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A Review on Crank Slider Mechanism, and Stress Analysis of a Horizontal Bailer Machine

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Abstract: A slider crank mechanism is an inversion of four bar mechanism more or less known as a reciprocating engine. A horizontal bailer is used in waste squeezing such as, paper, soft plastics, tins, cans and fabrics, compressed as bales. This paper presents a review on stress analysis on the crank slider mechanism of a horizontal baler machine. Analysis of the stresses includes maximum principal stress of the baler and frame which were 2.0658e8N/M^2 and 9795.5N/M^2 with minimum stress of -2.1622e7N/M^2 and -2.2607N/M^2 respectively. The working principles, applicability and crank efforts are presented in this paper. Also, ansys software was used for the modeling and simulation of the components of the baler machine. It was recommended that analysis using the finite element method will give a clear understanding of the stress concentrators magnitude and location, especially when the horizontal hand baler machine is in it useful life.

Keywords: Stress Analysis, Slider Crank Mechanism, Connecting rod, Crank efforts, Baler, Linear Motion, Rotary Motion

INTRODUCTION

The crank slider mechanism operational features includes the conversion of linear motion into circular motion in a piston reciprocating engine, and also it can used in the conversion of motion that is rotary to linear motion in a reciprocating pump. Its applicability also includes combustion engines, oscillating cylinder engines and rotary engines. The piston moves to and fro while the crank rotates. If the rotation is restricted to 180^o a slider crank is gotten. However, this mechanism is employed in the fabrication and working principle of a horizontal baler used as a recycling equipment or press machine in most engineering works with modifications. The horizontal baler deals with the pressing and squeezing of Aluminum and foil i.e. tins, cans, as well as fibrous materials such as wool, cotton, papers etc. A stress analysis was also conducted in the design and implementation phases of the produced equipment

OBJECTIVES

I. To design a human powered baler with maximum efficiency and stress analysis and concentration
II. To review the working principles of presses such as crank slider mechanism
III. To produce effective bales and bailing machines

MATERIALS AND METHODS

The study considers a shaft that is aligned with two bearings placed at the ends with free rotation about a given point with three degree of freedom. A rod is linked at one end at right angle to the shaft, which gives a resultant rotation of the shaft whenever there is a displacement of the rod due to circular motion. The torque at the crank is produced by the applied force through the connecting rod. Slider crank produces the required force that is needed for compression of the wastes placed in the forming box of the baler machine and in the process creates bales for recycling and reuse. Components employed in the design includes a frame assembly that is rectangular, a receiving chamber as well as a compression chamber with top, slides and bottom for each chamber and base. Main parts of the slider comprises of a rigid body, driving torque, sliding mass, prismatic joint and a beam that is flexible. The stress analysis was conducted using Ansys.

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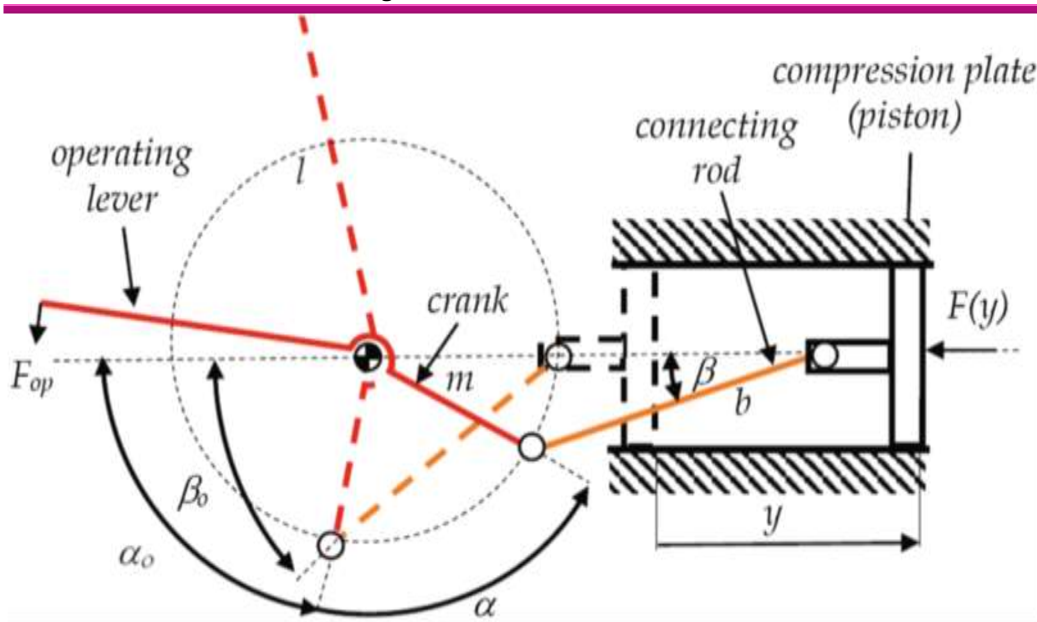

Figure (1): Baler slider Crank actuation mechanism (Carlo Ferraresi, 2017)

RESULTS AND DISCUSSIONS

In the field of engineering, numerous approaches are used in determination of stresses and strains on materials and structures subjected to loads or forces. Before any design implementation, there ought to be a stress analysis on the intended design component. The parameters considered for the stress analysis are the loads, weight and the mass properties of the baler. The stress analysis of the baler is shown in the appendices which includes the principal maximum stress of the baler, frame and also using ansys software. Safety factor was obtained based on mean stress in the model, yield strength, and construction material. This shows that the model is suitable and safe. It is better to design the model with fatigue loads. These loads were chosen by Godman, Gerber and Souderberg criterions (Shigley and Mischke, 1989).

The actuation mechanism that moves the compression plate is very simple. Considering that, in order to increase the straw density, it became necessary to increase the pressure on the piston surface (and the resultant force), therefore an actuation mechanism with variable transmission ratio was used.

In all cases, for ergonomic reasons, it is considered appropriate an input actuation operated by a lever. The lever, in order to be easily grasped even in vertical position, has a maximum length of about 1 m; the operator, during a compression cycle, should rotate the lever to almost ac = 90°, from a vertical position to a horizontal one, optimizing the application of the force. In the type synthesis of the actuation mechanism, it is taken into account, first of all, the specification of simplicity and constructability, rather than the requirement of optimization of the transmission ratio. For this reason, simple planar link mechanisms were chosen instead of cam mechanisms. The actuation system used is a centered slider crank mechanism. The actuation lever is rigidly connected to the crank. Making the dimensional synthesis of the mechanism as described previously. The proper length of the crank m, of the connecting rod b, and the optimum initial angle of the crank **ao**, such that the compression plate can be moved of desired stroke **yc**, minimizing the operating force $\mathbf{F_{op}}$, are all defined.

The torque of the crankshaft of an engine varies considerably throughout the working circle, due to variations in the crank position in the cylinder and the inertia force on the piston and connecting rod.

It depends on how the link is defined. Figure (2) considers the frame that holds the pivot and the slide guide a link and the slide part as link. Also, the connecting rod and the crank as links.

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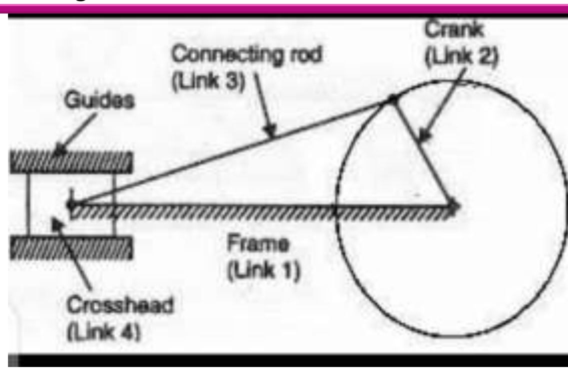

Figure(2): Cranked Slider Mechanism With Four Links

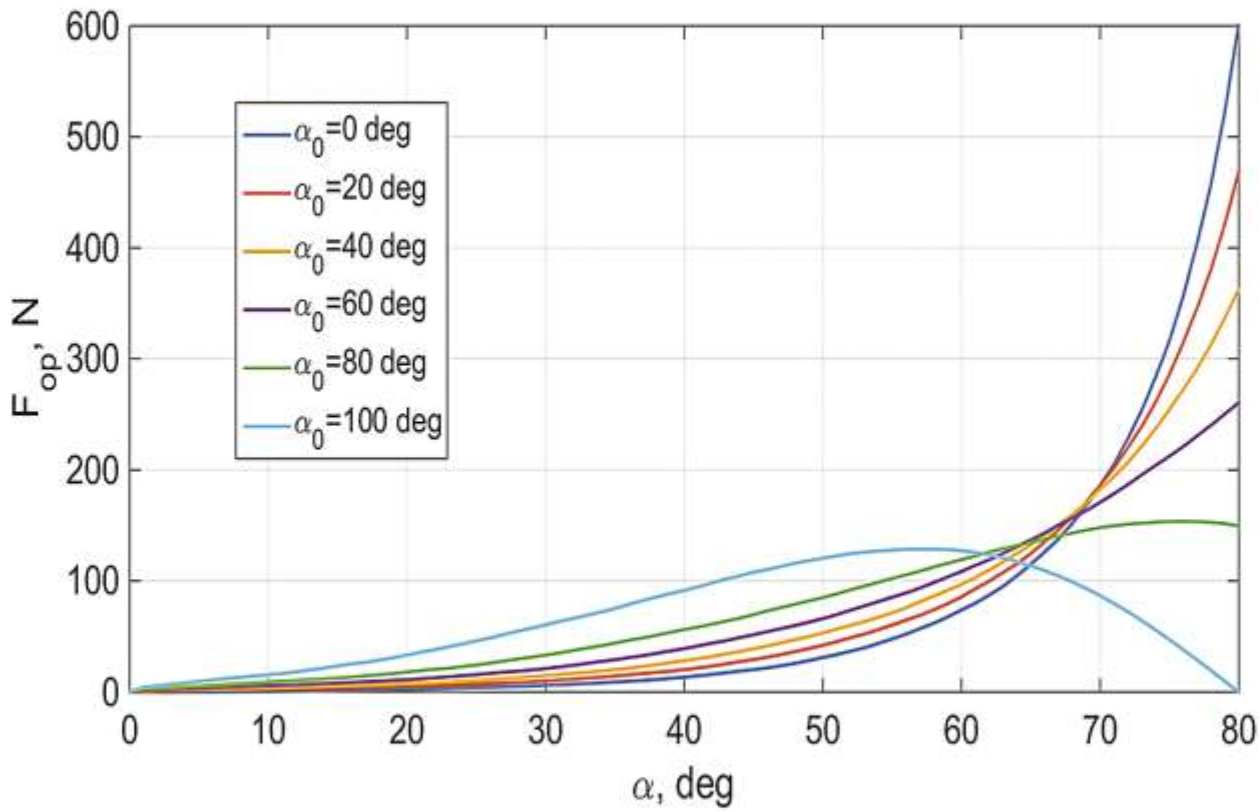

Figure (3): Force versus rotation of lever α in case of slider crank mechanism actuation (Carlo Ferraresi, 2017)

CONCI

An indepth review of a slider crank mechanism with crank efforts as well as stress analysis is studied. It is an inversion of a 4 bar chain mechanism with the possibility of connecting different links successively with its applicability in most automation works. Its applications are in,scotch yoke Oldham,s coupling and elliptical trammel, rotary engine as well as hand pump,. For a mechanism to be created, it is pre-requisite that at least one member should be able to make a complete revolution. That member is technically named as crank. Such member should also satisfy grashoffs law which states "the total shortest and longest link in any mechanism that is four bar should not be greater than the total of the remaining links."

The review study provides useful insights of the hand baler in terms of modeling of machine's components simulation. Analysis of stresses includes maximum principal stress of the baler and frame which were 2.0658e8N/M^2 and 9795.5N/M^2 with minimum stress of -2.1622e7N/M^2 and -2.2607N/M^2 respectively. After fabrication of the baler, performance tests was carried out on the baler. Results showed that the baler machine was able to make bales of the required dimensions and density. It was recommended that analysis using the finite element method will give a clear understanding of the stress concentrators magnitude and location, especially in the machines useful life.

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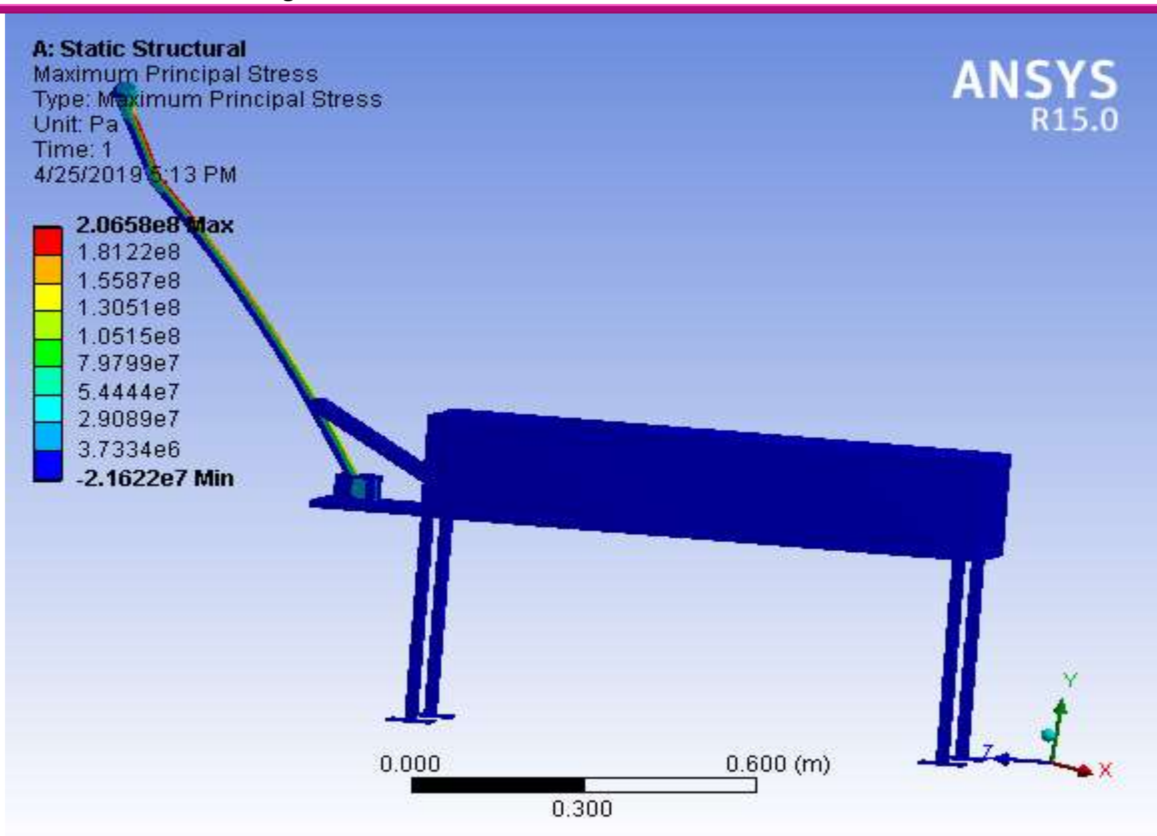
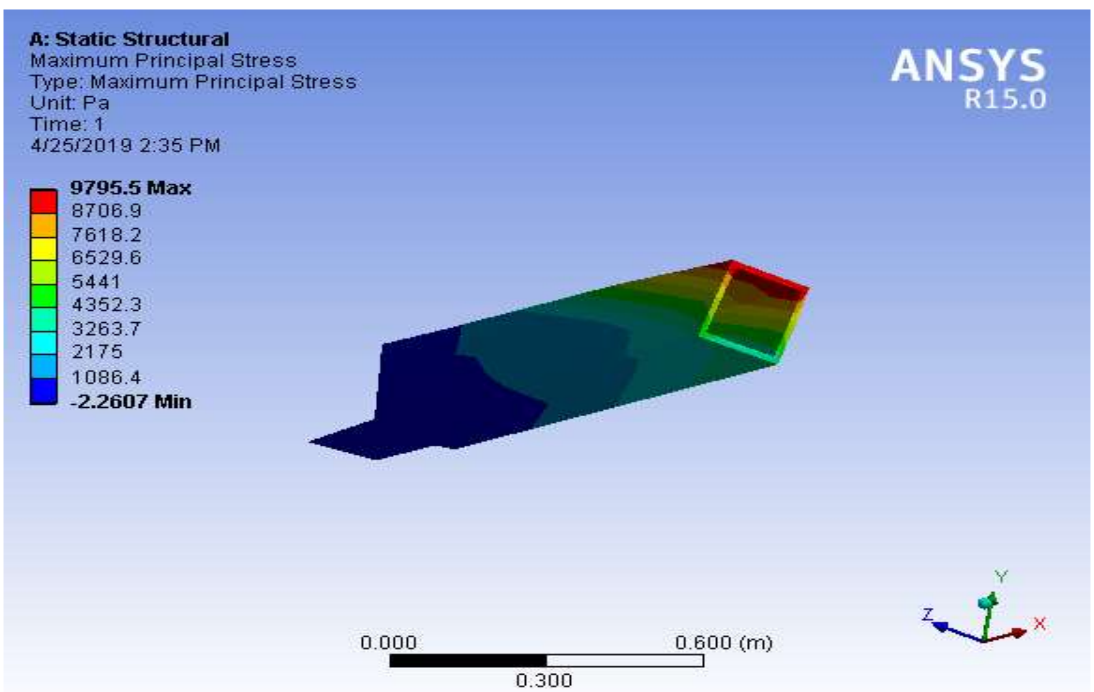
APPENDICES



maximum principal stress of the baler



maximum principal stress of the frame

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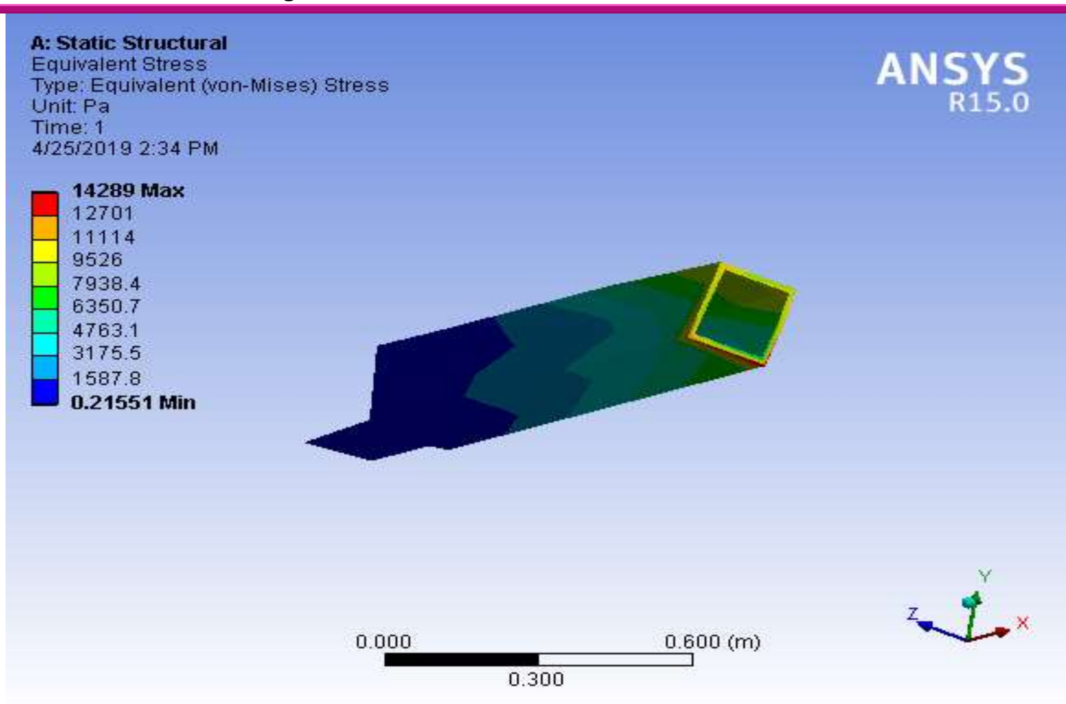
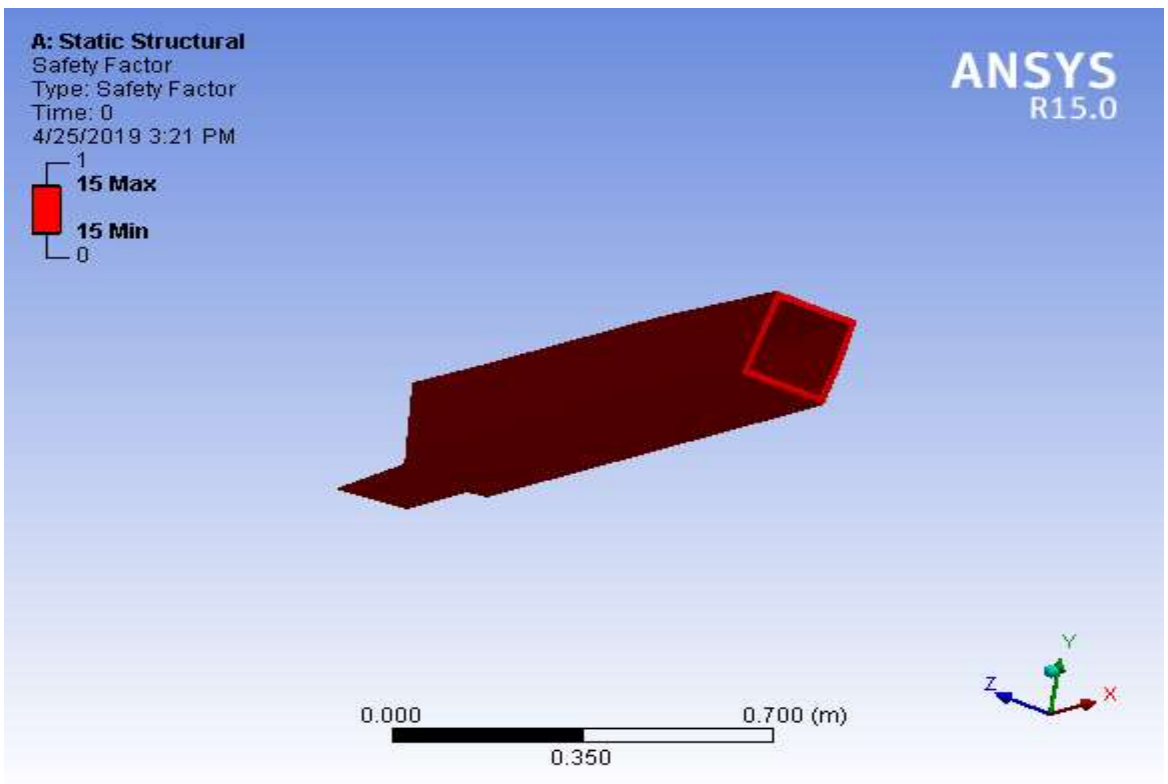


Equivalent (Von-Mises) stress of the frame



Safety factor for the frame

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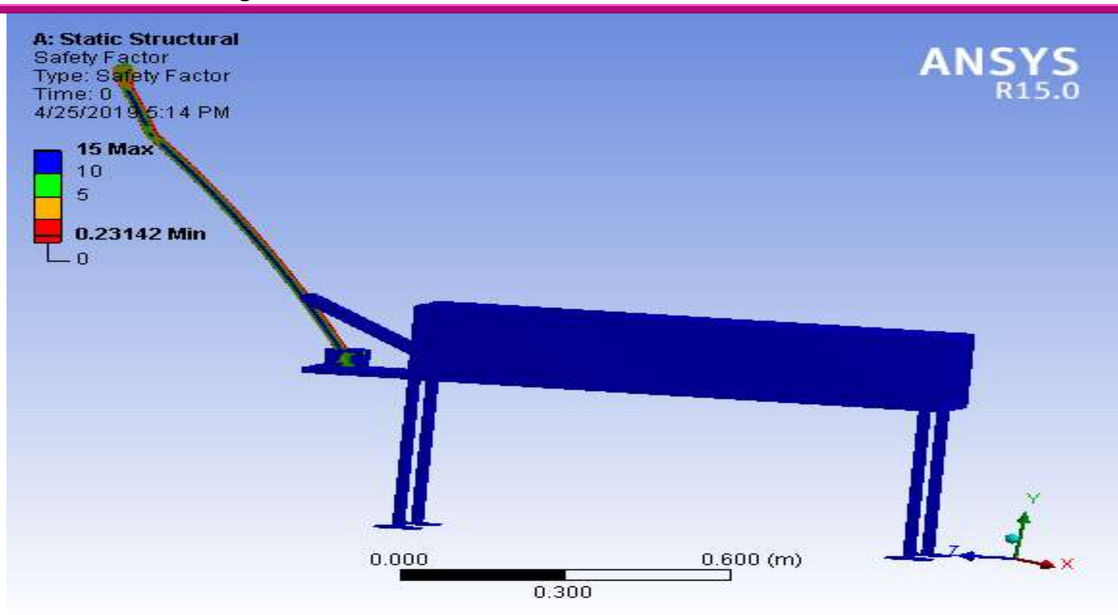

Safety factor for the baler