EFFECT OF GLASS BEADS NATURE, MANUFACTURING AND AGEING ON THE BEHAVIOUR OF SHOT PEENED AERONAUTICAL MATERIALS

P.ARKER , SOVITEC , Florange , FRANCE
J.LU , J.F.FLAVENOT , CETIM , Senlis , FRANCE

ABSTRACT

The present study shows the effects of glass beads nature, manufacturing and ageing on microstructure, residual stresses of shot peened aluminium alloy (2024) and titanium alloy (TA6V). The results obtained on the components shot peened by two types of glass beads will be compared : classical glass beads (soda-lime-silica) and new special glass beads (alumino-silica).

This study concerning the ageing effect of glass beads on the microstructure and residual stresses as a function of the number of the using cycles of the beads. The mechanisms of beads failure is analysed for two types of beads. The influence of the ageing of the glass beads on the surface roughness is also studied .

This study shows that the research on the mechanism of failure of glass beads during ageing is very important for the development of the new glass beads to improve the surface quality and the mechanical behaviour of the shot peened component . It is possible to manufacture the new glass beads with optimised properties .

KEYWORDS

New glass beads, ageing, aluminium alloy, titanium alloy, roughness, residual stress, hardness

INTRODUCTION

The shot peening is largely employed as a corrosion preventive or for improving the fatigue life of components. The effect of shot peening is to introduce surface compressive residual stresses which are effective to a depth below the surface. Shot peening also modifies the surface roughness of the component.

The present study shows the effects of glass beads nature, manufacturing and ageing on microstructure, residual stresses behaviour of shot peened aluminium alloy (2024) and titatium alloy (TA6V). The results obtained on the components shot peened by two types of glass beads were compared : classical glass beads (soda lime silica) and new special glass beads (alumino-silicate).

This study concerns the ageing effect of glass beads on the microstructure and residual stresses as a function of the number of working cycles of the beads. The influence of the ageing of the glass beads on the surface roughness is also studied.

This study shows that the research on the mechanism of failure of glass beads during ageing is very important for the development of the new glass beads to improve the surface quality and the mechanical behaviour of the shot peened component. It is possible to manufacture the new glass beads with optimised properties.

AGEING EFFECT

In this study, the ageing of two types of glass beads were studied for different used lifes during a vapor shot peening after a number of cycles of use. The shot peening conditions for one cycle is definied as following :

For aluminium alloy, the particule velocity is about 60 m/s.

For titanium alloy, the particule velocity is about 45 m/s.

For both cases, the peening time for one cycle is 30 seconds and the diameter of shot is 300µm. After a certain number of ageing treatment and a given breaking rate of glass beads, the test samples for the studies of the surface state, of the residual stresses and of the hardness are treated with following conditions (table 1).

Fig 1 and Fig 2 show the comparison of the ageing of glass beads as a function of the number of the cycles of use. It can be seen that the alumino-silicate beads has more important ageing life than those of classical beads in both case of the shot peening of the aluminium alloy and of the titanium alloy. The ageing effect is very small for the new class of alumino-silicate beads. After 1210 cycles of shot peening on an aluminium alloy, the breaking rate is about 6% for the new beads, and after only 350 cycles, the breaking rate of the classical beads is about 27%. For a breaking rate of 6% in the case of classical beads, the life time is about only 125 cycles. So the increasing of the life time is about 10 times for an equal breaking rate of 6%. Due to the low speed of ageing of alumino-silicate beads, a high speed test was used to increase the ageing of this type of beads, the pressure used is increased to 60 PSI (40 PSI up to a breaking rate of 6%) for the case of aluminium alloy. Fig 3 shows the comparison of ageing of two types of beads with two particule velocities with a initiated breaking rate of 6% for the case of aluminium alloy. It can be seen that the speed of ageing is similar. So for the same speed of ageing, the new beads can be used with a higher particule Velocities. This increase corresponds to about an increase of 50% of the pressure used. So the ageing properties of new beads are very interesting. In following paragraph, the effect of modification of microstructure and residual stresses of peened samples was studied.

MICROSTRUCTURE MODIFICATION

Fig 4 and Fig 5 show the surface state obtained on the aluminium samples, shot peened with 5% breaking rate beads. It can be seen that the presence of inclusions of damaged beads in the surface of material treated are more important for the sample shot peened by classical beads.

On the titanium sample, the behaviour of the surface state is similar for two types of beads for a given damaged rate. Fig 6 and Fig 7 Shows an exemple of the samples shot peened by the unaged beads.

HARDNESS MODIFICATION

The effect of hardening is observed up to a depth of about 100 µm for all cases.

The evolution of hardness obtained on the samples don't give the significant modification. Figure 8 shows the example of maximum hardness obtained as a function of number of ageing cycle on the aluminium sample. The conclusion for the titanium case is the same (Fig 9).

ROUGHNESS MODIFICATION

The modifiction of roughness as a function of the ageing cycles was studied. Figure 10 shows the results obtained. It can be seen that the ageing of glass beads don't modify significantly the surface roughness for both beads. The roughness obtained for two types of beads are similar.

MODIFICATION OF RESIDUAL STRESSES

The residual stresses are measured by X-Ray diffraction method on the surface of samples.

Table 2. Shows the residual stresses measured on titanium samples. It is difficult to separate the results obtained by the two types of beads. The surface residual stresses is not modified with the number of cycles.

Table 3 shows the results obtained by the X-Ray method on an aluminim alloy sample. The difference is not very big between the two types of beads. But the residual stresses are higher (5 to 17%) in the case of new beads with a normal speed ageing.

CONCLUSION

This study shows the effect of glass beads nature on the ageing and on the shot peened materials behaviour.

Two aeronautical alloys were analysed : aluminium alloy (2024) and titanium alloy (TA6V). The new special glass beads (alumino-silicate) has an ageing property largely higher than the classical beads (soda line sicila) (up to 10 times).

Concerning the surface state obtained by shot peening, the new special glass beads induce a better surface state for the case of aluminium alloy. The difference is not significant in the case of titanium alloy. The roughness obtained is very similar for the materials shot peened by both beads.

Concerning the hardness the new special beads don't induce a significant modification of hardness for a comparable number of ageing cycles.

Concerning the residual stresses obtained, for the Ti case, the difference of nature of beads is not very important. But for the case of the Aluminium Alloy, the new special beads seems to induce a small increase of surface stresses (5 to 17%) for a comparable number of ageing cycles.

The fatigue tests will be carried out to evalute the effects of ageing and of the nature of glass beads on the fatigue behaviour.

This study has shown that it is possible to manufacture high ageing resistance glass beads for shot peening. The quality of the shot peened component will surely be increased.

ACKNOWLEDGEMENT

This work is carried out in cooperation with AEROSPATIALE and Metal Improvement Company. The authors wish to express their thanks to Miss I. MAUPILE and Mr D. GILLEREAU, and Mr Y.LEQUERNIC for their help.

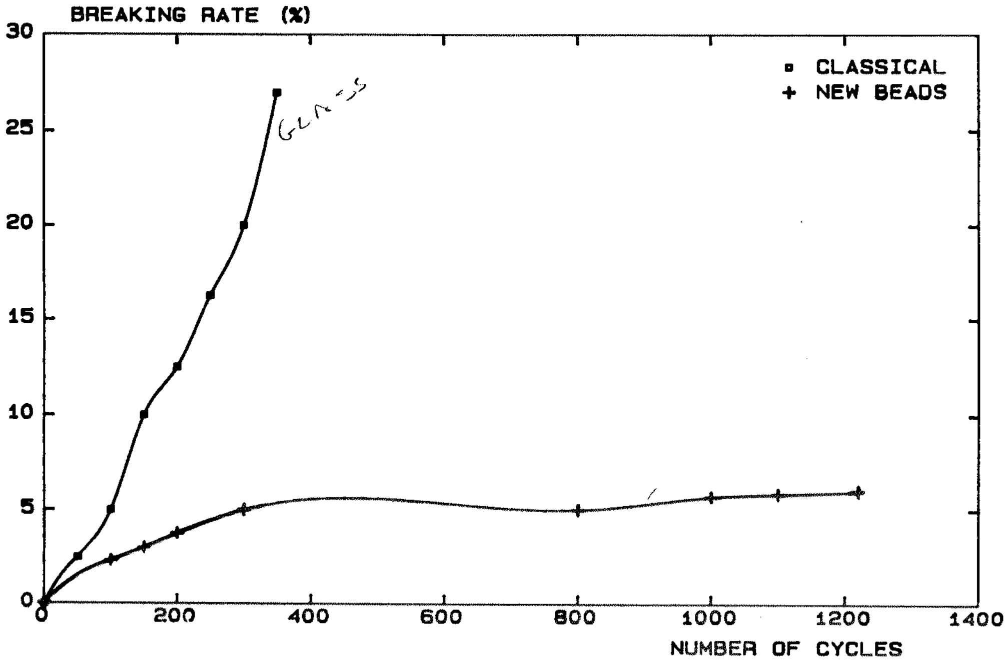

Fig 1 : Ageing of beads for shot peening of Aluminium Alloy (2024)

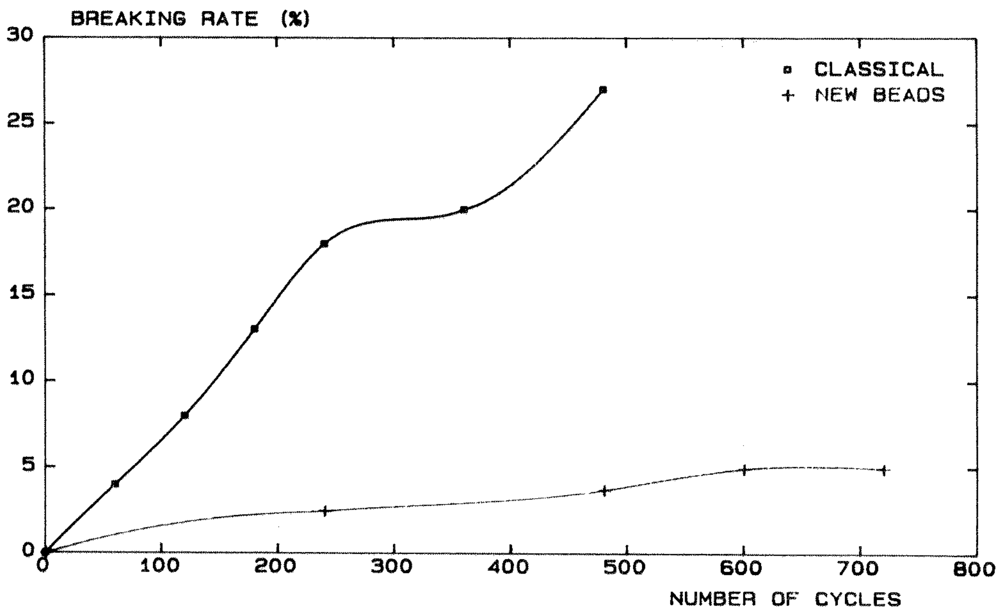

Fig 2 : Ageing of beads for shot peening of Titanium Alloy (TA6V)

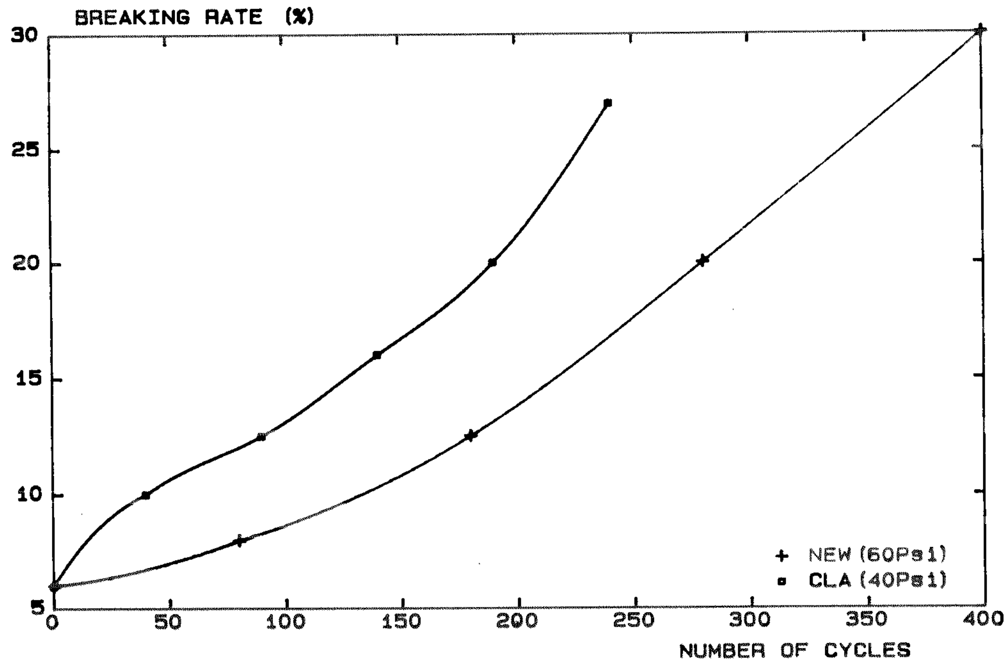

Fig 3 : Comparison of ageing of the classical beads (60 m/s) and new beads (80 m/s) with two particule velocities

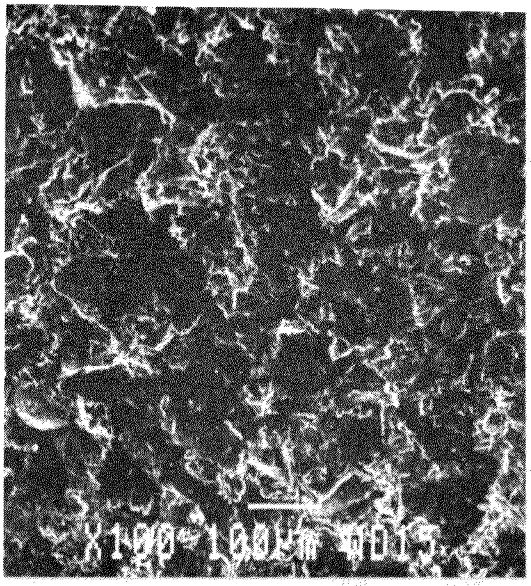

Fig 4 : Microstructure obtained by SEM on an aluminium sample shot peened with a classical bead (5% breaking rate 100 cycles)

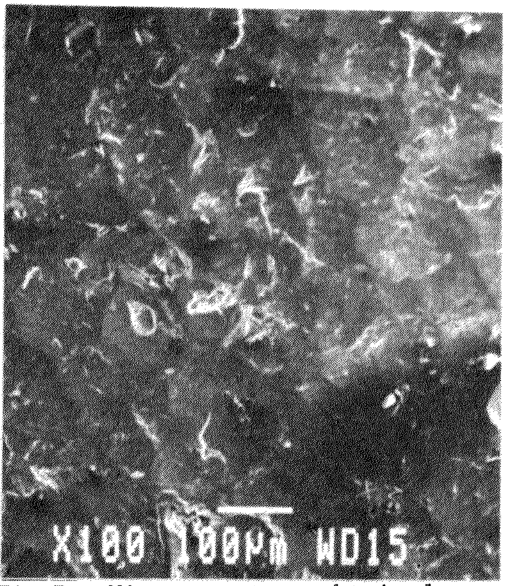

Fig 5 : Microstructure obtained by SEM on an aluminium sample shot peened with the news type beads (5% breaking rate, 800 cycles)

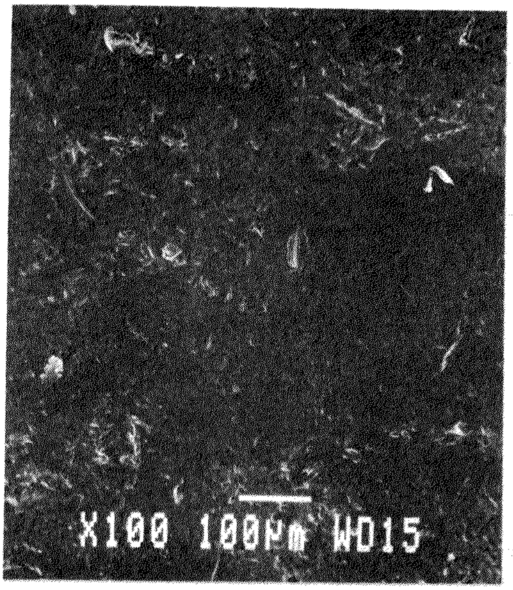

Fig 6 : Microstructure obtained by SEM in a titanium sample shot peened with no aged classical beads

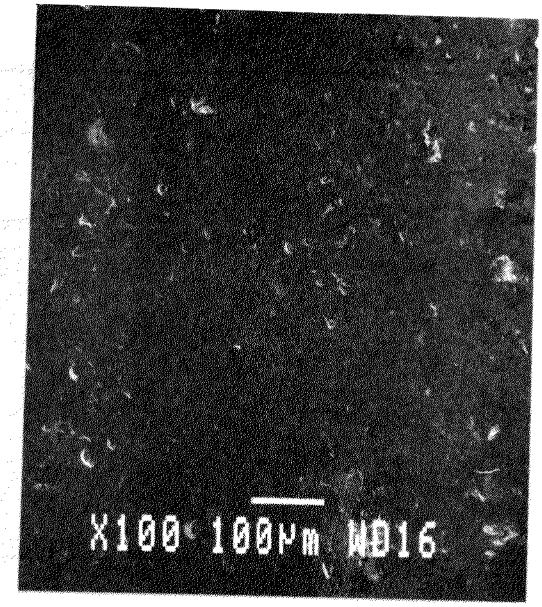

Fig 7 : Microstructure obtained by SEM on a titanium sample shot peened with no aged new type beads

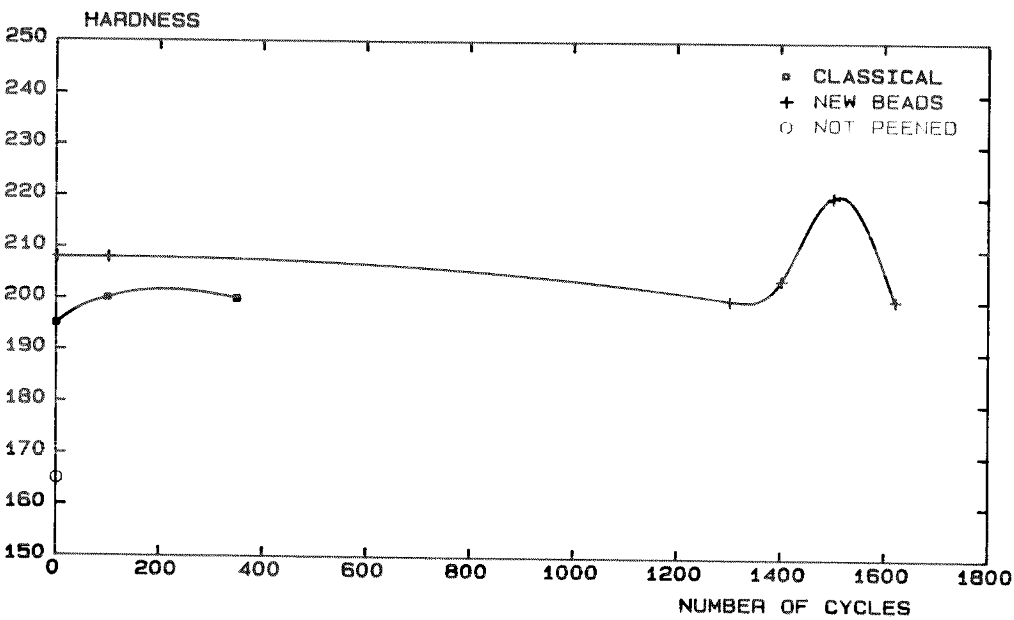

Figure 8 : Modification of the hardness as a function of the number of ageing cycles, comparison of the two types of beads (2024).

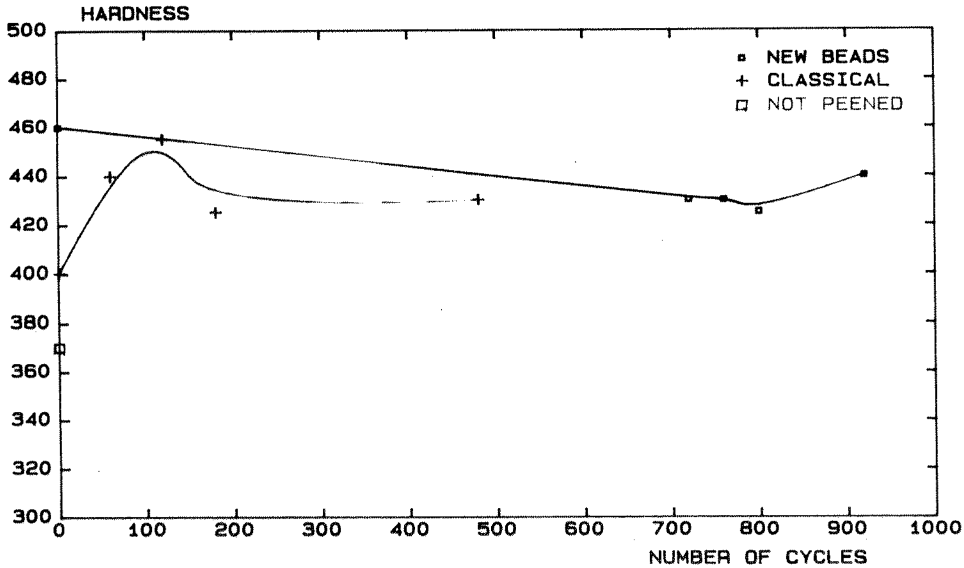

Figure 9 : Modification of the hardness as a function of number of ageing cycles, comparison of two types of beads (TA6V)

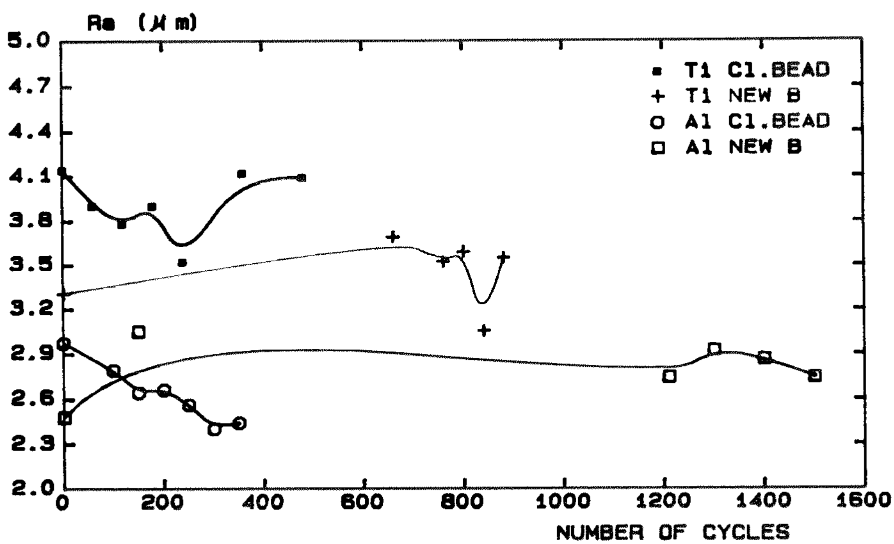

Fig 10 : Modification of the roughness of shot peened sample as a function of the ageing cycles

Materials	Almen Intensity	Coverage
Al	5 - 6 A	125%
Ti	12 -15 N	125%

Table 1

Classical beads	Number of cycles of ageing	0 cycles	60 cycles	180 cycles	360 cycles
	σ0 (MPa)	-652±85	-587±98	-531±75	-537±70
	σ90(MPa)	-825±56	-729±60	-678±60	-742±63
New beads	Number of cycles of ageing	0 cycles	700 cycles	760 cycles *	840 cycles *
	σ0(MPa)	-602±60	-543±64	-608±71	-592±84
	σ90(MPa)	-730±48	-770±103	-674±63	-775±52

Table 2 : Effect of ageing on residual stresses on surface of shot peened Ti Alloy.

* High speed ageing (80 psi).

Classical beads	Number of cycles of ageing	0 cycles	100 cycles	350 cycles
	σ0 (MPa)	-159±14	-183±14	-165±14
	σ90(MPa)	-167±14	-183±14	-179±14
New beads	Number of cycles of ageing	0 cycles	800 cycles	1030cycles*
	σ0(MPa)	-195±13	-193±13	-150±14
	σ90(MPa)	-192±14	-193±14	-141±14

Table 3 : Effect of ageing on residual stresses introduced on surface of the shot peened Al Alloy.
* High speed ageing (60 PSI).