Original Article

Micro-fractures in visors of flying helmets

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ABSTRACT

A MKIIABEU helmet has an acrylic tinted visor. One such visor showed a specific type of damage during its inspection after an ejection. The type of damage gave a suspicion of a possible loss of strength at the edge. Microscopic examination revealed a break in the visor through one of its holes for mounting the arm screw. Microscopic examination revealed multiple radial fractures of varying length originating from the hole. Subsequently 49 visors of 'in-use' helmets were subjected to microscopic examination for possible findings of loss of strength. A total of 41 visors revealed micro-fractures at one or more of its holes, of which 11 visors had the fractures merging into the edge. Those 11 visors were withdrawn from use and sent for defect investigation. This paper discusses the various aspects of the micro-fractures and its possible impact on aircrew safety.

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KEY WORDS: Micro-fractures, Visors, Flying helmets

Amk II ABEU helmet is being used as aircrew equipment in aircraft like Kiran, HPT-32, Cheetah, Chetak etc. This helmet has an acrylic tint ed visor, which is often changed with a spare unit because of multiple scratches on its surface sustained during its use. In a visor, "-.ether original or a spare unit, four holes are in lied for mounting it on to the metallic arms of helmet. These holes are drilled because the -rulding die does not have it and without which: cannot be mounted on to the helmet.

The holes are drilled in to the visor with i -.ind-held drill, which do not have spot cooling or lubrication. As a result, the vibration and heat iterated by drill cause various types of damage to the visor. These damages range from a mere irregular edge to a perceptible crack, which could adversely affect the strength of the material.

Aim

This paper aims at finding out the various types of damages sustained by the visors as a result of the drilling of the holes and its possible impact upon aircrew safety.

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Material and Methods

Forty nine visors of 'in-use' Mk-II ABEU helmets of different sizes, both original and spare units were collected. Having cleaned the surface thoroughly with spirit to remove all dirt / stain / markings etc., it was examined under low power lens of a light microscope. All the four holes (A, B, C, D) of the visors were examined for its complete thickness by changing the lens focus, all along 360° of its curvature. The findings of various types of defects in the holes were noted as follows:

a. Clean: Where the edge of the hole was without any damage.

b. Radial fracture (RF): With material damage radiating from the hole.

c. Concentric fracture (CF): Where the damage was of concentric nature.

d. Chipping off (CO): Where the edge showed chipping off.

e. Crack: Where the visor surface developed a visible crack.

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f. Extent i.e. length, number and distribution of the fractures etc.

g. Severity of damage vis-a-vis distance of the hole from the visor edge.

h. Any other anomaly i.e. irregular edge (IE) or double whole (DH) etc.

Since a large number of the 'in-use' visors revealed the damage, twelve randomly picked new helmets were also subjected to microscopic examination.

Result

The microscopic findings of the 49 visors, with a mean thickness of 2.76 mm, having 203 holes (196 + 7 DH), are given in Table 1. At times a single hole showed multiple defects hence the total number of defects in a column varies from that shown in the total (n). Three visors showed double holes one by the side of the other totaling to seven. Only one such DH showed few short radial micro-fractures. It was worth noting that only 8 of the 49 visors showed all their holes without any damage (4 each of original and spare units; Table 3)

Table 1

Findings under microscope of 49 visors with 196 + 7 (DH) holes

Findings	*Hole* **A**	*Hole* **B**	*HoleC*	*Hole D*	*Total (n* **= 203)**
Clean	*24*	*27*	*20*	*28*	*99*
RF	*25*	*19*	*27*	*19*	*90*
CF	**Nil**	*2*	*1*	*2*	*5*
Crack	*1*	*2*	**Nil**	*2*	
CO	*4*	*3*	*3*	*4*	*14*
DH	*2*	*1*	*1*	*3*	*7*
E	*11*	*8*	*9*	*18*	*46*

RF-radial #, CF-conc #, CO-chipping off, DH-double hole, IE-irregular edge.

Radial micro-fractures outnumbered all other defects. The extent of these radial fractures ranged from being limited to the cut edge to running a long way away from the hole. When such long radial fractures ran towards the edge of the visor, it merged into it as shown in Table 2. The concentric fractures, though multiple, were mostly limited to one quarter of the circumference only. Chipping off, mostly incomplete, were also accompanied with concentric fractures. Cracks were seen at the holes also having multiple radial fractures.

Even though >48% of the holes were clean, only 16% (8 number) visors were found to be without defect. A similar finding was seen in the new ex-store visors also (Table 3).

Discussion

The Mk-II ABEU helmet has a single tinted acrylic visor of 2.7 (+ 0.3) mm thickness in small, medium and large sizes. Whereas the visor curvature and the sizes are made on a moulding die, the holes are drilled later. The vibration and heat generated by the drill make it vulnerable to damage. Damages in both original and spare units of visor points out to either a faulty technique of drilling or a defective material. Demonstration of micro-fractures even on newly received helmet proves that the damage is not as a result of its use, but is pre-existing at manufacturing stage.
The radial fractures have been found in significantly higher number of the holes, unrelated

Table 2

Severity of damage vis-a-vis distance of the holes from the edge

Type of damage	*Distance 5-10 mm (n=56)*	*Distance 11-15 mm (n=97)*	*Distance 16-25 mm (n=50)*	*Total (n=203)*
All Rad #	*32 (57%)*	*37 (38%)*	*21 (42%)*	*90 (44%)*
Rad # upto edge	*9 (16%)*	*2 (2%)*	*Nil*	*11*

** These cracks involved the radial # also.*

Table 3 Distribution of damage in visors

Type of damage	*Original in-use (n=21)*	*Spare in-use unit (n=28)*	** New ex-store helmets (n=12)*
Radial #	*17*	*24*	*5*
Rad # upto edge	*5*	*6*	*Nil*
Cone. #	*2*	*3*	*1*

** These helmets / visors are not among the 49 'in-use' visors.*

to its distance from the edge of the visor. On the other hand, the radial fractures merging in to the edge have specially been found in the holes which were mostly within 10 mm from the edge. Two patterns of these fractures emerged: one radiating out from the hole and the other originating from the edge and running very close to the former, overlapping it for some distance. The latter types of fractures were seen only opposite the holes where the long radial fractures also originated. No where else along the entire edge did the fractures show up. Hence, it was obvious that the drilling injury was also responsible for the fractures that originated from the edge when it was short distance away (<15 mm). In all the 11 holes where the radial fractures merged into the edges, there were multiple fractures. At least two fractures originated from the holes and radiated a long way towards the edge either merging or overlapping the other fractures originating from the edge.

In all the holes where the radial fractures merged into the edge, the strength of the visor would have reduced to an extent that could compromise aircrew safety. It is especially so because the visors are mounted from these holes on the under surface of the metallic arm with only four screws. Hence any force (e.g. windblast) on it will be transmitted to the helmet only through these four holes to the mounting screws. If the fixing had been onto metallic arms without sided grip (front and back), the distribution of the force per unit area would have been within acceptable limits and the strength of the holes might not been affected as adversely. Whether the other hole on the same side will be able to hold the visor to its place during wind blast following ejection remains unanswered and could be established only if subjected to such test. But it is certain that if broken, the visor itself could injure or make the eyes vulnerable to injuries, leave alone protecting it. The other types of damage like concentric fractures, chipping off, double whole and irregular margin are considered of little consequence as they are unlikely to affect the force distribution.

The micro-fractures under discussion would not have originated had the holes been made during moulding of the visors. Two visors were subjected to two sets of multiple drilling, one on a vertical drilling machine, and the other on a hand drill. Of the 20 holes drilled, none showed the fractures in the former but one hole in the latter was found to have few short distance radial fractures. Hence it was difficult to draw a conclusion if the former method was better than the latter.

Conclusion

Micro-fractures have been observed in visors of Mk-II ABEU helmets possibly as a result of drilling of the holes. There is a tendency of these fractures merging into the edge where its distance is <15 mm. All such micro-fractures merging into the edges are believed to have caused loss of strength, thus compromising aircrew safety.

Recommendations

All visors of the Mk-II ABEU helmets are inspected for presence of micro-fractures originating from the holes for the mounting arms and merging into the edge. All such visors may be withdrawn from use.

The visors may be examined for existence of micro-fractures during inspection for acceptance of consignment and if so found, may be rejected.
An alternative method of making the holes on the visors may be sought including those of the spare units or else the mounting arm may be modified to two-sided grip.