Design and Analysis of Crane hook with different cross section and materials by Computational and Analytical method

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Abstract : Modern technological period can't be imagined without several material handling equipment. Crane Hooks are highly liable components that are typically used for hold material in industries. Crane hook is the curved bar used for lifting loads in cranes. In order to reduce structure failure of crane hook, induced stress in crane hook is analysed properly. Stress analysis is considered an important factor in the design of structures like crane hook under its loading condition. In present work Crane hook is designed as per ISO 7597:2013 standard in Creo-parametric 4.0 by taking different cross-section area (Rectangular, Circular, Trapezoidal and T-Section) after that the designed hook is import in Hypermesh for analysis by taking four different types of materials (Structural steel, Aluminium Alloy, AISI 1040, ASTM Grade 60 steel) and applying three different loads (2KN, 5KN and 10KN). The outcome of the analysis presented that the Trapezoidal cross-section hook with ASTM Grade 60 material is found to be the best suitable hook from the above all arrangement of cross-section, loads and materials. After analytical verification the analysis concluded that there is only 0.334% dissimilarity between resultant stresses in analytical result and the Hypermesh result.

IndexTerms - **Creo4.0, Hypermesh, Trapezoidal, Circular, T-Section, Rectangular, FOS, material.**

I. Introduction

Crane Hooks are most responsible components that are used for industrial purposes. It is generally a hoisting fixture designed to engage a ring or link of a lifting chain or the pin of a shackle or cable socket and it must follow both health and safety guidelines. It is used to lift heavy loads in industries like marine industry, transportation etc. it is mainly used for lifting heavy loads and transporting them to other places. It uses one or more simple machines to create mechanical advantage and moves the load beyond the normal capability of a human. The following information helps us to select the crane hook: Capacity (tonnage). Material (carbon, alloy or bronze).Shank diameter, Shank length, Throat opening.

The FEM is one of numerical method for solving problems which are defined by partial differential equations or can be formulated as functional minimization. The present work is carried out by using HyperMesh. HyperMesh is Universal finite element pre- and postprocessor. HyperMesh is at the top as in the performance of finite element pre-processor and post-processor for major finite element solvers, which permits engineers to analyse design situations in a highly interactive and visual environment. HyperMesh's user-interface learning is easy and provision of the direct use of CAD geometry and current finite element models, providing strong interoperability and efficiency. An innovative automation tool in HyperMesh allows its users to improve meshes from a set of quality criteria, alter current meshes through morphing, and create mid-surfaces from models of variable thickness.

The present research of crane hook is according to ISO 7597:2013 standard. Firstly, the computational method is used for analysis of designed hook and then the optimized result is validated by analytical method.

II. THEORETICAL FRAMEWORK

Crane hook is designed as per ISO 7597:2013 standard in Creo parametric 4.0 by taking different cross-section (Rectangular, Circular, Trapezoidal and T-Section) after that the designed hook is import in Hypermesh for analysis by taking four different materials (Structural steel, Aluminum Alloy, AISI 1040, ASTM Grade 60 steel). The hook is analysed by applying three different loads (2KN, 5KN and 10KN). The stresses, displacement and factor of safety of the all combination is find out.
The further stage of analysis we take the trapezoidal cross-section hook for verifying the analysis by Analytical method and the variation between resultant stresses in analytical result and the HyperMesh result is tabulated. In further stage of the research we find out the fatigue life of the optimized hook and the result will be concluded as the result of the research. The hook design as per standard are show below in **Fig.1**

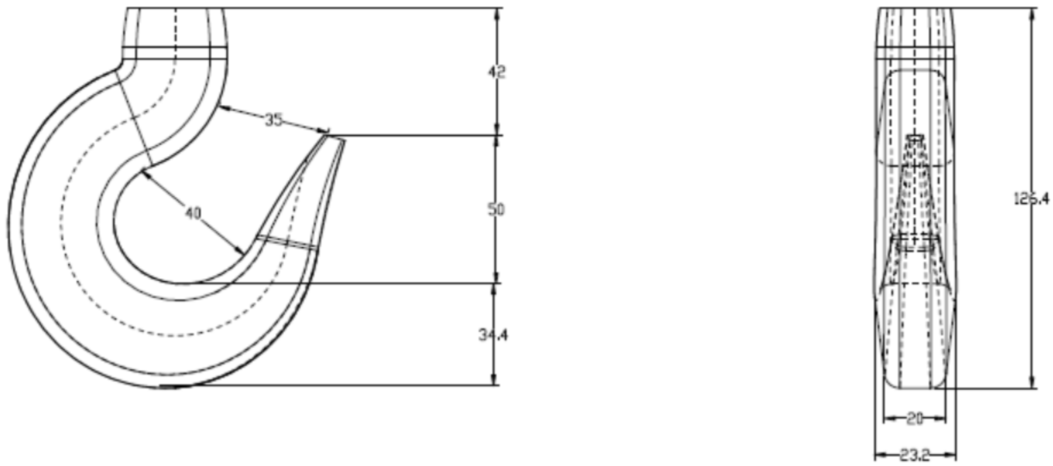
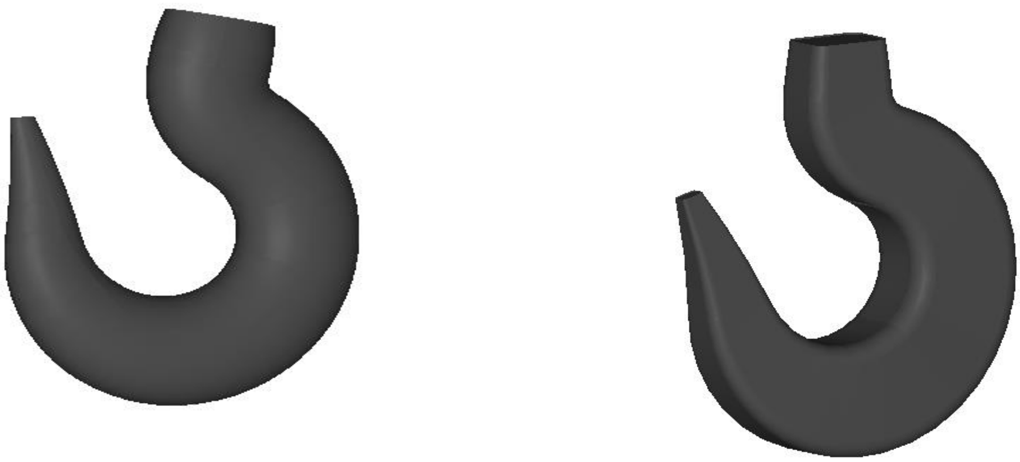


Fig.1 2D view of crane hook with Trapezoidal cross-section

III. COMPUTATIONAL MODELLING

3.1 Design of Hook in Creo

Design the hook with four different cross-sections namely Circular, Rectangular, Trapezoidal and T-Section in Creo 4.0 and import the design in Hypermesh for further analysis



[a] **[b]**

Fig.2 Design of hook with [a] Circular and [b] Rectangular cross-section

[c] **[d]**

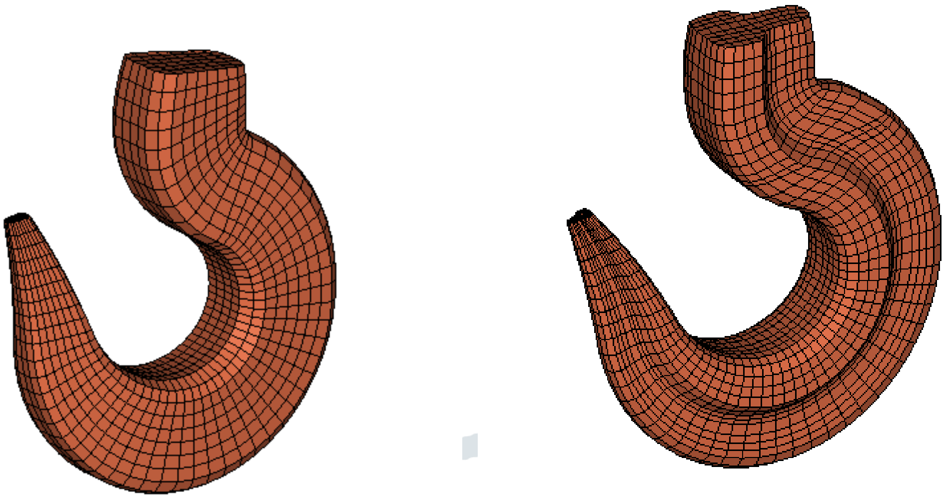
Fig.3 Design of hook with [c] Trapezoidal and [d] T-section cross-section

3.2 Meshing of hook

The design of crane hook by taking different cross-section and the dimensions of hook as per standard and when we import the design in Hypermesh the **Fig.4** shows the meshing of hook in Hypermesh. Following are the meshing details of trapezoidal and T-section. Rectangular and circular section has also same meshing

Element Type: Hex

Element Size: 3mm



[e] **[f]**

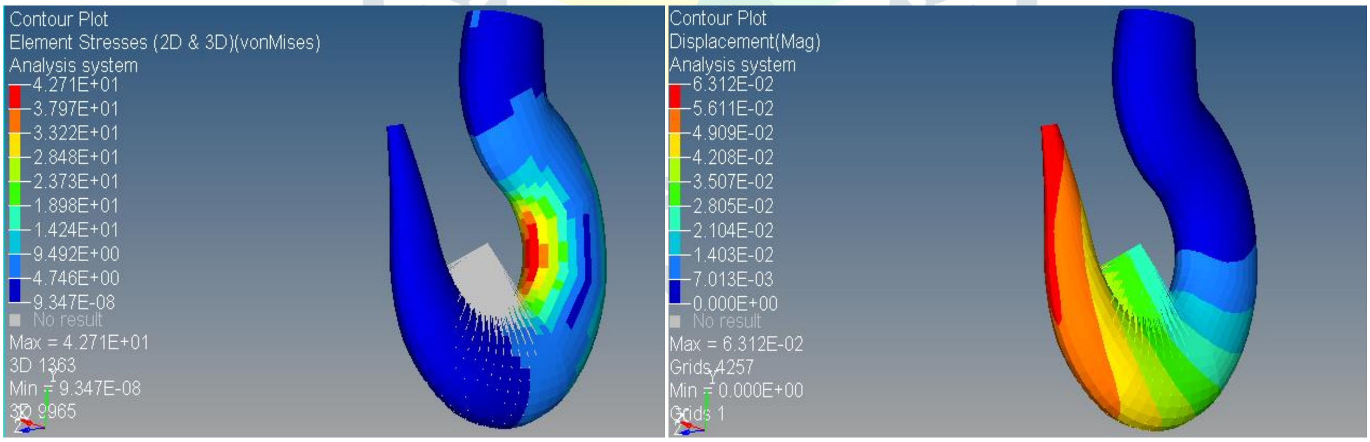
Fig.4 Meshed model with [e] Trapezoidal and [f] T-section in Hypermesh

3.3 Hypermesh analysis and Results

We performed test on different cross-section of crane hook for different loads and materials

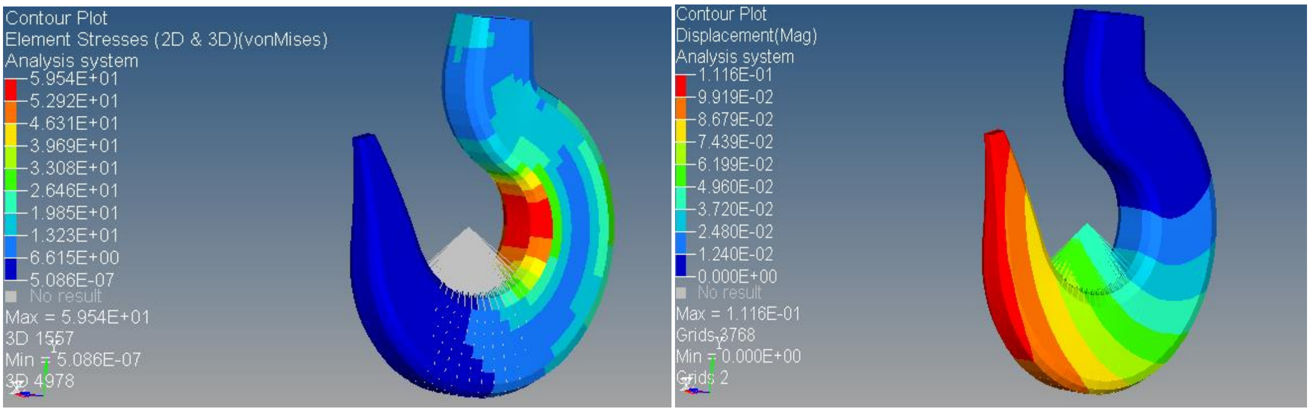
Pre Processor	: Hypermesh
Solver	: Optistruct
Result Viewed	: Hyper View
Types of Analysis Performed	: Displacement and Von Mises Stresses
Force Applied	: 2KN, 5KN, 10KN
Materials	: Structural Steel, Aluminum Alloy, AISI 1040, ASTM grade 60
Cross-section	: Circular, Rectangular, Trapezoidal, T-Section

Following are some analysis result obtained by Hypermesh Analysis.



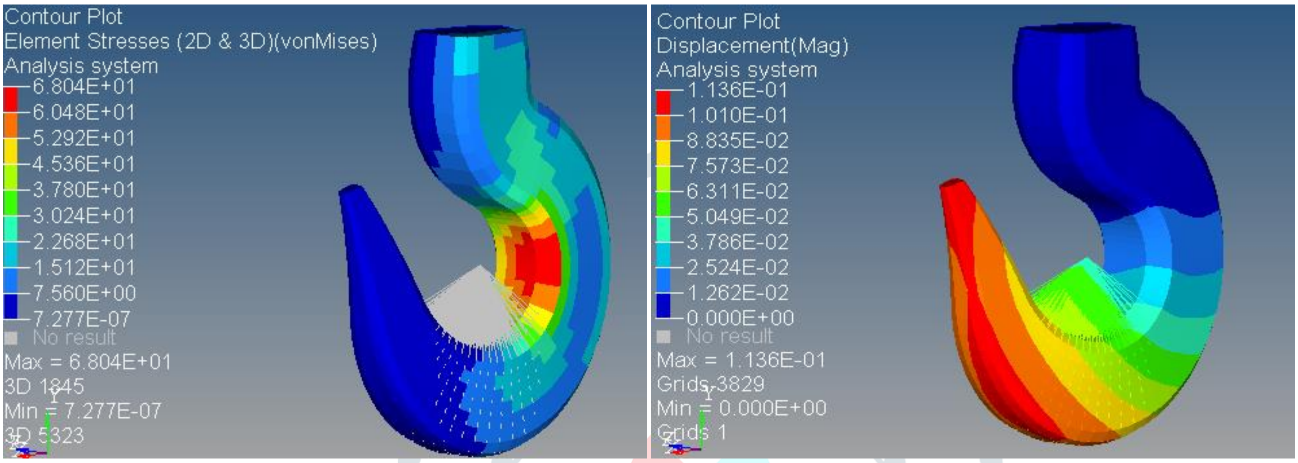
[g] **[h]**

Fig.5 Hypermesh analysis shows[g] Vonmises stresses and [h]displacement in Circular cross-section with ASTM grade 60 material and 2KN load



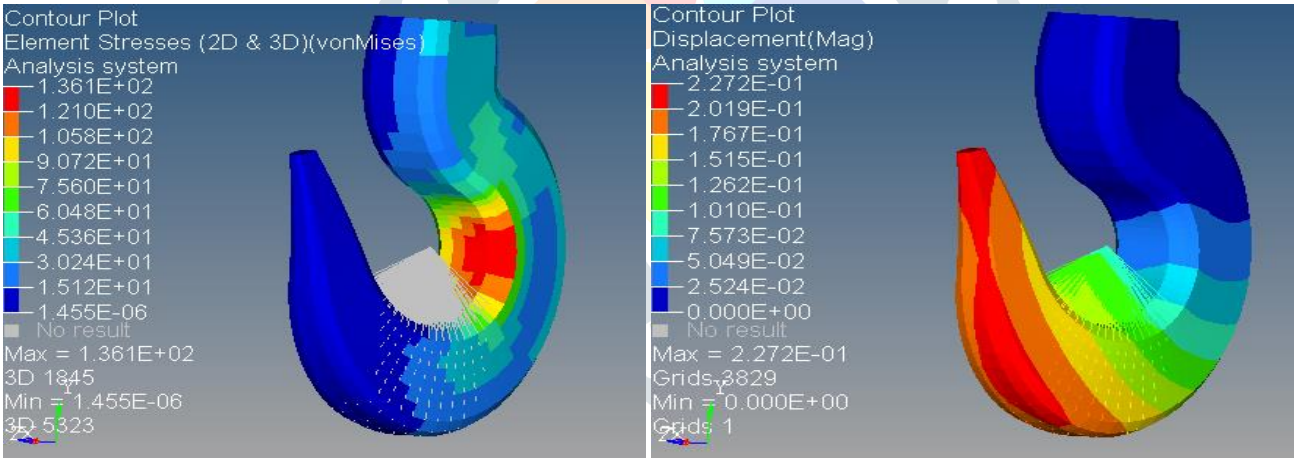
[i] [j]

Fig.6 Hypermesh analysis shows[i] Vonmises stresses and [j]displacement in Rectangular cross-section with ASTM grade 60 material and 5KN load



[k] [l]

Fig.7 Hypermesh analysis shows[k] Vonmises stresses and [l]displacement in Trapezoidal cross-section with ASTM grade 60 material and 5KN load



[m] [n]

Fig.8 Hypermesh analysis shows[k] Vonmises stresses and [l]displacement in Trapezoidal cross-section with ASTM grade 60 materials and 5KN load

IV. ANALYTICAL ANALYSIS

Bending of Curve beam formula for finding the maximum bending stress at inside fibre

$$\sigma_{bi} = \frac{M\, y_i}{A.e.R_i}$$

Where,

M is bending moment acting at the given section about the centroidal axis

y_i is the distance from the neutral axis to the inside fibre

A is the area of cross-section

e is the distance from the centroidal axis to the neutral axis = R-R_n

R_i is the radius of curvature of the inside fibre

R_i =20 mm

R_o =54.4mm

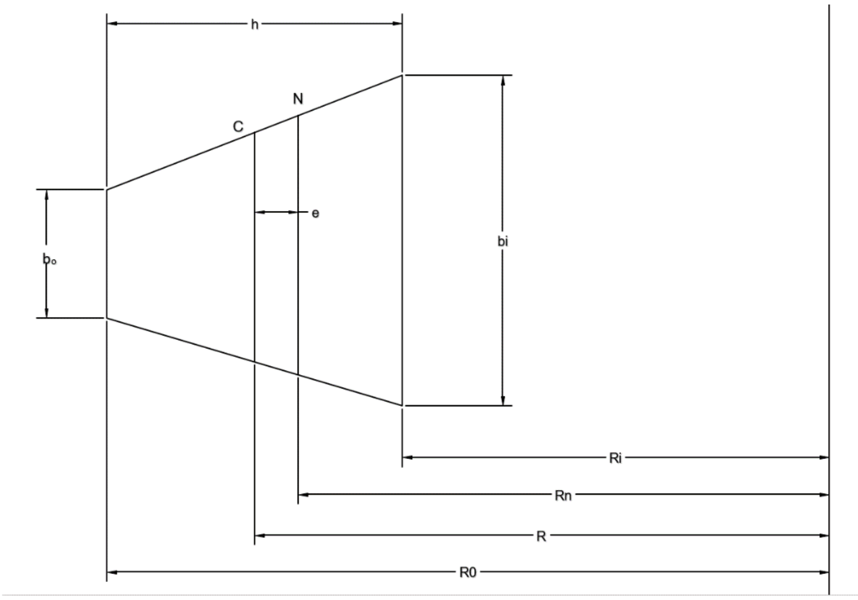


Fig.9 Trapezoidal Cross-section geometric relations

The Formula for finding the Radius of curvature of the neutral axis is given as

$$R_n = \frac{\frac{(b_i+b_o)h}{2}}{\left(\frac{b_iR_o-b_oR_i}{h}\right)loge\left(\frac{R_o}{R_i}\right)-(b_i-b_o)} = 33.9655 \text{ mm}$$

The Formula for finding Radius of curvature of centroidal axis is given as

$$R = R_i + \frac{h(b_i + 2b_o)}{3(b_i + b_o)} = 36.7753 \text{ mm}$$

Formula for finding the Distance between the load and the centroidal axis

$$x = R = 36.7753 \text{ mm}$$

Formula for finding the Area of Trapezoidal section

$$A = \frac{1}{2}(b_i + b_o)h = 743.04 \text{ mm}^2$$

Formula for finding the distance from the neutral axis to the inside fibre

$$y_i = R_n - R_i = 13.9655 \text{ mm}$$

Formula for finding the distance from the neutral axis to the inside fibre

$$y_o = R_o - R_n = 20.2345 \text{ mm}$$

Formula for finding the distance between the centroidal axis and neutral axis

$$e = R - R_n = 2.80977 \text{ mm}$$

We will find out the stresses for different load by putting load values as 2KN, 5KN and 10KN .Here we discuss 10KN load

4.1 Finding stress for 10KN load

Direct tensile load W= 10000 N

The direct tensile stress is given by

$$\sigma_t = \frac{W}{A} = 13.45822$$

Bending moment about the centroidal axis

$$M = W \times x = 367753 \text{ N-mm}$$

Maximum bending stress at the inside fibre

$$\sigma_{bi} = \frac{M\, y_i}{A.e.R_i} = 122.998 \text{ N/mm}^2$$

Maximum bending stress at outside fibre

$$\sigma_{bo} = \frac{M\, y_o}{A.e.R_o} = 65.5188 \text{ N/mm}^2$$

The Resultant stress at the inside fibre

$$\sigma = \sigma_t + \sigma_{bi} = 13.45822 + 122.998 = 136.45622 \text{ N/mm}^2 \text{(Tensile)}$$

The Resultant stress at the outside fibre

$$\sigma = \sigma_t + \sigma_{bo} = 13.45822 - 122.998 = -109.53978 \text{N/mm}^2 \text{ (Compressive)}$$

4.2 Analytical Result

The maximum stress for 2KN, 5KN and 10KN load for trapezoidal section are as follow

Table 4.1: Show analytical stress Results

S.No.	Load	Maximum Stress
1	2 KN	27.2912 N/mm^2
2	5 KN	68.228 N/mm^2
3	10 KN	136.45622 N/mm^2

V. DISCUSSION AND CONCLUSION

The main results of the tests and studies carried out can be summarized as follows:

The crane hook with Trapezoidal cross-section is found to be best optimized cross-section in comparison with all other cross-section (Rectangular, Circular and T-section).

The ASTM grade 60 steel is found to be best material in comparison with all other materials (Structural steel, Aluminum Alloy, AISI 1040)

The crane hook with trapezoidal cross-section and ASTM grade 60 steel material is found to be best suited for all combination and the design in tested in different load 2KN. 5KN and 10KN and it can bear all the loads and the stress induced is less than the permissible values. The designed hook has factor of safety 3 when loaded on 10KN.

The Analytical method is applied for the verification of computational method and the comparison of stresses of the both methods are tabulated below

Table 5.1: Show Comparative results between Analytical method and Computational method

S.No.	Load	Analytical Result Maximum Stress	Computational Stresses	Percentage deviation of results
1	2 KN	27.2912 N/mm^2	27.22 N/ mm^2	0.3%
2	5 KN	68.228 N/mm^2	68 N/ mm^2	0.3%
3	10 KN	136.45622 N/mm^2	136 N/ mm^2	0.3%

REFERENCES

[1] M. CunetyFetvaci, Ismail Gerdemeli, A.BurakErdil. 2006 .Finite element modeling and static stress analysis of simple crane hooks. Trends in the development of machinery and associated technology10, 797-800.

[2] A. Sloboda; P. Honarmandi.2007. Generalized Elasticity Method for Curved Beam Stress Analysis: Analytical and Numerical Comparisons for a Lifting Hook Mechanics Based Design of Structures and Machines

[3] Y. Torres, J.M. Gallardo, J. Dominguez, F.J. Jimenez E.2008. Brittle fracture of crane hook.2008.J-GATE Engineering journals

[4] Jiancheng Liu, PhD, Ashland O Brown.2008. Enhancing Machine Design Course through Introducing Design and Analysis Projects American Society for Engineering Education.

[5] C. OktayAzeloglu, Onur Alpay.2009. Investigation Stress of a Lifting Hook with Different Methods, Verification of The Stress Distribution with Photo Elasticity Experiments Electronic Journal of Machine Technologies, Vol. 6, No: 4, (71-79).

[6] Yu Huali, H.L. and Huang Xieqing.2009. Structural- strength of Hook Ultimate load by Finite Element Method international multi conference of engineers and computer scientists (IMECS), HONKONG.

[7] ApichitManee-ngam*, PenyaratSaisirirat, PatpimolSuwankan.2017. Hook Design Loading by The Optimization Method With Weighted Factors Rating Method. International Conference on Alternative Energy in Developing Countries and Emerging Economies 2017 AEDCEE, 25-26 May 2017, Bangkok, Thailand ELSEVIER