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APPLICATION OF NANOSTRUCTURAL Ti ALLOY FOR PRODUCING A FACE FOR A GOLF CLUB

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Abstract. Creation of new improved faces for wood golf clubs is impossible without providing such advantages as decreased shock experienced at impact, elevated stored energy from the club head to the ball at impact for increasing ball distance and more efficient usage of the face material having the required strength. The paper presents a new structure of golf club face and a method of its production.

1. INTRODUCTION

The task dealing with decreasing shock experience at impact is very urgent in terms of preventing professional deceases of players. The long distance driving of the golf ball is a main characteristic of wood style golf clubs. The useful application of the face metal interior assumes redistribution of metal aimed to increase the strength of face areas mostly subjected to shock experience. At the same time the task to increase strength characteristics of the golf club face as a whole remains as well.

It is known a number of solutions aimed to reduce shock experience by using various damping facilities connected with the face inner surface. In particular, it is known the application of high ductile materials [1,2] or flexible metallic ribbons for this purpose [3].

The drawback of such models is lack of reliable attachment of damping material. Moreover, the weight of a face and a club head as a whole is increased.

Traditionally the club head face is produced from titanium alloy ingots by casting, die forging or machining.

The proposed method assumes application of a goffer type model instead of a monolithic one. The club head face is a multiple layer goffer type structure which is provided with a covering and a filler forming strengthening ribs (Fig. 1).

In the proposed face structure pads 4 are placed between coverings 1, 2, and filler 3 to be bonded. The central portion of covering 1 being striking is strengthened by ring insert 5.

The present manuscript develops a mathematic model of the club heads face and by means of com-

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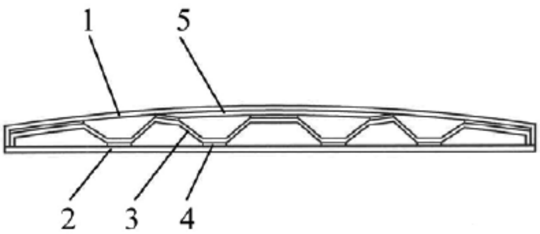

Fig. 1. Club head face structure.

parative analysis evaluates the potentialities of a goffer type structure.

2. MATERIAL AND EXPERIMENTAL PROCEDURE

The method of finite element was used to develop a model of the club head face. While modeling a cross section of the face along the smallest dimension in projection (44 mm) was selected. Due to the symmetry one haft of the section selected was considered. The task was solved in 2 D approximation. The simulated area was divided into axially symmetric finite elements and the model described the behavior of the round face plate.

Fig. 2 shows the initial shape of the monolithic face model. Fig. 3 shows models of the goffer type club head face. The goffer type structures are differed in tilting angles of rids. The models had a spherical external surface, 250 mm in radius. The thickness of cross section of the monolithic club head face was 2.7 mm.

The physical parameters of the material are the following: Young's modulus – 110 GPa, Poisson's ratio – 0.35. The stress corresponding to 0.2% strain was 1200 MPa. The material model was considered as an isotropic solid body with non-linear hardening.

Conditions of face attachment in the club head were taken as rigid along the side line of the simulated area. Load was applied along the model axis. The task was solved statically. The force imitating the ball impact was set in the form of distributed load P = 50 MPa, affecting on the area 5 mm in radius with the center located on the axis of the face symmetry. The distributed load was equivalent to the concentrated force 3.9 kN. The area of pressure applied was selected reasoning from the results of mechanical tests of a golf ball. At compression of the ball on flat heads under a load of 1000 N the contact area was 14 mm. A value of pressure was determined on the basis of experimental tests so that a value of plastic strain in a monolithic face,

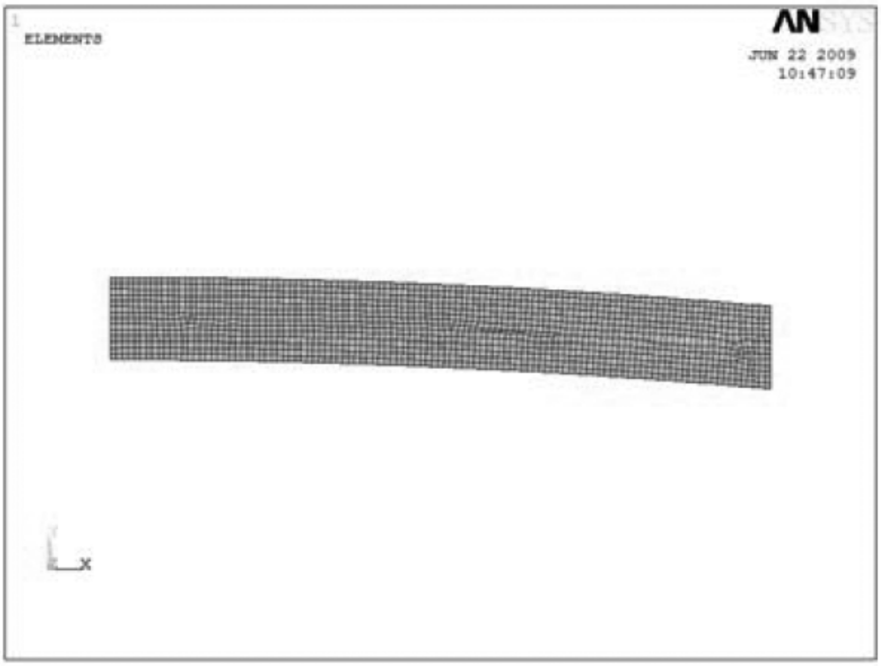

Fig. 2. The initial shape of the monolithic club head face.

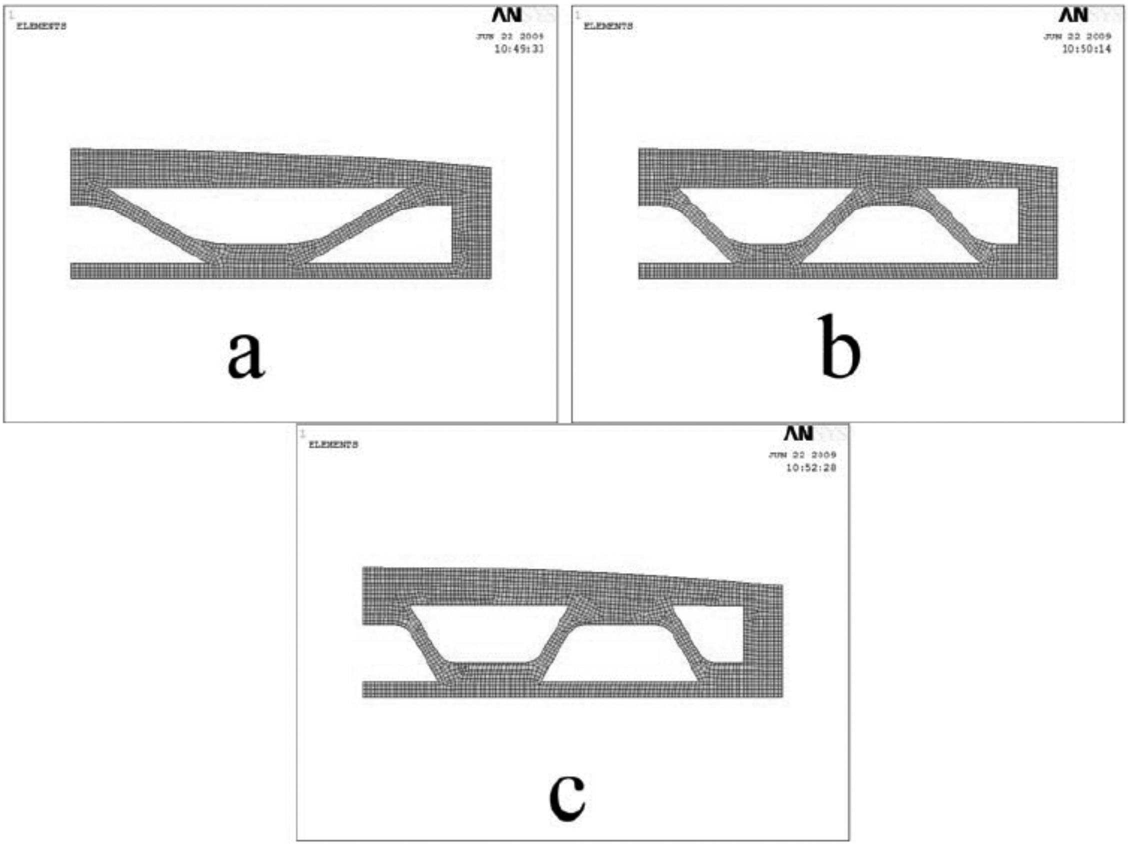

Fig. 3. The initial shape of goffer type club head faces with different tilting angles of ribs: a) 30°, b) 45°, c) 60°.

2.7 mm in thick, should be no more than 0.2%. Under the pressure P = 1 MPa a value of plastic strain was equal to zero and under the pressure P = 100 MPa the strain was 0.3%.

3. RESULTS OF EXPERIMENTS AND THEIR DISCUSSION

For analyzing the stress-strain state of the club head face models the following parameters have been determined: a shape after deformation, distribution of equivalent plastic strains and distribution of equivalent Von Mises stresses. Models of a goffer type structure were compared with the base variant (Varient 1) – a monolithic club head face, 2.7 mm in thick. The strength of modeled structures was valuated by the following data: a face flexure, maximum intensity of plastic deformation, maximum intensity of stress. Figs. 4 and 5 show the stress distribution in the monolithic club head face and in goffer type faces with different tilting angles of ribs.

Table 1. Results of analysis of modeled club head faces.

Model (tilting angle of ribs)	*Flexuremm*	*Maximum plastic strain,* %	*Maximum equivalent stresses,* MPa
Monolitic	0.33	0.18	880
Goffer (30°)	0.4	0.4	950
Goffer (45°)	0.22	0.178	860
Goffer (60°)	0.39	1.97	1000

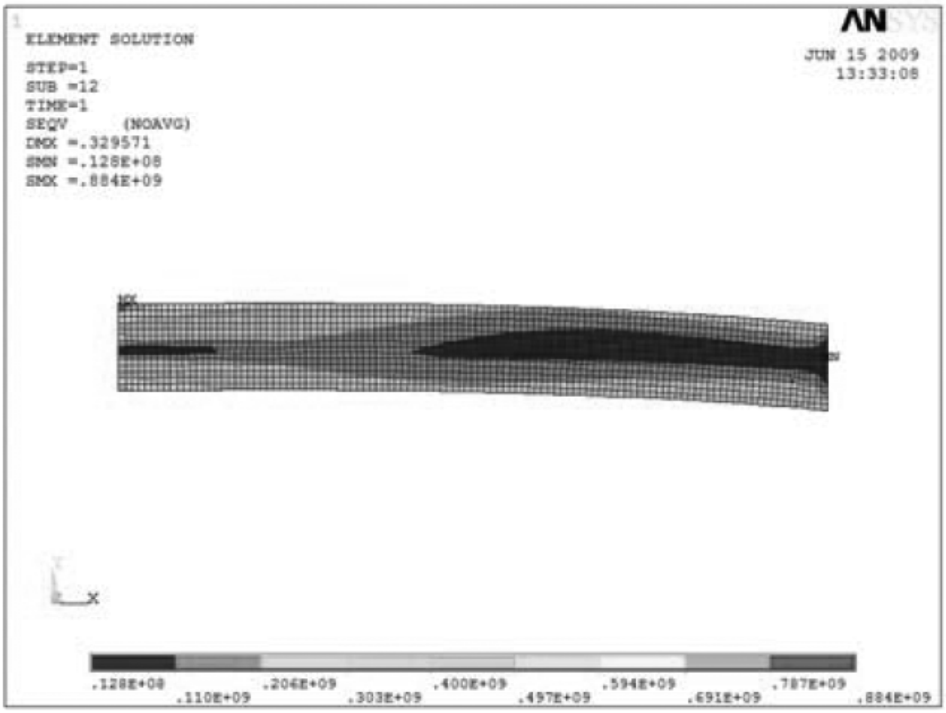

Fig. 4. Stress distribution in the monolithic club head face.

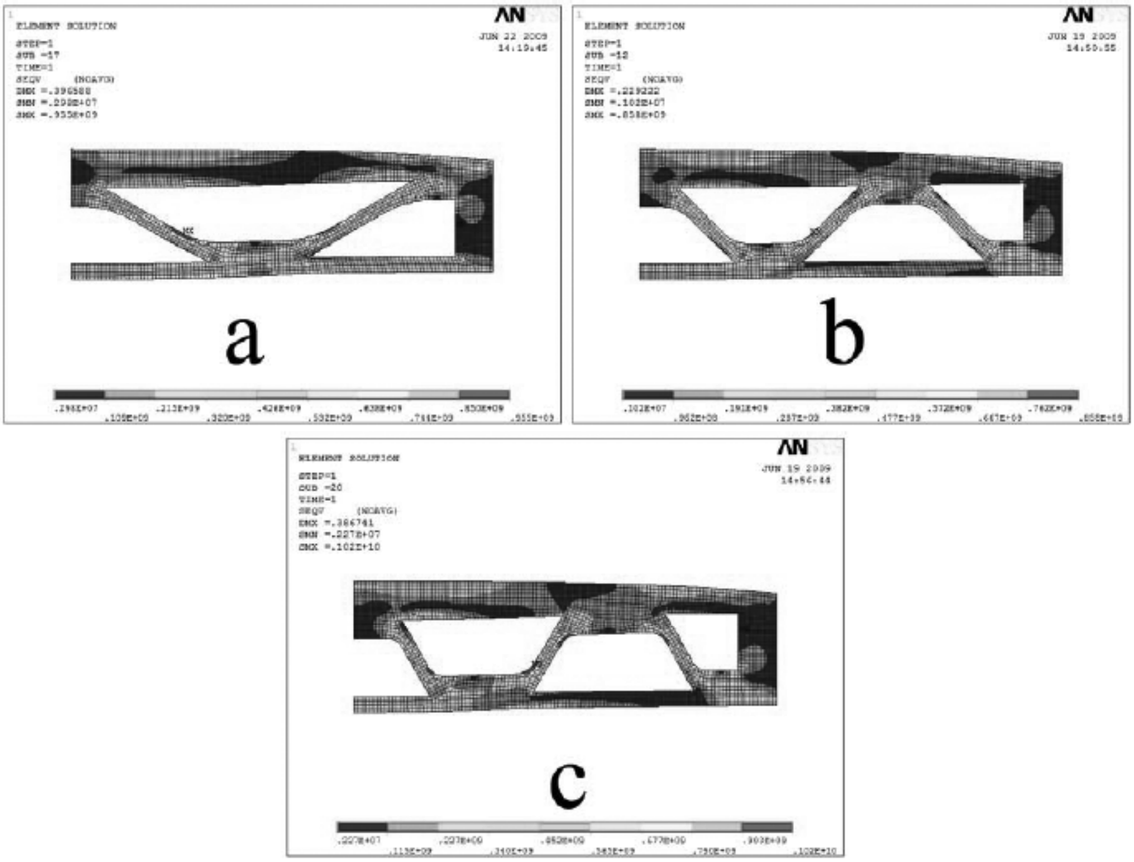

Fig. 5. Stress distribution in goffer type faces with different tilting angles of ribs a) 30°, b) 45°, c) 60°.

Fig. 6. Processed samples of faces and golf club heads.

The results of analysis of the stress-strain state of the monolithic face and goffer type models with different tilting angles are shown in Table 1.

It is seen that the goffer type face with the tilting angle of 45 is most preferable. Its maximum plastic strain being less than 0.2% is the smallest one. Its flexure and maximum equivalent stress are also minimal. The manufacture of such a face is possible by means of superplastic forming and pressure welding using a pad in the central portion.

The club head face of the considered structure was produced from three processed sheets by pressure welding combined with superplastic deformation for one processing cycle. Processed sheets out of commercial titanium alloy VT6 (Ti-6Al-4V) with a grain size of 2 mm and 200 nm were used for producing the face. Fig. 6 shows integral and cut samples of the face and golf club heads processed by the method proposed.

It is known that nanocrystalline materials possess elevated strength and improved solid state weldability as well as high damping properties. Nanostructured titanium alloy is used as pads 4 and ring inserts 5.

The method for producing a goffer type face using nanostructured pads and inserts provided processing faces characterized by improved strength and high impact efficiency that was confirmed by developed and field tests. Moreover users noted decreased shock experience at impact Development tests were performed at Company Nike, and field ones on playing grounds of Russia, USA and Republic of Korea.

Accumulation of residual plastic strain takes place both in cast and proposed faces influencing their service life. The results of mathematic modeling and development tests have shown that as compared the cast face the face proposed is characterized by high elastic strain concurrent with low residual plastic deformation.

The obtained results provide new potentialities for applying nanostructured materials.

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