to withstand the workload of 3 – 10 kg. One analysis to perform is by stress distribution occurs in two models with two-dimensional photoelasticity experimental methods. Experimental method was carried out by modeling of light translucent material that was Araldite B. Results of the provided photoelasticity was isochromate pattern by merging light and dark area with a load of each hook model by 1 – 5 kg. Analysis of isochromate pattern of these hook models have the same fracture critical areas to various loading. Stress distribution pattern formed on the same loading, it indicates that the first hook model hold up the load better compared to the second hook model. The average stress that occurs between the two hook models is around 1.204%.

Keywords: Two Aluminium Hook Model 6061 series, Stress Distribution, Photoelasticity, Isochromate.

INTRODUCTION

There were two models of series 6061 aluminium profile, this model is made by extrusion. These two profile models can be referred to figure 1. This profile works to lift the load. One model was self-attached one as well as other models. Length of the applied hook was about 620 mm, while the working area of these hooks is corrosive and operational loads of the two hooks models was around 3 – 10 kg [1]. In designing a component, it shall be safe or have suffered no fractures under certain circumstances. One analysis to apply in the design was analysis of stress distribution by photoelasticity method.



(a) (b)

Figure 1. Aluminium Hook Model

(a) First model and (b) Second model

Photoelasticity is one of experimental methods applied to analyze stresses that occur in an experimental model [2, 3, 4, 5, 6]. Photoelasticity is an experimental method to determine the stress distribution in a material [7]. From those two hook models can be identified on which model is more optimal in its use and performance of each model in receiving the stress.

LITERATURE REVIEW

Crane hook is very significant component used for lifting the load with the help of chain or links. Crane hooks are highly lia-ble components and are always subjected to failure due to the amount of stresses con-centration which can ultimately lead to its failure. To minimize the failure of crane hook, the stress induced in it must be studied. The stress concentration factors are broadly used in strength and durability eva-luation of machine elements [2].

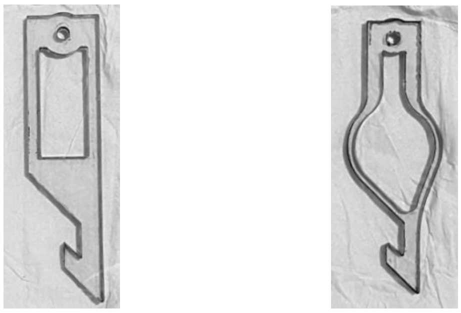
Photoelasticity (PA) was chosen since this method makes it possible to visualize the stress distribution and the magnitude of the refractive index on a birefringent material. The photoelastic fringes represent tension and compression stresses. The PA was performed with photoelastic resin blocks where implants were included and different abutments were bolted. Specimens were observed in the circular polariscope with the application device attached, where loads were applied on same conditions as finite element analysis (FEA) . Data taken from photoelasticity method was isochro-mate pattern of circular polariscope. The circular polariscope consists of light source, the light source filter, polarizer, analyzer and two quarterly corrugated plates. Analysis result of the photoelasticity exceptionally resembled to FEA method with its resin block system [4].

Photoelasticity is an experimental method to determine the stress distribution in a material. The method is mostly used in cases where mathematical methods become quite cumbersome. Unlike the analytical methods of stress determination, photo-elasticity gives a fairly accurate picture of stress distribution even around abrupt dis-continuities in a material. The method serves as an important tool for determining the critical stress points in a material and is often used for determining stress concen-tration factors in irregular geometries. Photoelasticity has been used for a variety of stress analyses and even for routine use in design, particularly before the advent of numerical methods, such as finite elements or boundary elements. The method is based on the property of birefringence, which is exhibited by certain transparent materials. Birefringence is a property by virtue of which a ray of light passing through a birefringent material experiences two refractive indices. The property of bire-fringence or double refraction is exhibited by many optical crystals. However, photo-elastic materials exhibit the property of birefringence only on the application of stress, and the magnitudes of the refractive indices at each point in the material are directly related to the state of stress at that point. Thus, the first task is to develop a model made out of such materials. The model has a geometry similar to that of the structure on which stress analysis is to be performed. This ensures that the state of the stress in the model is similar to the state of the stress in the structure. By applying the load on the tested model, loci of points under stress are seen as dark areas. These dark surfaces represent the main stress in the model [7].

The structure-strength is the key index to response the load – bearing ability of the elevating equipment. Crane hook is a curved beam and is widely used for in-dustrial and construction work site for lif-ting loads by cranes. From the view point of safety, the stress induced in crane hook must be analyzed in order to reduce failure of hook [8].

RESEARCH METHODS

1. Test Objects Model



(a) (b)

Figure 2. Test Objects Model. (a).first hook and (b).second hook.

Table 1. Test objects data for two hooks [9].

Data	Description
Material models	Araldite B
Thickness	5 mm
Elasticity Modulus (E)	3275 Mpa
Fringe constant (fr)	10,2 N/mm
Yield stress (σy)	55,2 Mpa

2. Devices and Test Order

The device consists of several parts, i.e. light source, polarizer, quarter wave plate, specimens, test object holders, loads hanger and loads. The loads provided to specimens were 1, 2, 3, 4 and 5 kg. The orders of testing device can refer to figure (3). While loads testing device can refer to figure (4).

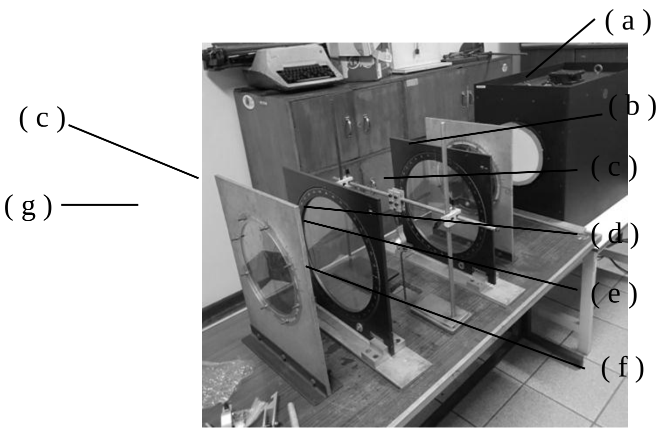


Figure 3. The Arrangement of Experimental Testing Device.

(a).Light Source, (b). Polarizer, (c). Quarter Wave Plate,

(d). Specimen Holders, (e). Specimen, (f). Load Hangers

and (g). Analyzers

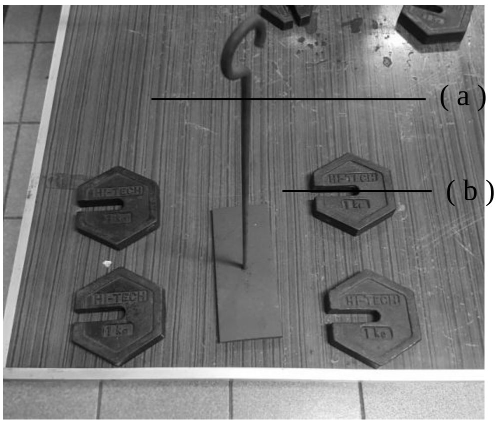


Figure 4. Loads Testing Device.

(a). Loads Hangers and (b). Testing Loads weighing respectively 1 kg.

3. Research Procedures

The research process consists of several stages:

a) Preparation of photoelasticity models made of araldite B with thickness of 5 mm by CNC process in accordance with CAD drawing of two existing hooks models. Results of the model of CNC process can refer to Figure 2.

b) Taking isochromate image patterns with circular poriscope for each model. Amount of the applied loading same for both of these hooks models, which was equal to 1, 2, 3, 4 and 5 Kg.

c) Combination of isochromate image pattern between dark and bright area for each model and each load.

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d) Stress distribution analysis of the combined isochromate pattern image by using stress method. Afterwards, there was also dimen-sional analysis of model correlation to prototype of photo-elasticity.

RESULTS AND DISCUSSION

After obtaining the result of a dark and light field from the isochromate pattern, then there is combination of both these fringe into one. Data taken from photo-elasticity method was isochromate pattern of circular polariscope [4]. Combined pattern for the first hook models can refer to Figure 4. The second hook model can refer to Figure 5. From figure 4 and 5, it can be seen that the isochromate pattern occurs in the second hook is much more than the first hook. The critical area for both models are identical, it can be seen in the area marked by white box.

(a) (b) (c) (d) (e)

Figure 5. Results of combination of dark and light area for the first hook model, on loading of (a). 1 kg, (b). 2 kg, (c). 3 kg, (d). 4 kg and (e). 5 kg.

(a) (b) (c) (d) (e)

Figure 6. Results of combination of dark and light area for the second hook model, on loading of (a). 1 kg, (b). 2 kg, (c). 3 kg, (d). 4 kg and (e). 5 kg.

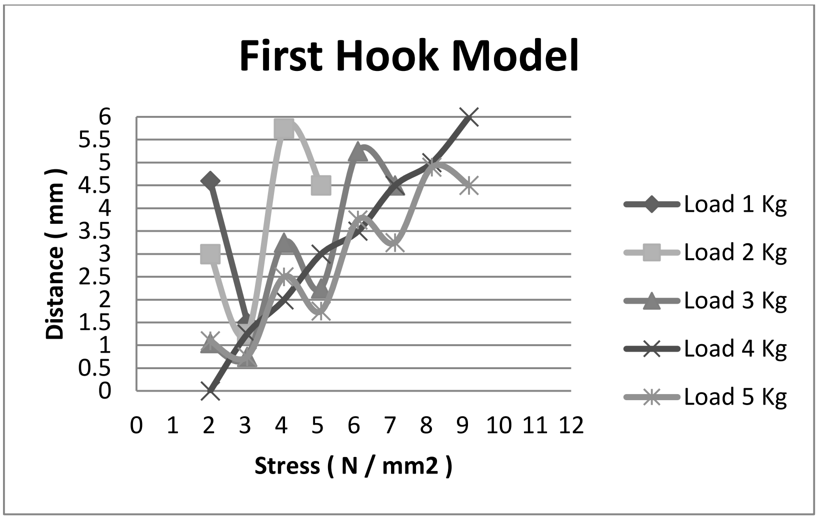
Observations of stress distribution for two hooks model took place on the area marked by white box; it obtained the dis-tances between light area pattern and the dark one. By using the formula below, it results in stress values across the pattern [3].

$$\sigma_1 - \sigma_2 = f_r \; x \; \frac{N}{h}$$

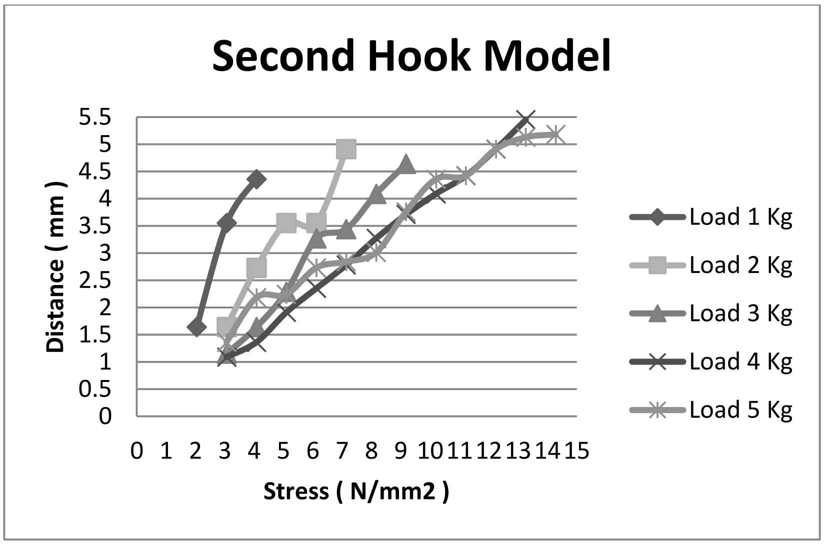
$$\sigma_1 = 10{,}2 \; x \; \frac{N}{5} = 2{,}04 \; N \quad N/mm^2$$

Stress distribution on the first hook model fluctuated when provided the load of two, three, and five kg, while at load of 4 kg, the graphic indicated relatively increase in the formed distance. This can refer to graphic 1. Response to the second hook models was different from the first one. Graphic 2 indicates each load received towards the formed order distance rela-tively increase from the beginning. At the same load, the second hooks model it was formed some amount of orders more than the first hook models.

Graphic 1. Graphic of stress distribution occurring on the first hook model.



Graphic 2. Graphic of stress distribution occurring on the second hook model.



The graphic also represents that the first hook model in receiving loads has am-plitude characteristics of large stress distri-bution. The second hook models provide stress response to less larger or smoother given load. According to this experimental modeling, it carried out dimensional ana-lysis towards the actual dimensions of the two hook models using 6061 aluminium material. The difference of model dimen-sions and the real one simply lies in the material thickness, as the model has thickness of 5 mm, while the actual one was 620 mm. Moreover, load calculations analyzed on real objects used the maxi-mum working load of 10 kg. The results indicated that average stress on the first hook models was 77.774 MPa and the second hook models were 76.837 MPa. Thus both hook models were still working under 6061 aluminium yield stress of 240 MPa, that it was still safe to use for maximum work load of 10 kg.

CONCLUSIONS

Stress distributions occurring on two hooks models were located on the same critical area for all loading. The first hook models are capable of holding more than two hooks models, the difference between the obtained average stresses was about 1.2%. Although the second hooks models had less performance towards the load, but both hooks models are still safe to use for maximum working load at 10 Kg. Total order formed on the second hook model are more than the first one.

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