Shape optimization of striker cap of automotive shock absorber

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Abstract

While driving the vehicle safety is very important. It is depended on the suspension of vehicle and breaking and other systems in vehicle .Comfort is very important for the driver and also the passengers and that comfort is dependent on the suspension system of the vehicle. Shock absorber plays most important role in suspension system which is connected to the wheels of vehicle. Shock absorber reduces the effect of impulse and road irregularity experienced while driving. Shock absorber of car used a striker cap. Automotive shock absorber have actively working cylinder of inner and outer cylinder. Striker cap is mounted on the outer cylinder. Cap is of U shaped which is forming the ring on outer cylinder. When that cap is fitted on damper pressure applied on top surface of cap and sometimes that cap is failed. So for meeting the current demand and minimizing the failure of cap we must have design the cap by changing some design parameters. Design of striker cap is prepared in CATIA V5 and CAE is done in ANSYS.

Keywords — *Shock absorber, strut, damper, striker cap, FEA, Ansys.*

I. INTRODUCTION

A shock absorber is the mechanical device which is designed to damp and smooth out the rough shock impulse and dissipate kinetic energy. In a suspension of vehicle, it improves ride quality by reducing effect of the travelling over the rough ground, which overall increases in comfort due to substantially reduced amplitude of disturbances. Shock absorber is based on strut, striker cap spring, cylinder etc. components. The modified strut configuration is used for automobile suspension system. The strut having strut cylinder and pressure cylinder at upper end. A piston with the piston rod from within the pressure cylinder and it is attached to the body of a vehicle. A bumper is attached on the piston rod between the body and the top end of the pressure cylinder, and a striker cap is mounted on the piston rod between the bumper and the end of the strut cylinder. The striker cap is mounted on cylinder with the interference fit it includes lower circular parallel surfaces extending radially inward to a working cylinder. The striker cap which is used is made up 0of an elastic polymer. [1, 3] Striker cap in automotive shock absorber provides protection to the cylinder from spring forces while different road conditions. Strut cylinder's striker cap is protected from contact between the bumper during full jounce motion of the vehicle suspension. The top and bottom surfaces of the striker cap have radially extending open channel which provides discharge passages for the water and other contaminants that may collect near the central bore and on the pressure cylinder's top end. Such cap is used in VW passenger's vehicle which is made up of a Nylon 66 material. Striker cap is molded of a polymer composition. While assembling cap on the strut with the help of pressure on its upper flat surface cap is failed or damaged on the portion of cap.

Fig 1 - A model of strut system with striker cap.

II. LITERATURE SURVEY

In the interest of Optimization techniques lot of research in completed & in process. Out of which many articles are focused on Topology and Shape Optimization of component. The main interest of this research is to modified or optimize the weight of component to increase the efficiency of machine & reduce the cost of component. In optimization techniques research authors using finite element analysis to find out stresses which occurs on component before optimization. From this reference by finding out the non-design area researcher remove or add the material to optimize the component [1] [2] [3] [7].

U.S. Pat. No. 4,480,730 [4] invents a shock absorber having a closure cap which is mounted on the outer cylinder. This of course necessitates the additional parts comprising the closure cap, which must be installed by means of a unique operation. For minimizing the additional shocks to the cylinder and minimizes damages chances of shock absorber because of shocks and increasing life of shock absorber.

Pinjarla. Poornamohan et al [1] design the shock absorber which is optimized by changing the material of the spring. They calculated the parameters of the spring and analyzed the result of different load conditions against CAE results

Paul B.Mccormick et al [5] In that invention U.S.Pat.No.6,199,844 B1 issued Mar.13,2001 they focused on a specially countered striker cap which include an axial projection of limited surface area to restrict the metal to metal contact when load acts because of this the cross-section of the projection is preferably decreases in the axial direction towards the bumper so that a gradual and progressive contact and displacement area develops between the striker cap and bumper during severe jounce movement.

Sushovan Chatterjee et al. [6] Crack and failure propagation study is a futuristic criterion to design better and more adaptive engineering structures; hence it becomes imperative to distort in a concrete study of crack propagation. CATIA V5 CAD tool is used to estimate the Critical cracks and the critical load. Comparative study is done based on critical length of various engineering structures which like rectangular beam, I shaft and a solid shaft from which hollow shaft is been found better over the other structures for engineering design.

Y.S. Kong et al. [9] to perform the Topology and topography structure optimization for the spring bottom seat is performed to reduce the weight of a passenger car spring bottom seat design under stress and structure compliance constraints. The topology optimization performed to identify the parameters like density of the elements, whereas topography optimization is used to strengthen the structure of the lower seat by applying bead parameters in a model. Topology optimization, the mass of a model is improved by a reduction of 36.5%. With the combination of that topology and topography optimization techniques, the weight of coil spring of lower seat has been successfully reduced while preserving of its strength.

III. PROBLEM STATEMENT

Striker cap is used in shock absorber assembly mainly for reduction of noise and protection from striker on cylinder body. Also used as protector from dust and moisture contains on cylinder body. At time of assembly 10 components are fails out of 50 components. Thickness, material, interference fit, deflection are the factors affecting the failure of cap. Failure will be reduces by changing some design parameters where deflection and stresses are changes by changing design parameters.

IV. OBJECTIVE

Various numerical approaches are used to determining the problem solution The objective of that paper is to optimize the cap by making some dimension changes in model with the help of ansys which helps to predict the effects of stresses and deflection for design changes. Checking the stresses and deflection of the objects and compare that analysis with the experimental results. The main focus of the current research as developed here is to analyses the failure and optimize the cap.

1. Model prepare by Catia V5R21
2. Analysed the striker cap design by ansys and evaluate deflection and stress for different design changes.
3. Compare the deflection and stress for both.
4. Evaluate Experimentally Result for design change.

V. OUTCOME FROM REVIEW PAPERS

From various literature review it's found that the optimization can be done with two technics shape optimization or Topology optimization. Both techniques are used in industries for optimization purpose following are some optimization techniques.

A. Topology optimization is nothing but an approach that optimizes the layout of material within given design space, for the given set of loads and boundary conditions like that the resulting layout meets the required set of performance targets. Topology optimization need to find out non design area of component where load is not acting & stresses are very less from where we can remove the material in such manner that manufacturing feasibility is also considered. [9]

B. Shape optimization is part of the field of optimal control theory. The typical problem is to find the shape which is optimal at given constraints in that it minimizes a certain functional cost while it satisfying the given constraints.

C. Size optimization is to obtain the optimal thickness of component.

VI. FINITE ELEMENT ANALYSIS

Finite element analysis is carried out in 3 steps-

A. Pre-processing: For pre-processing, Ansys 14.0 is used. In Ansys CAD model is imported in the form of neutral format. Meshing criteria is decided as per geometry. Material property, load and boundary conditions are applied to meshed model.

B. Processing: For processing, solution are obtain in ansys would be used to solve the model.

C. Post-processing: After obtaining solution Ansys would be used to study the results in the form of graphs or contour, tables.

Two possibilities are considered for design optimization analysis are as follows:

1) Analysis result with given condition:

Component analysis of original cap without fillet

Material Properties:

Young's Modulus (E): 10000MPa

Density: 1.36g/cm3.

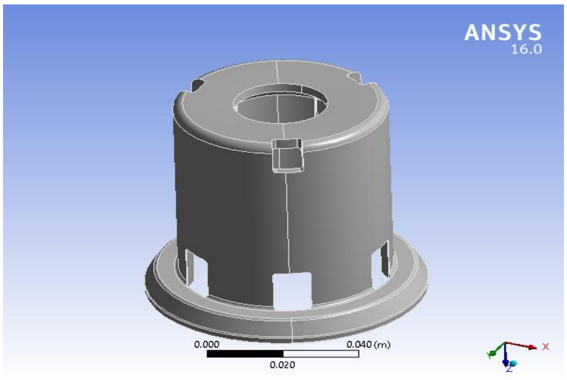

Fig 2 Striker cap CAD Model of original design

- ***Meshing***:

A tetrahedron element is used for meshing of size 0.001mm details as follows:

Table No.1-Meshing Details

No. of nodes in model	257122
No. of elements in model	146008

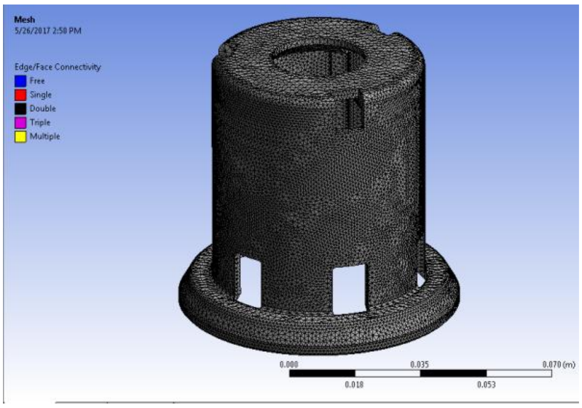

Fig 3 Striker cap in meshing

- ***Loading and Boundary Conditions:***

Boundary condition for cap is given in table.

Table No.2-Boundary conditions

Sr.No.	Boundary conditions	Value
1	Load	9384 N
2	Displacement	1 mm
3	Fixed support	At bottom surface of cap

Fig.4 shows the cap with all boundary conditions.

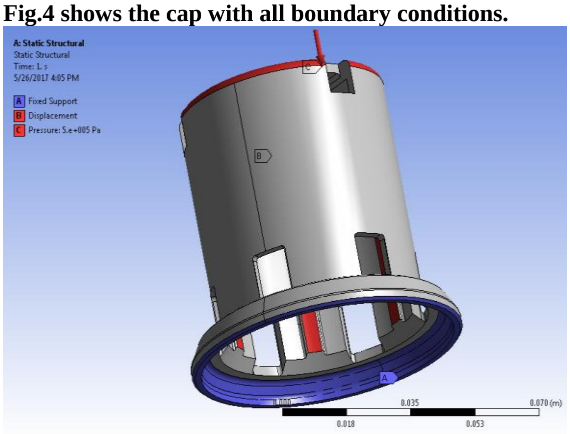

Fig 4 Boundary conditions

- ***Total deformation:***

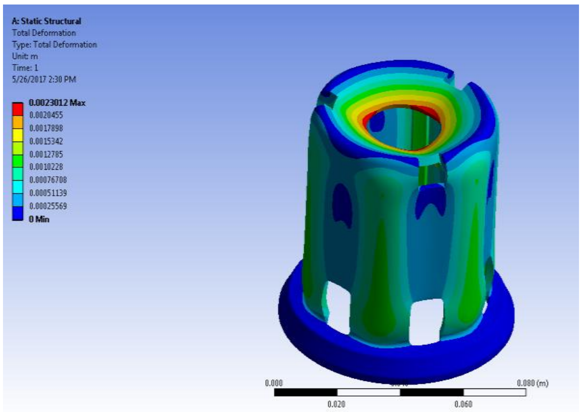

Fig 5 Total Deformation

Figure shows total maximum deflection on cap of original dimensions

- ***Maximum stress:***

Figure 6 shows total maximum Von misses stress on cap of original dimensions and Figure 7 Maximum principle stresses.

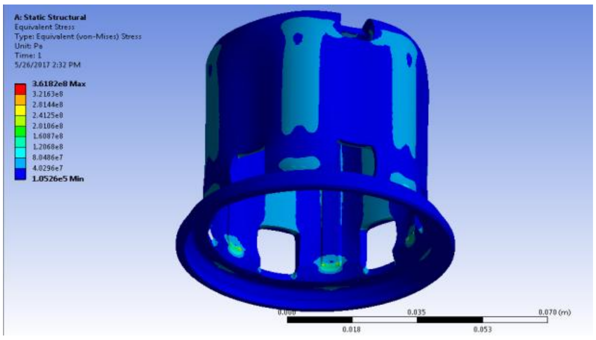

Fig 6 Equivalent Von-misses stress

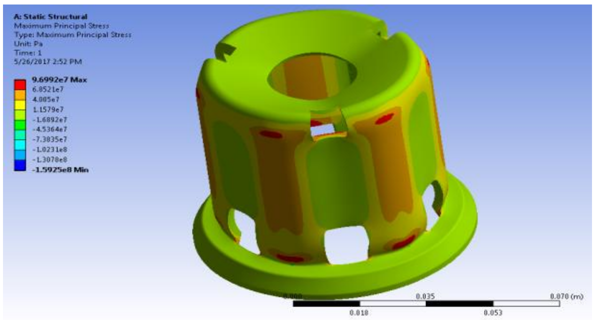

Fig 7 Maximum principle stress

2) Analysis of component with giving fillet radius:

Same procedure follows as original component. Figure.8 shows the catia model of cap after modification 1 further figure shows maximum deflection and Stresses in cap at design change.

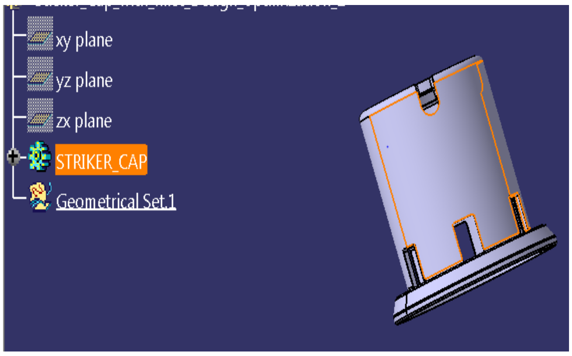

Fig 8 Catia model after modification 1

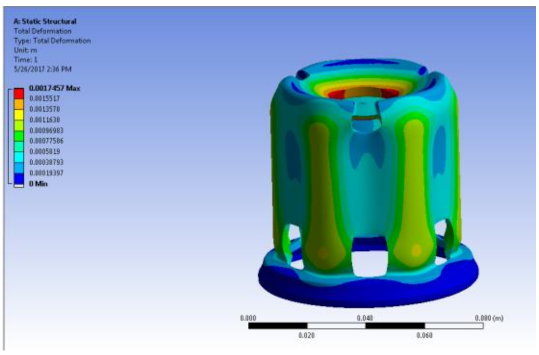

Fig 9 Total deformation

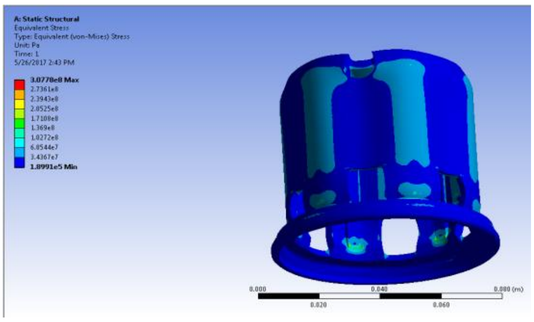

Fig 10 Equivalent Von-Misses stress

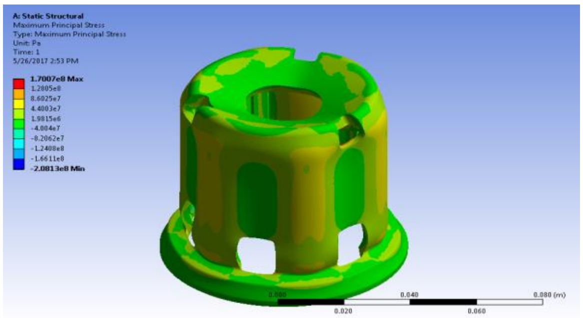

Fig 11 Maximum principle stress

3) Analysis of component with increasing thickness:

Increasing component thickness with 1mm on upper side. Following figure 10 shows the catia model for design modification:

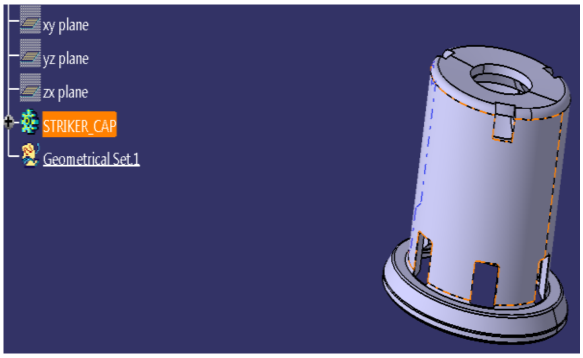

Fig 12 Catia Model after modification 2

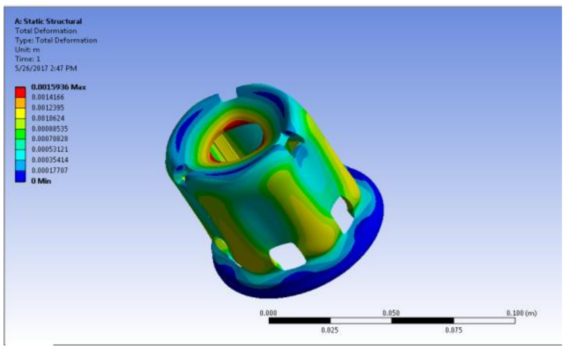

Fig 13 Total deformation

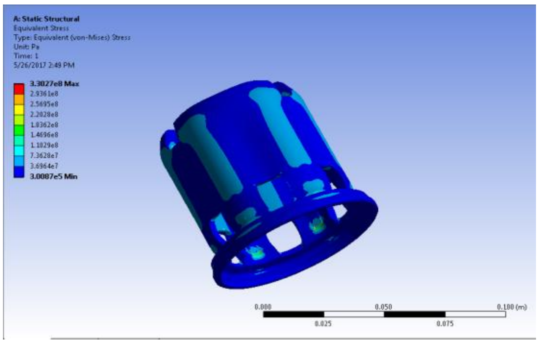

Fig 14 Equivalent Von-Misses stress

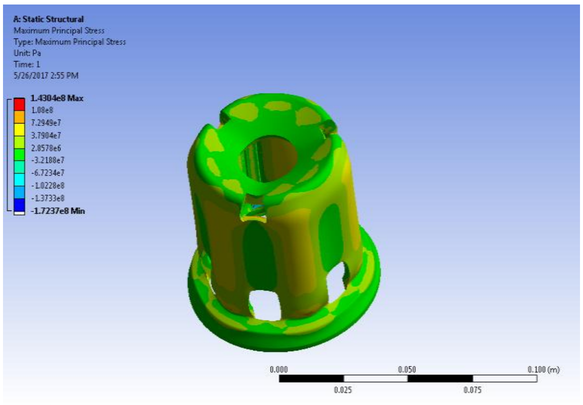

Fig 15 maximum principle stress

Fig 13. Shows Maximum deflection of 1.5936mm Fig 14. Maximum stress of 3.3027e8 Pa fig 15. Shows principle stresses which is 1.4304e8.

VII. RESULTS

Table No 3- Result comparison sheet

Sr.no	Model	Deflection (mm)	Von-misses (pa)	Principle stress (Pa)
1	Original	2.3012	3.6182e8	9.6992e7
2	With Fillet	1.7457	3.0778e8	1.7007e8
3	With thickness increase of 1 mm	1.5936	3.3027e8	1.4304e8

From stress and displacement values, it is observed that Deflection and Von misses stress of original cap is more than two new design striker cap. With increases thickness Deflection of cap with thickness increase is 1.59 mm which is less than the original and with fillet design. And also the stresses values are less as compare to another two.

VIII. STRIKER CAP DEVELOPMENT

Injection molding is the manufacturing process to obtain molded products by injecting molten plastic materials into a mold, and then cooling followed b solidification. Injection molding is suitable for the mass production of the products with required shapes, and takes a large role in the area of plastic processing. The process of injection molding is completed in 6 major steps as shown below:

1. Clamping on machine
2. Injection process
3. Dwelling process
4. Cooling object
5. Opening mould
6. Removal of products

Fig 16 Molding machine

Fig 14 shows the molding machine which is used for the injection molding of product.

IX. EXPERIMENTAL TESTSING AND VALIDATION

For testing the components a Universal testing machine is used. By using the fixture base which is having a cylinder outer body part on which cap is press fitted with the help of load which is given by the load cell as shown in figure 17. We are carried out test of different component as per our design changes and measure the deflection of it. Figure shows the typical test setup for determining the failure of striker cap. Load is applied to cap and regarding values are display on the display setup of machine.

Fig 17 Experimental Setup

Fig 18 Cracked model

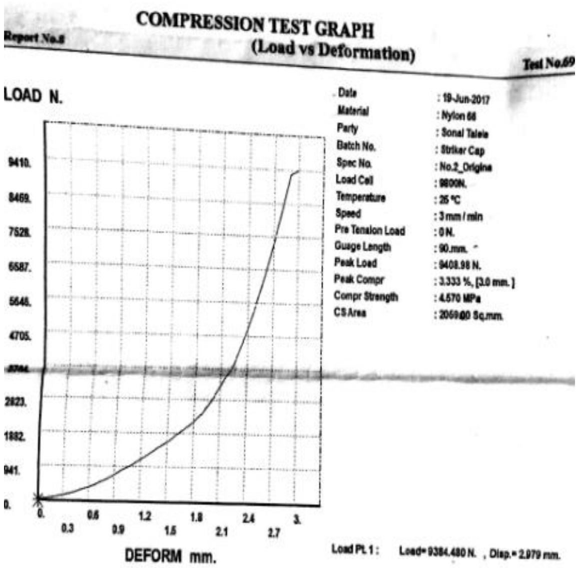

Fig 19 Compression graph for original cap

Fig 19. Graph shows the deformation vs load where displacement is 2.97 mm at load of 9384 N

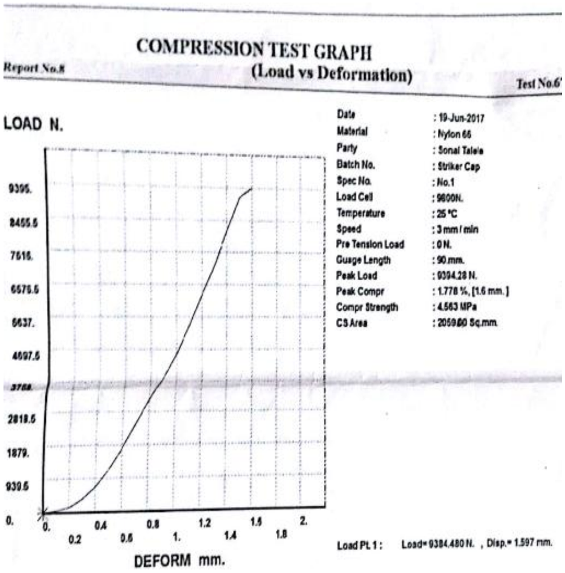

Fig 20 Compression graph for modification 1

Fig 20 shows the experimental graph for test of modification 1 where tritangent radios is given to upper block window. Deformation vs Load graph is given to where 1.5 displacement at load of 9384 N found.

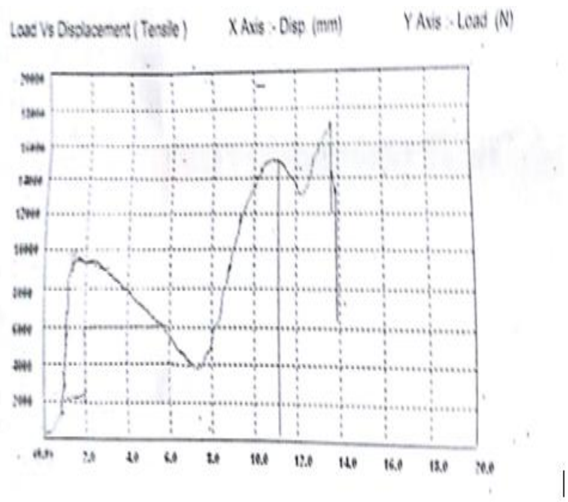

Fig 21 Compression graph for modification 2

Fig 21 shows the test for modification 2 where thickness is increases from 7 mm to 8 mm from original cap. Deflection is 1.5 mm at load of 9384 N which is near to analytical result.

IX. RESULT COMPARISION

Following Table.3 shows the result comparison of experimental and analysis results for the striker cap for load of 9384 N.

Table No 3- Result comparison sheet

Sr. no	Model	Analysis Results		Experimental Results	
		Deflection (mm)	Von-misses (Mpa)	Deflection (mm)	Von-misses (pa)
1	Original	2.3012	361	2.97	359
2	Modification 1	1.7457	307	1.59	295
3	Modification 2	1.5936	330	1.52	325

X. CONCLUSION

In this project designed striker cap is in a shock absorber of vehicle used passengers car. Model of both existing and new design spring is constructed by using CatiaV5. To validate the strength of design and stress analysis, structural analysis on the cap models are perform in Ansys14.0 By comparing FEA results and experimental results for original design, and the modified designs, from which the value of modification 1 with fillet radious having the better results than original. But Modified design 2 with the thickness increase having good results against remaining two designs. So conclude that as per analysis and experimentations the modified design 2 having the good results is the best option for striker cap design.

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