Study and Design Optimization of Autofeeder Side Cover of Ginning Machine

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Abstract— The process of separation of cotton from seed of cotton which is term as a ginning requires a remarkable technology to meet the continuous demand of cotton to produce the fabric. The mechanism employed for the process can be categorized according to the rate of production and volume of production of the various machine employed for the purpose. Double roller ginning machine is widely favored for higher volume of production and calls for continuous interrupted operation of ginning machine. To maintain the continuous production process of ginning it is likely to execute analysis of factor affecting the life of various component of which ginning machine is comprised one such component is Side Cover of ginning machine which provide a platform for bearing through which shaft of roller are passed. Due to continuous operation this side cover is subjected to vibration and this leads to fatigue failure of side cover. The present paper attempt to find the optimum thickness of side cover which is a sheet metal component so as to sustain the vibration generated in conventional side cover employed today. This is done by the aid of computer aided design and analysis domain by firstly employed CAD Software that is CATIA V5R21 in which sheet metal component I.e. side cover is efficiently modeled. The modeled component is rendered to change in thickness from 2.5 mm to 3.0 mm and 3.5 mm and finite element approach is used to calculate the value of fatigue stress acting on each thickness. ANSYS Workbench 14.5 provide the platform to optimize the thickness of side cover under study.

Key words: Side Cover, Ginning, Auto feeder, CAD, FEA

I. INTRODUCTION

Agriculture which is characterized by the process it involves is revolutionized due to aid of various machines in its prior as well as post processing stage. Cotton farming has been an agricultural activity in which humans were engaged form early of rise of civilization and this cotton processing formed one of the basic need in the form of clothing required by this civilization.[1][2] With the progress of time various methods developed to produce the fiber from cotton which can be used as raw material for other process and this progress can be witnessed in terms of development in the machinery which serves the purpose.[3] This was the certainly the period of sixteenth century when European countries witnessed the industrial revolution. This revolution along with the rapid development of economics gave some of machines which were basic in their sense of essence of dynamics and proved to be boon to the prosperous growth of agriculture.[4][5]

Ginning, in its strictest sense, refers to the process of separating cotton fibers from the seeds. The cotton gin has as its principal function the conversion of a field crop into a salable commodity. Thus, it is the bridge between cotton production and cotton manufacturing. At one time the sole purpose of cotton gin was to separate fibers from seed. But today's modern cotton gin is required to do much more. To convert mechanically harvested cotton in to a salable product, Gins of today have to dry and clean the seed cotton, separate the fiber from the seed, further clean the fibers and place the fibers in to an acceptable package for commerce. The Cotton Gin actually produces two products with cash value i.e. the fiber and the cotton seed. Cotton seeds are usually sold to cotton oil mills for conversion into a number of important and valuable products, but in some cases they may be saved for planting purpose. The fibers are the more valuable products, and the design and operation of cotton gins are usually oriented towards fiber production. In essence, the modern cotton gin enhances the value of the cotton by separating the fiber from seed and by removing objectionable foreign matter, while preserving as nearly as possible the inherent qualities of the fiber. [6]

By hand ginning we can get its maximum length which is ultimately desired and can be used to produce optimized yarn to make fabrics or other products. However, when we mechanically process the same in a Ginning Factory in bulk quantities after high volume harvesting, we get lower fiber length with high trash and varied moisture parameters, which ultimately produce low value final products. We all know that good fabric can be made from high quality yarn, which in turn demands excellent fiber as raw material. Further, the cost of processing of cotton plays a vital role in making it competitive and acceptable, thus every effort should be made to achieve the target of preserving inherent qualities of fiber at lowest cost in the Ginning. [7] Earlier methods were of manually drafting the geometries and manufacturing the same on various conventional machining stations in synchronous order to produce the result which were subjected to rejection due to inefficiency to meet the standards. The validation of design and manufacturing process was dependent on the statistical analysis of failure data which engulfed large amount of observation and corresponding time. But with advent of microelectronics and mainly due to uprising of computer numeric control in 1952 this techniques of conventional drafting are study of history. [8]The present day witnesses the drafting of various ginning components along with their complex geometry in software which runs on the subroutines and algorithms known by the name of computer programs for manipulation, creation and representation of geometric models. The use of CNC machines has given the accuracy with in limited amount of manufacturing time in manufacturing of the machine and the statistical data of failure of various components can be analyzed with greater convenience with software's algorithms mainly intended to do so. [9] The technological developments in Ginning & Pressing Machinery has acted as an driving force in structural shift from old out dated to more productive advanced machinery. By and large the good pace of technology development has been witnessed in the last 10 years. This has helped to produce good quality cotton and also met the need to gin and press additional quantities of cotton produced in a better way. [10]

A. Cotton Ginning

Ginning is the first mechanical process involved in processing cotton. Its primary objective is separating the fibers of cotton from the seed. Cotton ginning machine is use for preparing the raw or seed cotton for the cotton mills. The cotton gin has as its principle function that is conversion of a field crop into a salable commodity. The ginning operation is the bridge between cotton production and cotton manufacturing. But today's modern cotton gin is required to do much more. [7]The cotton ginning machine converts mechanically harvested cotton in to a salable product. The design and operation of cotton gins are usually oriented towards fibers production. In essence, the modern cotton gin enhances the value of the cotton removing objectionable foreign matter, while preserving as nearly as possible the inherent qualities of the fibers. Many component used in ginning machine such as, pinion gear, eccentric shaft , connecting housing, clutch pin, roll flange, crank shaft for jumbo ginning machine.[8]

Fig. 1: DR Ginning Machine

II. RESEARCH PROBLEM

The side cover of Double Roller ginning provides the surface for tearing which in turn support the shaft of two rollers and this are subjected to continuous vibration due to extraction process. The vibration on the side cover body can be experimentally determined by using Accelerometer. The conventionally used side cover of thickness is to be varied in thickness form 2.5 mm to 3 mm and 3.5 mm and corresponding value of fatigue stress are calculated at each thickness of side cover.

III. METHODOLOGY ADOPTED

The methodology adopted can be illustrated as

1) To geometrically model the side cover suing CAD Software i.e. CATIA V5 R21.
2) To experimentally calculate vibration in terms of parameter such as acceleration and displacement of vibration.[11]
3) To perform the analysis of side cover using experimentally determine parameter to define the fatigue stress acting on side cover using analytical approach.
4) To calculate the natural frequency of side cover for varying thickness of 2.5 mm, 3 mm and 3.5 mm
5) To calculate fatigue stress using FEA approach by employing ANSYS Workbench 14.5[12]
6) To compare result of fatigue stress obtained to optimize the best thickness suitable for side panel for prolonged life.

IV. GEOMETRIC MODELING OF SIDE COVER

1) The geometry of side cover can be drafted by using CAD Software which is CATIA V5 R21. Since Side panel is a sheet metal component the modeling is done in generative sheet metal module of CATIA V5 R21. The initialization is done by generating a sketch of drafting of side cover geometry using basic 2D command available in sheet metal module. [13] The generated sketch is as follows.

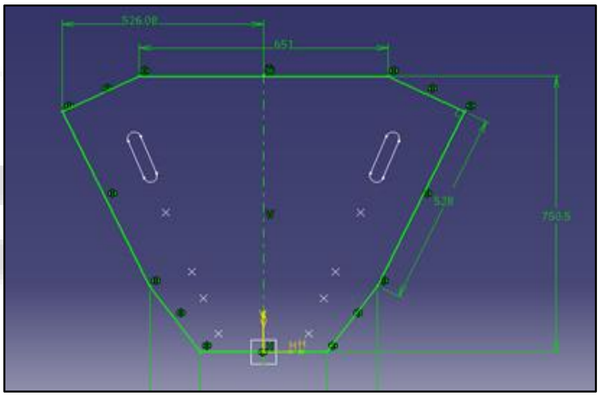

Fig. 2: Constrained profile For Side Cover

2) The generated sketch is subjected to 3D command such as wall cut out to provide the basic geometry of side cover that can be seen in figure below.

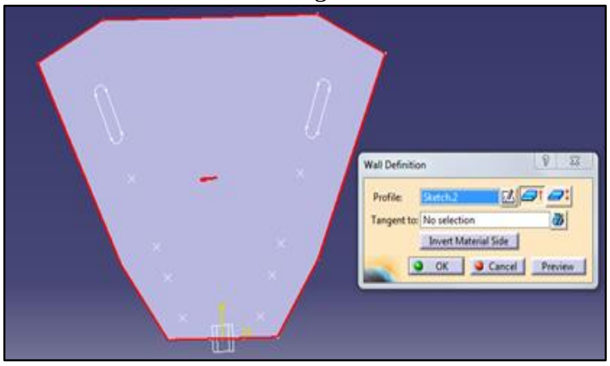

Fig. 3: Wall definition for Side Cover

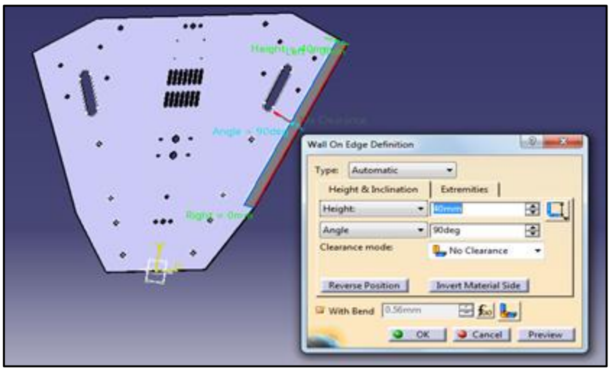

Fig. 4: Wall on edge definition for Side Cover

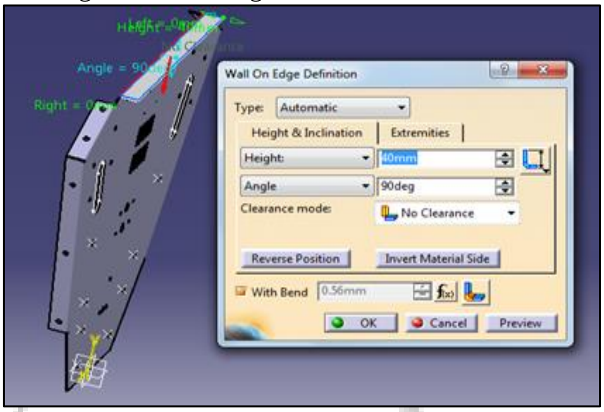

Fig. 5: Wall on edge Upper Side of Side Cover

3) The operation such as hole and cut out at various constraints can be done by using operation tool bar to complete the geometry of side cover which can be depicted as follows

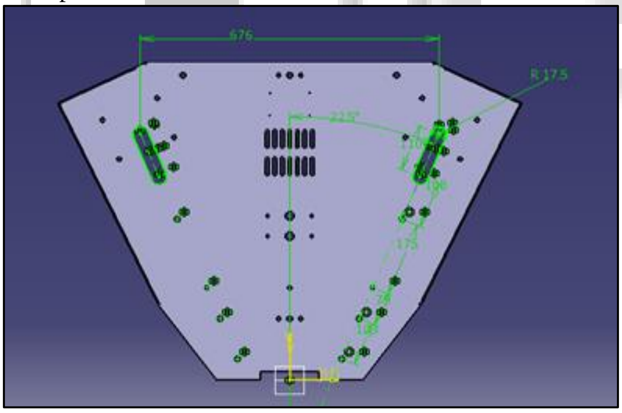

Fig. 6: Side Cover for DR Ginning Machine.

V. ANALYSIS OF SYSTEM

1) Vibration fatigue failure
2) Vibration in ginning and side cover
3) Experimental determination of vibration is done with aid of acceleration in terms of vibrating acceleration and displacement that are measured by contacting the side cover under working condition to accelerometer. The value of acceleration and displacement were found to be 0.8 m/s^2 and 0.586 mm respectively.
4) Calculation of frequency of vibration.

To calculate the forced vibrational frequency following relation can be used

$$\text{Acceleration} = a \ m/sec^2$$

$$\text{And } x = \text{maximum displacement in mm}$$

As we know that

$$\text{Acceleration} = \omega^2 x$$

$$\omega = \text{Frequency of vibration And}$$

$$v = r\,\omega_n$$

Hence the value of ω can be calculated using above relation.

Next step is to calculate the force which causes the forced vibration of side cover and this can be calculate by using the Forced vibrational Frequency equation as follows

$$X_{max} = \frac{F}{m\,(\omega n^2 - \omega^2)}$$

Where

X_{max} = Maximum Displacement
F = Force acting on side cover
M = Mass of the side cover
Ω_n = Natural frequency of side cover
ω = Force vibrational frequency of side cover

5) Calculation of fatigue stress.

From the above equation of forced vibration the value of force acting on side cover at each frequency can be calculated. This force results in the stress which can be evaluated by using the following relation

$$\sigma = \frac{F}{A}$$

Where

F = Force acting on side cover due to vibrations
And A = Cross sectional area of plate.

Result of fatigue stress for various thicknesses can be seen as follows.

Thickness (mm)	Fatigue stress (N/m^2)
2.5	68.97×10^3
3.0	14.25×10^3
3.5	9.37×10^3

Table 1

6) Model analysis of side cover body for various thicknesses is the first step in analysis of side cover using FEA Approach. Model analysis reveals the natural frequencies of system under study are provide the limit of vibration that can be sustain by body. The value of model frequency for node can be seen in following table.

Thickness of Side Cover (mm)	Modal Frequency (Hz)
2.5	81.069
3.0	146.93
3.5	165.74

Table 2

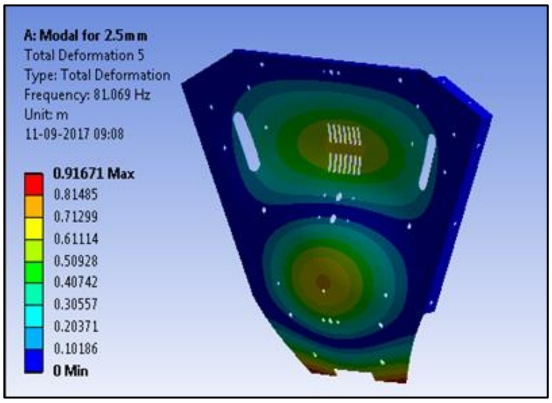

Fig. 7: Mode Shape Result for 2.5 mm thick side Cover

7) Fatigue analysis due to vibration can be efficiently done by using random vibration module of ANSYS Workbench 14.5. This can be initialized by providing the positive spectral distribution of acceleration i.e. PSD acceleration to the geometry of the side cover imparted from the CAD Software. The next step followed is to calculate the equivalent or Von-misses stress for the various thickness of side cover. The result can be shown as follows.

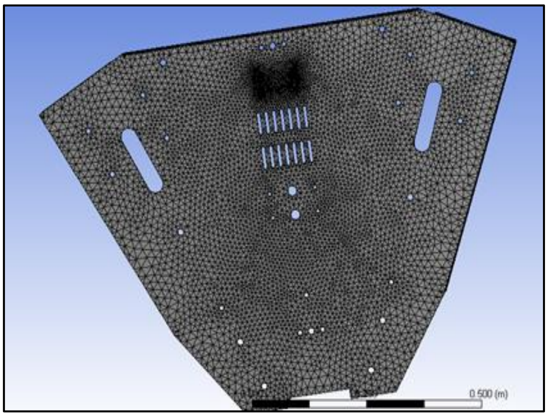

Fig. 8: Meshing of side Cover

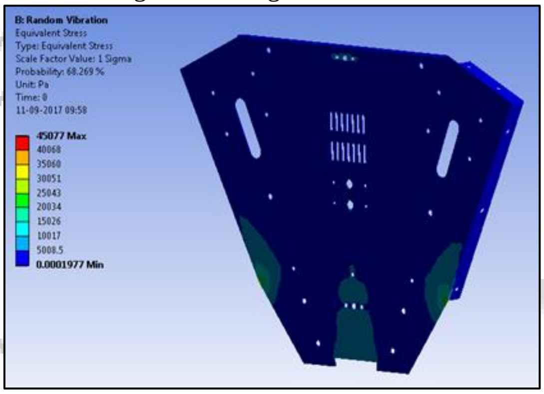

Fig. 9: Von-misses Stress on 2.5 mm thick Side Cover

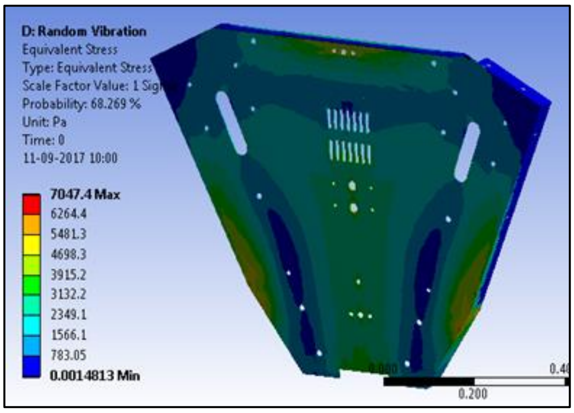

Fig. 10: Von-misses Stress on 3.0 mm thick Side Cover

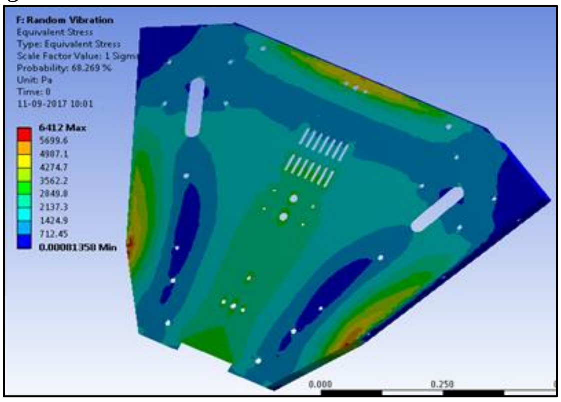

Fig. 11: Von-misses Stress on 3.5 mm thick Side Cover

The process of designing and analyzing the side panel with relevant parameters of study is followed by inferences generated by evaluation process of the data obtained during the process of analysis.

The side cover under constant dynamic loading shows failure at certain interval of time which is termed as fatigue. The results calculated can be drawn on the lines of effect of vibrations which is Von misses or equivalent stress in this case. The various input values which are same for both conditions are presented and the variation in the effect due to design variation of change in the thickness can be presented as follows.

Property	Analytical Analysis of Side cover								
Thickness of Side cover in mm	2.5			3.0			3.5		
Side cover material	Cold Rolled Steel			Cold Rolled Steel			Cold Rolled Steel		
Boundary condition	Fixed Support on Side Face of Cover			Fixed Support on Side Face of Cove			Fixed Support on Side Face of Cove		
Natural Frequency of Vibration in Hz	81.069			146.93			165.74		
Displacement (mm)	0.586	0.50	0.45	0.586	0.50	0.45	0.586	0.50	0.45
Acceleration (m/s^2)	0.8	0.7	0.5	0.8	0.7	0.5	0.8	0.7	0.5
($\times 10^3 N/m^2$)	68.97	61.93	57.63	14.25	10.92	1.226	9.37	6.92	8.27

Table 3: Analytical Results for Side Cover of Various Thicknesses

Property	Finite Element Analysis of Side cover								
Thickness of Side cover in mm	2.5			3.0			3.5		
Side cover material	Cold Rolled Steel			Cold Rolled Steel			Cold Rolled Steel		
Boundary condition	Fixed support on side face of cover			Fixed support on side face of cover			Fixed support on side face of cover		
Natural Frequency of Vibration in Hz	81.069			146.93			165.74		
Displacement (mm)	0.586	0.50	0.45	0.586	0.50	0.45	0.586	0.50	0.45

Acceleration (m/s^2)	0.8	0.7	0.5	0.8	0.7	0.5	0.8	0.7	0.5
Stress ($\times 10^3 N/m^2$)	51.76	43.77	42.36	19.61	11.14	5.52	10.73	5.85	6.55

Table 4: Results of Finite Element of Analysis of Side Cover for various Thicknesses

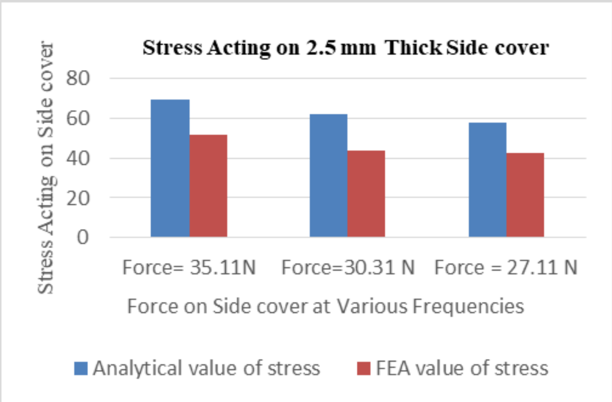

Fig. 12: Comparison of Analytical Values and FEA values of Equivalent Stress Acting on 2.5 mm plate at different frequency

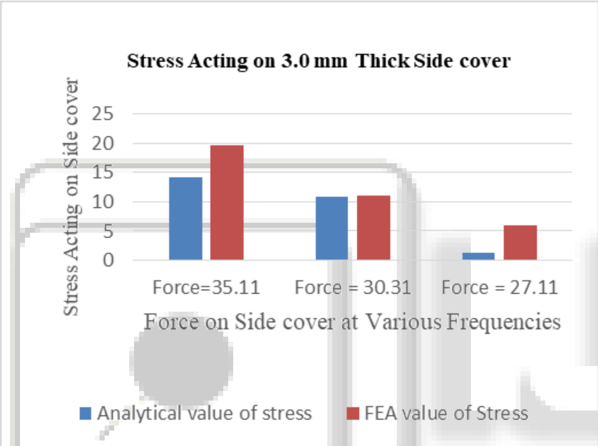

Fig. 13: Comparison of Analytical Values and FEA values of Equivalent Stress Acting on 3.0 mm plate at different frequency

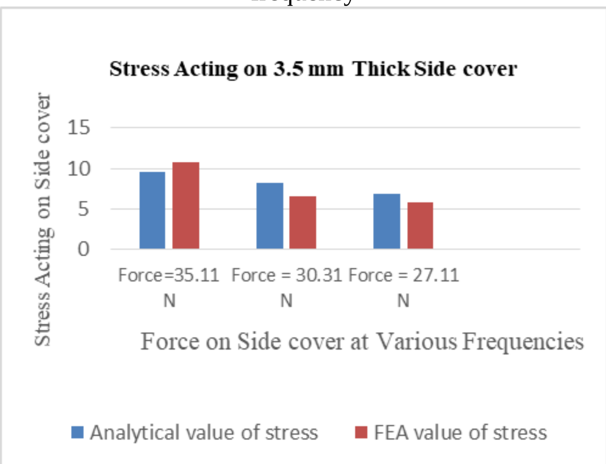

Fig. 14: Comparison of Analytical Values and FEA values of Equivalent Stress Acting on 3.5 mm plate at different frequency

Thus from the above calculated value of equivalent stress acting on side cover of varying thickness can be compared and it can be interpreted that the computer aided analysis software employing solver equations provides approximate values of equivalent stress which can cause fatigue failure of side cover and lead to its replacement. The fatigue stress that can be sustained by body is determined by the endurance limit of the material of the body and in this case the material subjected to fluctuating load is cold rolled steel. The endurance limit of the cold rolled steel is 270 N/ mm2 which is much higher than the value of stress generated in the side panel of the Ginning machine.

Also it can be seen from the above graphs that the value of equivalent stress for 3mm thickness of side cover shows a reduction as compared to the 2.5 mm thick plate and further change from 3mm to 3.5mm does not show a considerable change which states that the best value for thickness of side cover can be taken as 3mm because it shows lesser value of stress and would certainly save the material which would rather increase if thickness of side cover is increased.

VI. Conclusion

The results of equivalent stress acting on the side cover of various thickness forms the evaluative platform to generate the effect of thickness variation on dynamic loading of side cover. The results are interpreted to draw the following conclusions from it

- The side cover subjected to varying load condition is subjected to thickness change in order to increase its fatigue strength.
- Three thickness of side cover which are 2.5 mm, 3 mm and 3.5 mm are considered for studying the effect of dynamic loading on side cover of DR Ginning machine
- The proposed design is geometrically modeled in a CAD software which is CATIA V5 and this led to the application of computer aided design to represent , manipulate and model the geometry of the new side cover under study
- The geometry modeled is successfully applied with the boundary conditions and loading conditions similar to the conventional side cover in context of vibrations acting on actual panel that is used in the computer aided analysis software named as ANSYS Workbench 14.5.
- The values of equivalent stress are calculated for three thicknesses and it can be interpreted that the value of 3mm of side cover can serve efficiently to reduce the effect of vibrations acting on side cover by increasing its fatigue life and optimizing the mass of side cover.

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