Implementation CAD and EF Composite Parts for Aerospace Industry

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***Abstract**: The objective of this study was to investigate the use of composite as an alternative in the aircraft wing and thus help to reduce the weight of the plane. In general, the composite material is used in the aviation industry to reduce the overall weight as much as possible in order to improve aircraft maneuver performance, decrease aircraft manufacturing and operational costs while keeping the stress levels under a certain value (static or fatigue allowable). The wing structure is design in CATIA V5, and the skin of wing is applied with CATIA composite design. Then the model is exported to Abaqus to calculate, simulate and optimize.*

***Keywords**: Composite Wing, Modelling in CATIA V5, Finite element Analysis in Abaqus, Composite Grid design.*

1. Introduction

For many years, thanks to excellent features, composite material has been widely used in many industries, especially in Aerospace. Added to that, the development of informatics field and particularly the CAD application have supported us in reducing time and risks as well as saving money.

The application of composite material on airplane wings has been done before, mainly in unmanned aerial vehicle. That the process has been tested by using simulation and informatics application not only helps us with better understanding of composite material but also delivers us a deeper look of composite field. This research has widened our abilities to apply all the advantages of composite material in many other aerospace sectors and still remains an exciting and potential topic for us to keep studying.

Regarding the implementation CAD and EF composite parts for aerospace industry, we need to prepare clearly the knowledge of software modeling design, composite material and the aerospace parts. So, the main work that need to do includes as below:

- Use CATIA V5 to design an air-plane wing, which using composite material. Study some workbench of CATIA: Part Design, Shape Design, CATIA Assembly. Study Composite Design, Composite Grid Design analysis and decide zone to apply composite material.

- Analysis case study, create the model and apply composite design in the model.

- Simulate and optimize the wing by Finite Element Analysis Software. Use Abaqus /SIMULA to analysis the model. (Defining the boundary condition, ad load for the case of calculation, connecting

Abaqus and CATIA then make the simulation and analyzing on Abaqus, following by making the optimization and give the conclusion).

1.1 Wing's geometrical configurations.

A wing structure includes spars, ribs, skins and stringers. They are designed to optimize the contrast and maximum stress. Besides that, the profile of the wing – airfoil is the specific of the wing can carry the aircraft to fly.

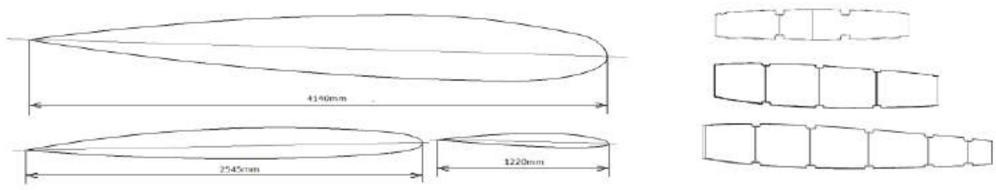

Figure 1. Wing's Airfoil and Ribs profile [exported from: CATIA drafting export].

The wing carries an elliptically distributed load along the span. Positions of ribs as well as dimensions and thickness properties of certain parts of the structure are the design variables.

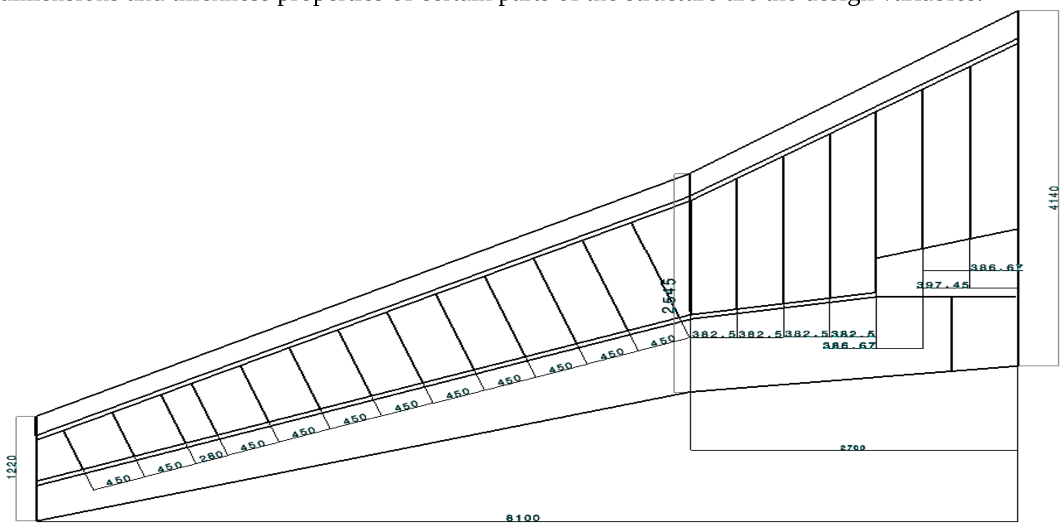

Figure 2. Wing's dimension in mm [exported from: CATIA drafting].

We build the surface from airfoil profile and solid structure.

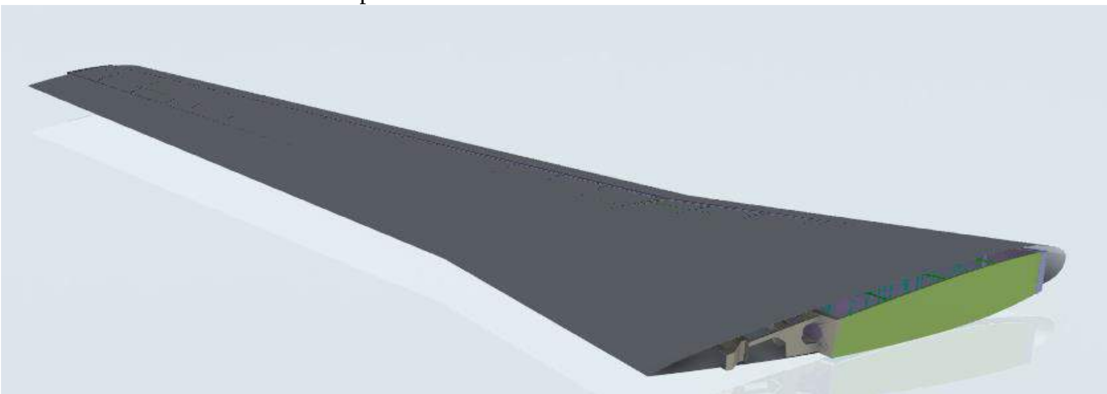

Figure 3. Complete Wing Model

1.2 Over review application of composite on a plane.

Based on the calculation of the force on the wing, we can apply the reinforced material at high stress gradient areas.

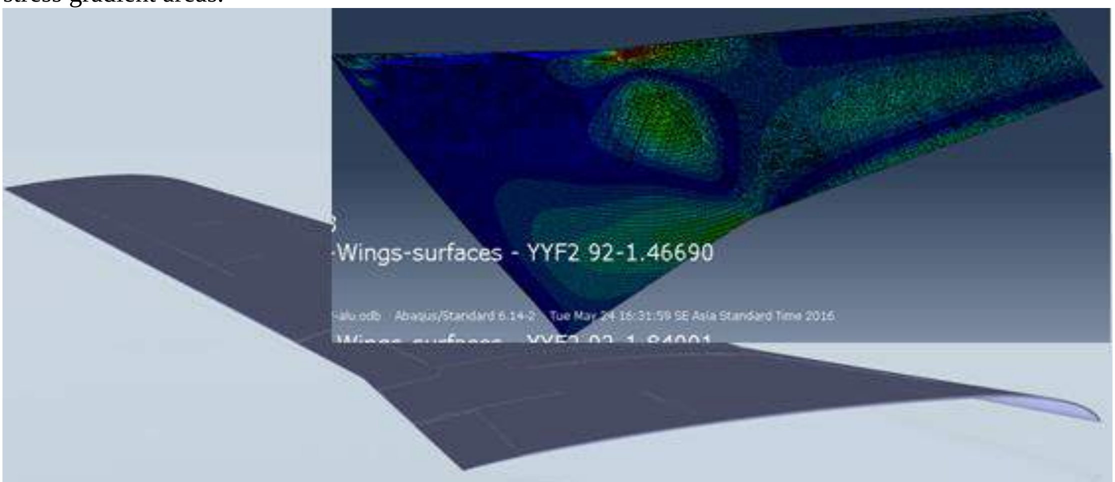

Figure 4. Wing surface analysis to apply composite

1.3 Application of Composite Grid Approach on the wing's surface.

A surface model created in a CAD program (CATIA) is often used as a start, when working with composite modeling. On this surface model, the designer has the ability to model and simulate different forms of materials compared to isotropic materials, is the fact that the composites inner structure must be defined.

Grid approach is implemented using a set of new commands enabling a better link between stress analysis and Composite design. It helps to take in to consideration structural elements such as stiffener, string, frames, etc. used in assemblies of composite parts during Composites Design.
Composite Grid design is an approach that uses a set of commands which enables a better link between stress analysis and the composites design. It considers the structural elements (such as stiffeners, strings, frames...) used during composites design.
The basic step in Composite Grid Design Composites is Design Parameters, the defining includes: surface to design, rosette, structural geometry, material…
Use Grid tool to define composite for the cells, for each cell we have to define ply information include: ply material name, ply orientation, ply number, stacking sequence for each individual cell, thickness laws.

2. Finite Element modeling structural analysis of wing

2.1 Connection CATIA to Abaqus

Dassault Systemes enables Abaqus simulations from within the CATIA user environment. It maintains and reuses the CATIA concepts of parts, virtual parts, and assemblies, making full use of associativity between geometry and the analysis model. Familiar CAD modeling constructs such as points, surfaces, and bodies which are the basis for familiar analysis constructs such as boundary conditions, loads, and contact associations. In addition, Abaqus for CATIA enables Abaqus nonlinear static, frequency extraction, explicit dynamic and thermal simulations, as well as sequentially coupled thermal-structural simulations

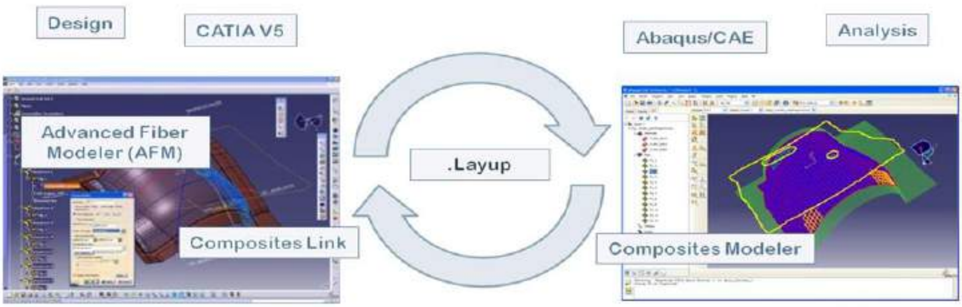

Figure 5. Integrating Design and Analysis.

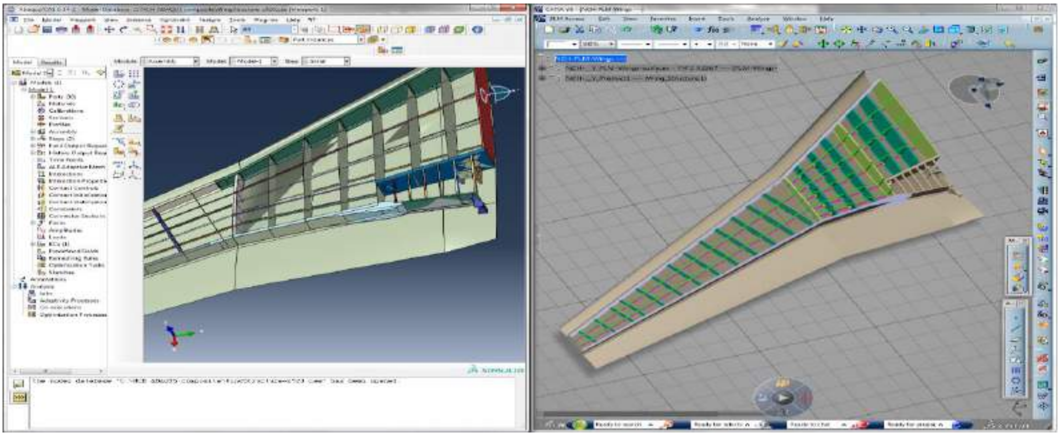

Figure 6. Design-Analysis Data Transfer.

2.2 Material Properties

Table 1. Alloys Aluminum property

	Material for Ribs and Fittings (Aluminum 2024-T3)	Material for Spars (Aluminum 7075-T6)
Density [kg/m3]	2780	2810
Young's Modulus, E [GPa]	73.1	71,7
Shear Modulus, G [GPa]	28	26,9
Poison's Raito, ν	0.33	0,33
Ultimate Strength [MPa]	483	572
Yield Strength [MPa]	385	503
Shear Strength [MPa]	283	331

Mechanical Properties of Aluminum Materials for Spars, Ribs and Fittings.

Table 2. Carbon fiber property

	Material for (Carbon – 0,24 Fabric)
Density [kg/m3]	1350
Young's Modulus, E11 [GPa]	150
Young's Modulus, E22 [GPa]	10
Poison's Raito, ν12	0.075

Shear Modulus, G12 [GPa]	4.8
Shear Modulus, G13 [GPa]	4.8
Shear Modulus, G23 [GPa]	4.8
Ultimate Compression Strength [MPa]	373
Ultimate Tensile Strength [MPa]	373

Lamina Mechanical Properties Carbon – 0.24 Fabric for skin

2.3 Wing generation in CAD/FEM

The model parts are imported from CATIA as we make the assembly of the wing from 30 parts. We create mesh in surface type S4R: A 4-node doubly curved thin or thick shell, reduced integration, hourglass control, finite membrane strains. Type 20mm for spar, type=50mm for rib and 60mm for surface.

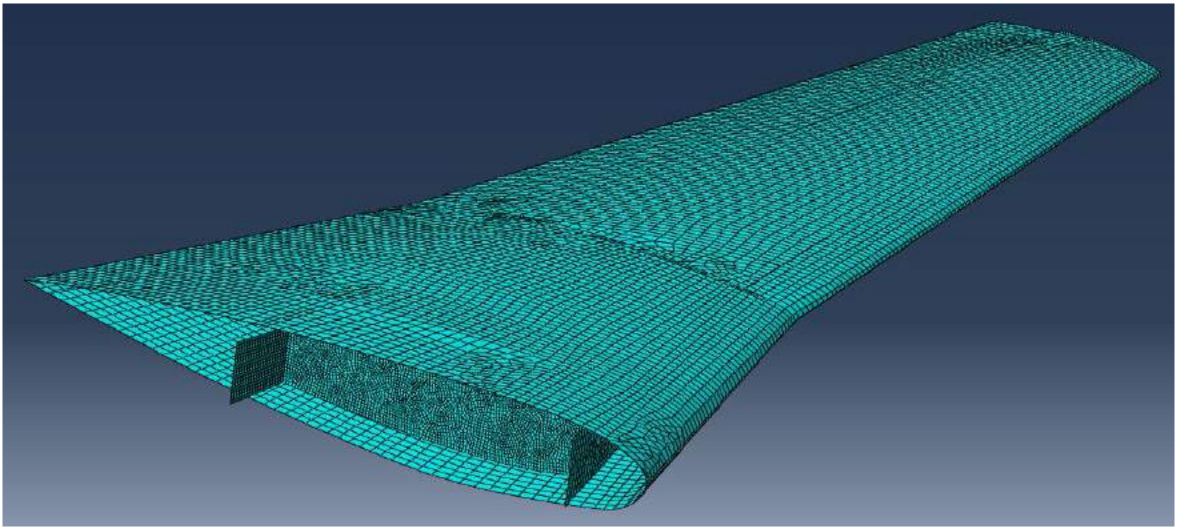

Figure 7. Mesh

The method to model this type of loading was to create an inertial acceleration field which was equivalent of the gravitational acceleration of 9.81 (m/s^2)
The method in order to model this type of loading was to create an inertial acceleration field which was equivalent to the gravitational acceleration of 9.81 (m/s^2). Figure 2-13 shows the inertial field created on the Model.

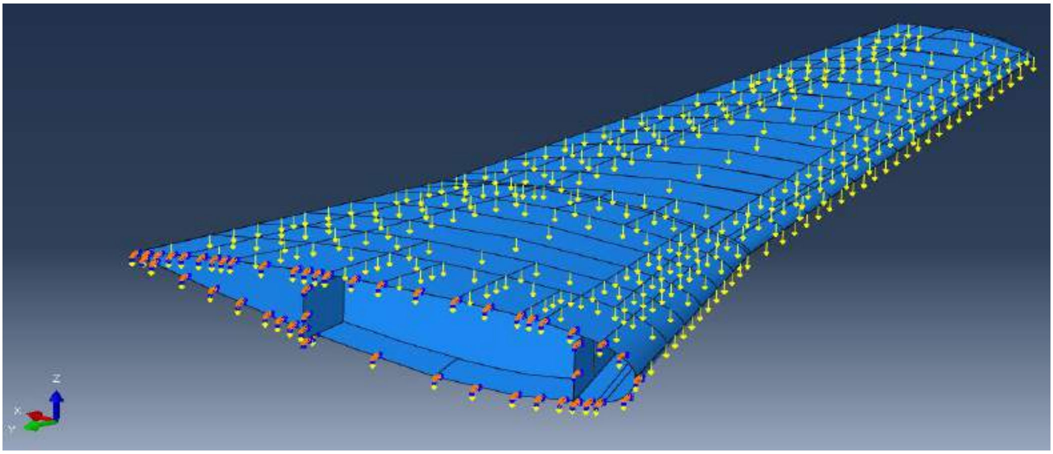

Figure 8 Wing interaction [Exported from Abaqus 6.14].

2.4 Calculation and Result

From figure 9 we can see that the maximum stress of composite case is 11,42 Mpa, and with the aluminum case is 17Mpa.

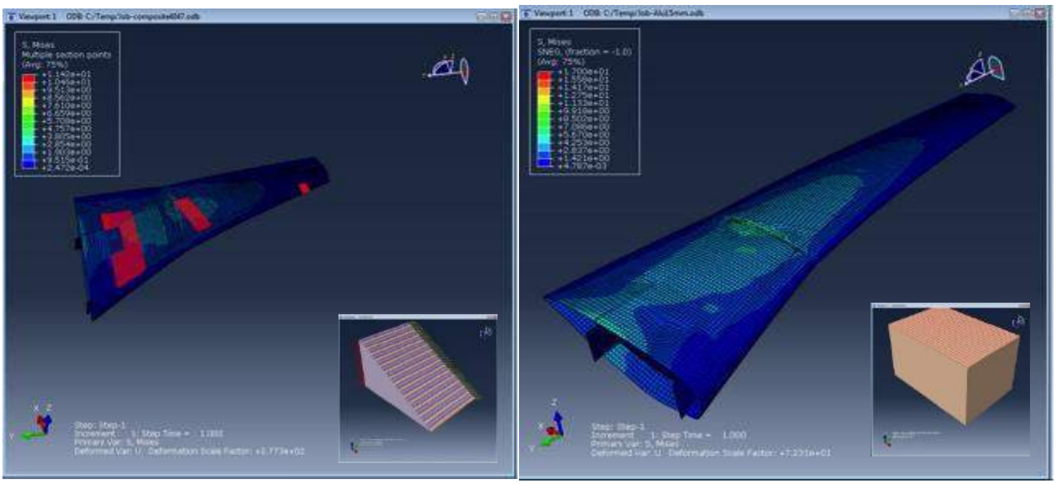

Figure 9. Stress of the wing in Composite and Aluminum.

From figure 10, we can see that the maximum displacement of composite case is 2,918mm, and with the aluminum case is 11,19mm.

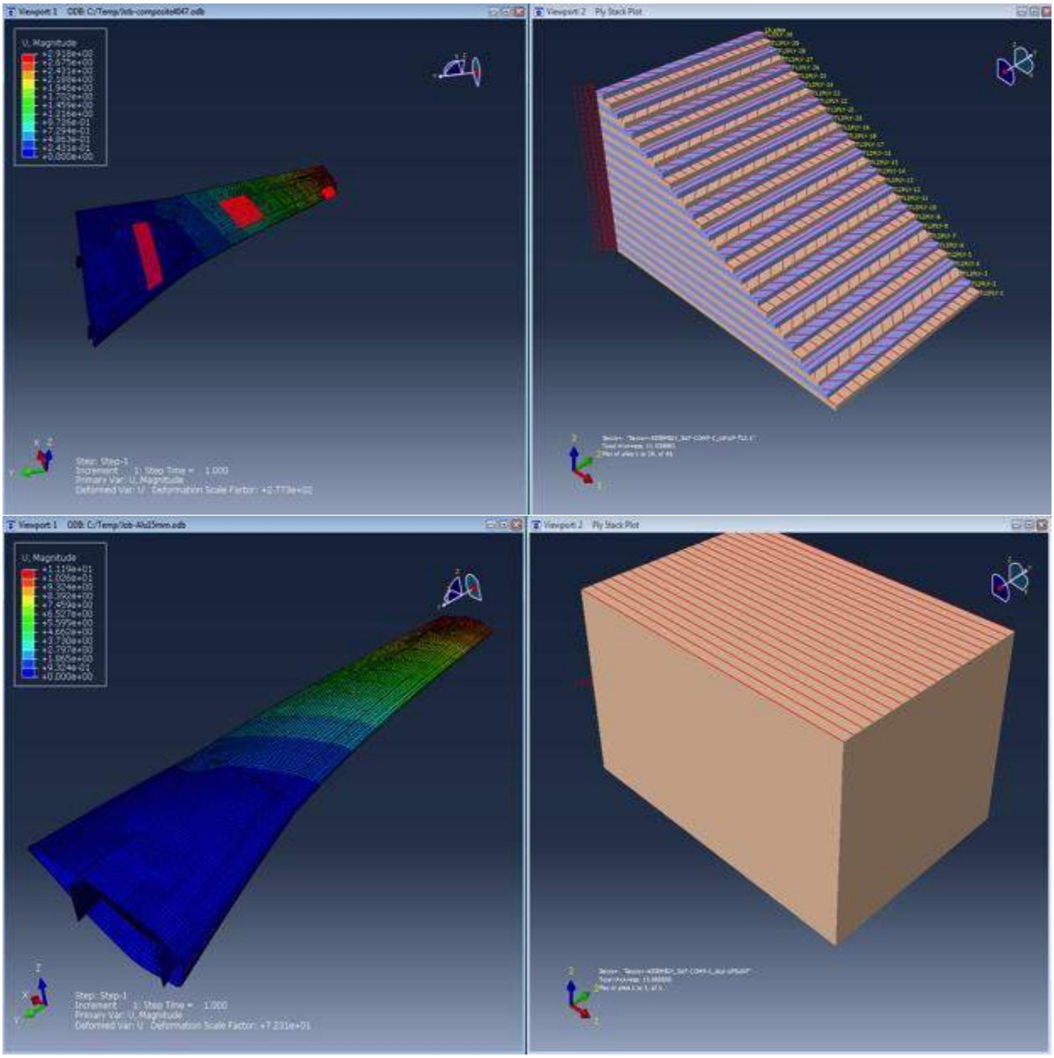

Figure 10. Displacement of the wing in composite and aluminum.

From the mass properties query, we have the mass of the wing in composite case is 0,897 ton, and with the aluminum case is 1,97 ton.

3. Conclusion and Perspective.

In this study, the objective was to investigate the use of composite as an alternative in the aircraft wing and thus help in reduce the weight of the plane. In general, the Composite material is used in the aviation industry to purpose as light as possible in order to improve aircraft maneuver

performance, decrease aircraft manufacturing and operational costs while keeping the stress levels under a certain value (static or fatigue allowable).
The wing structure is design in CATIA V5, and the skin of wing is applied with CATIA composite design. Then the model is exported to Abaqus 6.14 to calculate, simulate and optimize.

3.1 Conclusion

In this calculation, due to the difficulty in connecting between two software, the structure of the wing is simplified for the model simulation. In the sample test, we can consider that the FEA software is seen as relatively accurate, and the reason to replace aluminum by composite material.
The replacement of Aluminum alloy by composite material reduces the total weight of the aircraft wing by 54,8 %. Moreover, the maximum design stress (Von Mises) in the global FE model was reduced to 33% of its initial value. Finally, the stress of the wing depends on the number of the ply and the distribution of the reinforce phase.

3.2 Perspective

For the future work, we can apply composite material for the all the structure part and develop the cases of study such as: vibration, fluid, heart transfer.

4. Acknowledgments

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5. References

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