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Titanium Alloy for Golf Club Head

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In recent years, titanium alloy has been used for the golf club head more than previously particularly for the driver head. Titanium Alloy holds some unique characteristics to explain this phenomenon such as 1. Light Weight, 2. High Corrosion Resistance and 3. High Strength-to-Weight ratio. Since it has become possible to make the driver head larger and to make the club face thinner thanks to light weight and high strength-to-weight ratio, above all, the carry of the ball has become by far the longer than ever before. Due to the regulation of COR due to be applied from 2008 worldwide, it may become difficult to produce the titanium alloy club head with high repulsion by thinning the face.[1)] It is unlikely, however, that the demand for titanium alloy used for the driver head will decrease in that no other material may so far replace titanium alloy particularly because the manufacturing procedure and facilities for the titanium alloy are so well established. It is required thus to develop the club head that clears the COR regulation without lessening the carry of the ball drastically, where combination of material characteristics and its best application, combination with other materials or other titanium alloys with different chemical compositions would be thought of to achieve the goal. I intend to refer to the future application and its possibility of titanium alloy as the most suitable material for the golf club head. For its purpose, the techniques such as to combine between the combination of the material characteristics, and the establishment of the manufacturing point which adjusted a processing method, the other material, the ingredient type which is different with the same titanium alloy are thought of. This article is described about the promise of titanium alloy as the golf head material.

Keyword: *titanium alloy, golf club head, coefficient of restitution (COR), moment of inertia (MOI)*

1. Introduction

At first, driver head had been manufactured from persimmon, the material changed to stainless steel. Recently the main material of driver head has became titanium alloy. The reason why it was necessary to reduce its weight and to upsize to get a big carry.

But now the performance of the repulsion by the driver became regulated. To extend the carry, the following developments have been done :

(l)To expand the sweet spot and to make MOI (Moment of Inertia) bigger, the volume of driver head is made bigger

(2)To improve the performance of repulsion, the thickness of driver face is made thinner with high strength material as β type titanium alloy.

But these developments policy must be changed because of changing the regulation of driver head.

Therefore it is necessary to design the high performance of repulsion at the same time as clearing repulsion regulation.

In this paper, I write down how to conquer the problem and the future of titanium as the material of golf club head.

2. Titanium for driver head

2.1 How to manufacture titanium driver head

First of all, I explain how to manufacture driver head. In this case, I explain two main manufacturing methods, 'The Structure of Two Pieces' and 'The Structure of Four Piece'.

(1) The Structure of Two Piece

Fig. 1 shows the structure of Two Piece. It is the way of manufacturing a driver head, dividing it into 2 peaces of the body and the face and assembling it by the welding.

The body is cast. According to the design of face, it is manufactured by bar forging or plate punch press.

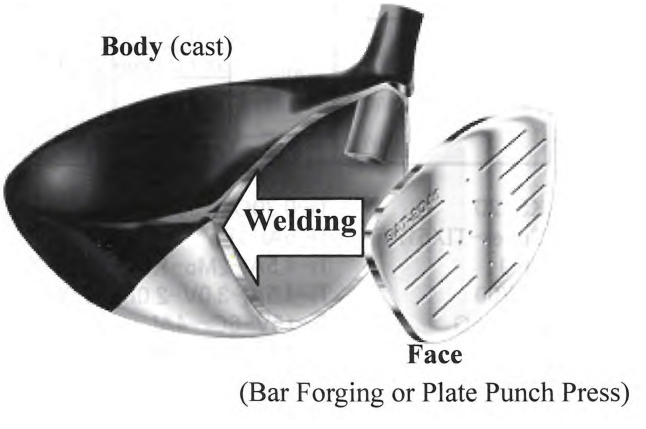

Figure 1. The structure of 'Two Piece'

(2) The Structure of Four Piece

Fig. 2 shows the structure of Four Piece. After dividing a driver head into 4 peaces of crown, sole, hosel and face, assembling these by the welding. The parts of crown and sole are manufactured by plate punch press. Hosel and face are mainly forged.

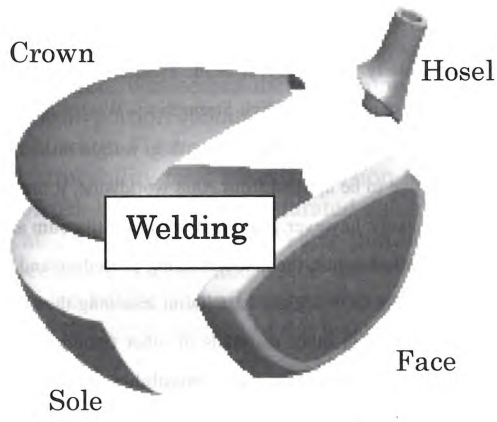

Figure 2. The Structure of Four Piece

2.2 The used titanium materials

Table 1 shows the used titanium materials at present. In the case of 'Two Piece', body is almost cast from Ti-6Al-4V. On the other hand, the case of 'Four Piece', hosel is made from pure titanium (ex. Gr.2). Crown and sole are made from pure titanium or β type titanium alloy (ex. Ti-15V-3Cr-3Sn-3Al) because of good formability. The face is made from various titanium materials.

First time, Ti-6Al-4V was major of face material. But β type titanium alloy has been became major because of its high strength and low young modulus to improve the performance of the repulsion. And then until it is decided that the performance of the repulsion will be regulated, β type titanium alloy was major in face material of driver head. But now it is necessary that face material has low density and high young modulus because of new regulation, therefore $\alpha + \beta$ type titanium alloy become major of driver face material again. (Refer to Fig. 3)

Table l. The used titanium materials at present (The results of research at The Japan Golf Fair in 2007) [2,3,4,5]

Club	Main Face material			Main Body Material		
Driver	Alloy	α type	KS120	Alloy	α type	KS120
		$\alpha+\beta$ type	Ti-6Al-4V Super-TIX51AF Ti-9 SP700 735		$\alpha+\beta$ type	Ti-6Al-4V
		β type	Ti-15V-3Cr-3Sn-3Al DAT55G TVC SAT2041 β		β type	Ti-15V-3Cr-3Sn-3Al
	Pure Titanium		–	Pure Titanium		Gr.2～3
Fairway Wood	Alloy	α type	KS120	Alloy	α type	
		$\alpha+\beta$ type	SP700		$\alpha+\beta$ type	Ti-6Al-4V
		β type	Ti-15V-3Cr-3Sn-3Al TVC DAT55G SAT2041 β		β type	Ti-15V-3Cr-3Sn-3Al
Iron	Alloy	α type	–			
		$\alpha+\beta$ type	350TITAN			
		β type	Ti-15V-3Cr-3Sn-3Al Ti-15Mo-5Zr-3Al			
	Pure Titanium		Ti-HARD			

KS120	Ti-0.30O-0.50Fe-0.60Si
Super-TIX51AF	Ti-5Al-1Fe
Ti-9	Ti-4.5Al-2Mo-1.6V-0.5Fe-0.3Si-0.03C
SP700	Ti-4.5Al-3.0V-2.0Fe-2.0Mo
DAT55G	Ti-15V-6Cr-4Al
TVC	Ti-13V-11Cr-3Al
SAT2041 β	Ti-20V-4Al-1Sn
350TITAN	Ti-3Al-5V
Ti-HARD	Corresponding to Gr.4

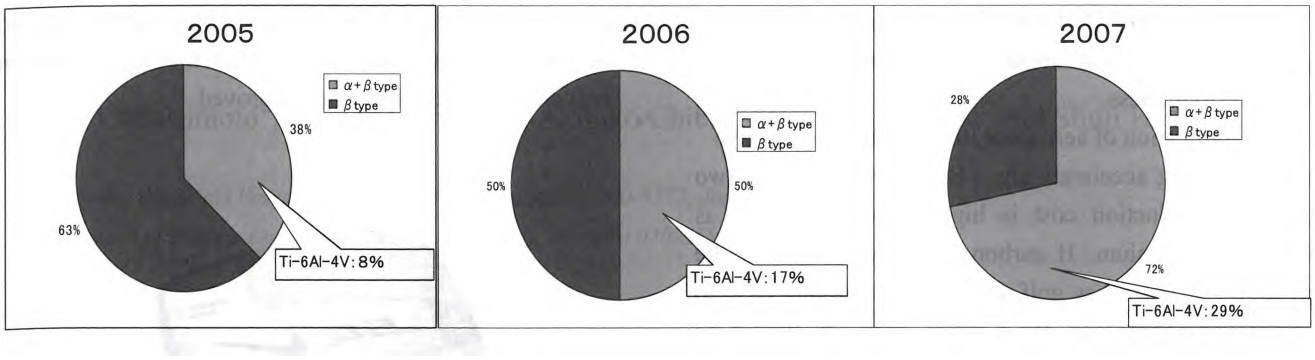

Figure 3. The change of driver face material (2005~2007)

3. The character of titanium driver head

Fig. 4 shows the regulation of driver head. As for the performance of the golf club, the capability of shaft concerns. But in this paper, only for head is mentioned. The purpose of driver for golfer is 'How correct direction and big carry'. Therefore it is important for the purpose that the face is as large as possible and the direction of ball is not concerned about hit point of the face as far as it is possible. When it is considered about that, it is said that the size of the face depends on the head size and the direction of ball depends on the size of MOI. The size of MOI depends on head size, it is advantage for MOI to make it bigger. That is to say, it is best that the head volume is upper limit of regulation.

Actually as for the volume of the driver head which is sold at present, the 460cc (upper limit) becomes mainstream. On the other hand, as carry, if considered about material, it is demanded that the face material has enough toughness, lightness and high performance of repulsion (low young modulus).

If concerning about the part of head except the face, it is demanded that the material has moderate toughness, lightness and the performance of good formability. According to above-mentioned result, actually titanium is the best material for driver head including the production cost.

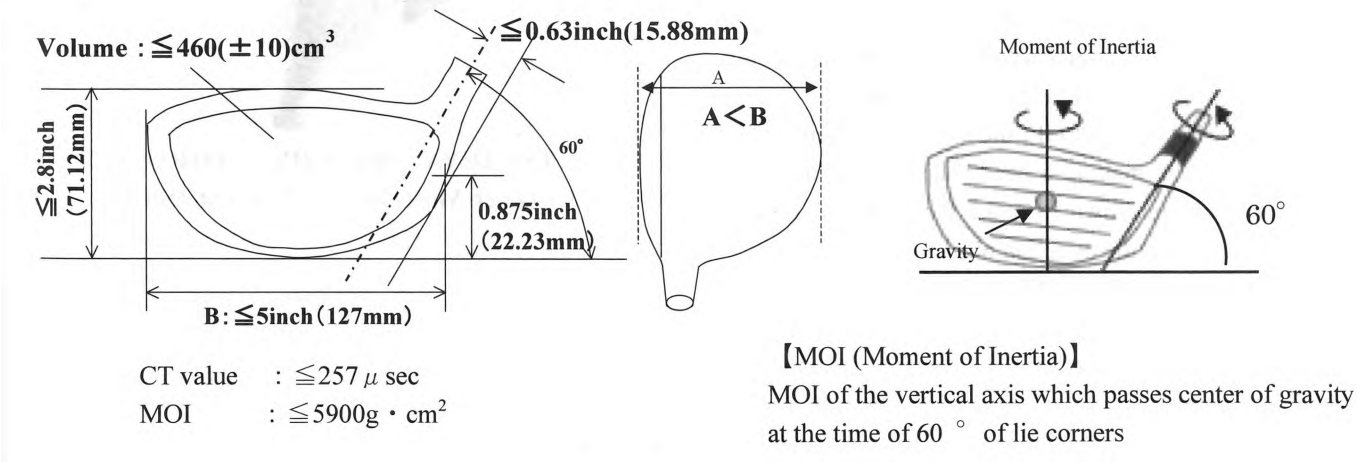

Figure 4. The regulation of driver head

4. The future of driver head

As concerning about the material of driver head, at present it is said that titanium is best. But if considering about to make it lighter, carbon fibers have advantage. Actually carbon fibers have been adopted as the driver head material

only in Premium. Carbon fibers hold much more superiority than titanium about the performance of to make lighter and toughness.

In the application of aerospace, these technologies have been developing acceleratingly. But they have main two faults that production cost is higher and formability is inferior than titanium. If carbon fibers are major in the application of leisure as golf, these inferior points have to be improved. Therefore, for a while, titanium should be main material of driver head, carbon fibers are adopted only in Premium. The carry is not decided by not only the performance of the face repulsion but also the transformation behavior of the whole head. The carry is improved by adjusting the transformation behavior of the whole head. As its technique, it is said that the computer simulation is suitable. The followings show the ideal as considering about full titanium driver head.

(1) The material of face : $\alpha + \beta$ type titanium alloy is best because of its suitable toughness and low density.
(2) The material of crown : $\alpha + \beta$ or β type titanium alloy is best because its thickness is able to be made thinner and the head gravity position is able to be made lower.
(3) The material of sole : β type titanium alloy is best because the head gravity position is able to be made lower by its higher density.

Fig. 5 shows the samples of Premium Driver Models in 2007. It is thought that they keep the possibility to become the basics of the driver design in the near future.

NIKE SQ SUMO[2] makes MOI (the moment of inertia) big to the best class in making a head shape square and also uses carbon for the crown to make the center of gravity lower and improving the direction of ball.

TSURUYA's AXEL DUAL IMPACT realize the big carry which they don't depend on the repulsion by the face for in the 'DUAL IMPACT' effect by the body transformation in making a body carbon incorporation formation and arranging a stainless weight in the face symmetrical position.

5. Conclusion

(1) It is said that titanium is suitable for the material of golf club (mainly driver) head at present.
(2) For more being made lighter, α type or $\alpha + \beta$ type titanium alloy becomes main because of lower density.
(3) In the future, the hybrid with carbon will be able to become main item, but it is important that the production cost and the productivity are improved.

NIKE SQ SUMO[2]
(Face Material : Ti-20V-4Al-1Sn)

TSURUYA AXEL DUAL IMPACT
(Face Material : Ti-20V-4Al-1Sn)

Figure 5. The examples of New Driver in 2007

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