Damage to cut diamonds

Dr H.A. Hänni, FGA, and G. Bosshart, GG

Swiss Foundation for the Research of Gemstones (SSEF)*, Zurich, Switzerland

Abstract

Diamonds are generally considered as extremely resistant gems. Thermal or mechanical damage is, nevertheless, possible during various stages of working (cutting, setting, soldering) or wearing the stones. Thus many cut diamonds reach the jeweller's counter with minor to distinct damage. Only a relatively small proportion of the observed injuries result from wearing. Minor blemishes can be removed with minimal weight loss by a specially trained cutter.

Chemical resistance

A diamond's high resistance to chemical attack derives from the strong covalent bonding between the carbon atoms in the diamond lattice. At low temperature and pressure conditions, it effects a strong inertia against all standard acids, caustics and solvents. However, at high temperatures, and in the presence of certain melts or gases, the diamonds do not comport themselves with such invulnerability any longer.

In our laboratory, several experiments were carried out on cut diamonds (Bosshart, in preparation) to shed light on their thermal behaviour. Exposed to air, the stones were heated in an electric laboratory furnace without any coating. Already during an annealing cycle of 30 minutes at 650°C, or after two hours at 600°C, a whitish turbidity appeared on the faceted surfaces. No transformation to (black) graphite or amorphous carbon was observed. Obviously alteration of the diamonds' outermost layers of carbon atoms by the oxygen in the air takes place as low as 600°C. During this oxidation process, the diamonds transform directly into gaseous carbon dioxide (CO_2). Whitish, shallow but rough burn marks are left behind. Considerably deeper burn pits are produced at higher temperatures and longer annealing.

In comparison with our static annealing experiments in the electric laboratory furnace, the turbulent supply of oxygen under the soldering torch of the goldsmith certainly leads to more serious burn marks at 600°C, if the mounted diamond has not, or not entirely, been coated by a borate (boric acid, Liquobor, borax, etc.). The function of the borate melt is to coat the diamond in order to prevent oxygen from reaching the surface of the stone. However, if the diamond has not been degreased, openings may form in the borate coating. Then corrosion of the diamond can start (Figure 10).

A borate melt is able to corrode corundums but not diamonds. The latter can be attacked only by the hot melts of metals like platinum, iron, tungsten, or by some strongly oxidizing compounds (De Beers Industrial Diamond Division: Properties of Diamond, special publication). Yet under all normal chemical conditions, diamonds do not react.

Mechanical Resistance

The hardness of a diamond, or more precisely its extremely high resistance to abrasion, is the prominent physical property which makes a diamond to be for ever. It is seldom that blemishes can be recognized by eye, even after decades of wearing the stone as a solitaire. A diamond occupies the uppermost level of the Mohs' scale of scratch hardness. This means that it is not scratched by any other mineral except by its own kind. The hardness depends on the direction of scratching on the crystal (hardness anisotropy). There are harder and slightly softer directions. This fact is taken into account during cutting because diamond surfaces can be worked successfully only in the softer directions.

The longevity of a diamond is limited by its tendency to split along very definite atomic layers when struck precisely parallel to them. This quality of developing flat separation planes is termed cleavage. Diamond possesses a perfect cleavage parallel to the eight octahedral crystal faces and less pronounced ones parallel to some other faces.

Another limitation is its sensitivity to knocks in any other direction, on facet edges and corners especially; bruises and percussion cracks are liable

*Schweizerische Stiftung für Edelstein-Forschung (SSEF).

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to form. Their size depends on the force of impact. Inversely, static pressure on surfaces does not harm a diamond at all.

Large inclusions represent yet another hazard for diamonds. However, it is a fairly rare accident when a piqué diamond with extended cleavages, or incorporating foreign mineral inclusions surrounded by tension haloes, breaks into pieces under mechanical or thermal stress.

Damage during cutting and polishing

Industrial cutting of diamonds cannot always be carried out with sufficient care, probably for reasons of time. Many a diamond cutter is entirely aware neither of the brittleness of all diamonds and of the internal strain inherent in many diamonds, nor of the corresponding vulnerability of the goods he is cutting. Consequently, many diamonds leave the cutting works with minor blemishes. The most frequent of these negative characteristics are small cleavages, pressure and percussion cracks, as well as burn marks.

An excessively strong pressure during the bruting process creates groups of tiny fissures parallel to the cleavage direction (Figure 1). They traverse the girdle and often appear at four different positions around the circumference, separated from each other by 90° (in the normal case of a 4-point brilliant). Finely bruted girdles show these tiny cleavages in a much less conspicuous manner than coarsely bruted girdles. In earlier days, these fissures were harmlessly designated bearding and wrongly considered external characteristics. Usually they can be removed; in these instances, the removal is easier and more complete by faceting of the girdle rather than by polishing it. Thus internal blemishes are eliminated and this results in an improvement of the clarity.

A further injury of the first hour, which is encountered quite frequently, consists of pressure cracks. They probably stem from the use of the dop, the tool which holds the diamond tight during cutting (Figures 2 and 4). The blemishes occur as small cracks, roughly on the same level of the pavilion, running across facet edges. They are caused by a too strongly tightened dop or by knocking vibrations (Figure 5). We also sometimes observe more or less circular fissures, mainly on pavilion facets, the origin of which we cannot yet explain. Possibly, however, there is a connection with the dop as well (Figure 3).

When a diamond is turned in the dop, scratches in the form of concentric arcs may occur on the table (Figure 6). The finger-like piece of metal pressing the pavilion of the brilliant into the dop causes these scratches when it is contaminated with diamond paste (Figure 4).

If diamonds are heated too much during the cutting operation, rough burn marks are incurred, especially on lower girdle facets, star facets and on the table. A build up of heat in the metal of the dop is responsible for this. As mentioned earlier, the superficial corrosion of the diamond already starts at 600°C with the formation of roundish to annular burn marks.

The view that fissures across facet edges are generated on diamonds as they are pressed against each other in a stone paper may be correct in certain cases. Stones in lots of considerable weight are particularly endangered. As a rule, however, the cause of the damage lies in the too strongly tightened dop. In order to form pressure cracks on diamonds in a stone paper, a greater force is required than that applied to such wrappings in general.

On the other hand, large diamonds merit individual packing because blemishes, like scratches and abraded facet edges can happen relatively easily.

The unpopular large culet of old-cut diamonds today has an equally extreme analogue in the pointed culet of the modern brilliant-cut (a pointed pavilion without any facet). The danger to this type of culet can be deduced from the fact that, during grading, we encounter less than ten undamaged pavilion pyramids for every one hundred diamonds originally with pointed culets. Usually the exact time of damage cannot be determined.

Damage during setting

Prominent parts of a cut diamond, i.e. not only the pointed culet but also the girdle, are especially sensitive to injuries. A girdle of medium thickness shows little tendency to cleave under the normal forces of impact during setting. However, the thinner the girdle, the easier it can chip under the influence of knocks, pressure or scratching. Thereby cleavage is stimulated if the direction of the destructive stress acts roughly parallel to it. Actually, irregularly formed fracture surfaces are encountered more frequently. Off to the sides, they readily change into short cleavage fissures.

Greater damage is occasionally caused by slipped punches, or by the stone-setter's electric hammer, and has a characteristic appearance. Mostly they are cataract fractures extending into the pavilion and are situated close to a prong (claw). In the central part of the depression, they have a conchoidal form and continue in cleavage steps towards the edge of the fracture (Figure 7).

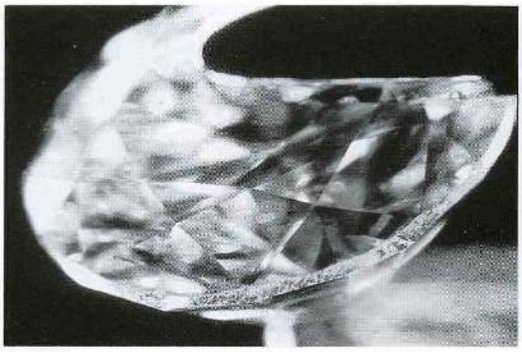

Fig. 1. Fine cleavage fissures running across the slightly polished girdle of a brilliant-cut diamond. Darkfield illumination. 11x.

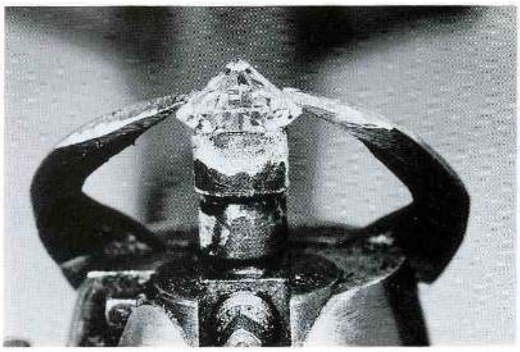

Fig. 2. Diamond fixed in a cutter's dop. Burn marks may appear at both points of contact on the pavilion.

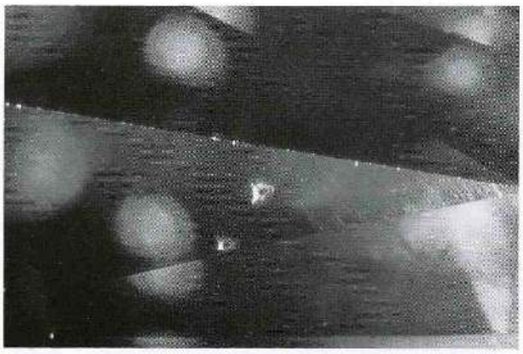

Fig. 3. Roundish cracks caused by percussion or pressure on a lower girdle facet. Darkfield illumination. 28x.

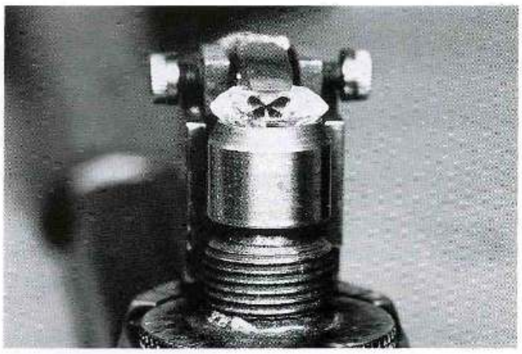

Fig. 4. Brilliant-cut diamond of 2 ct tightly mounted in the dop. Heat accumulation in the finger-like piece of metal sometimes leads to burn marks on the table.

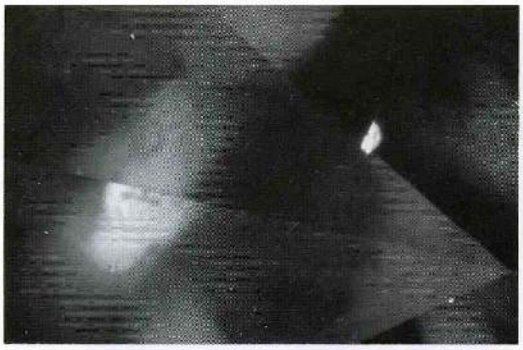

Fig. 5. Pressure crack across a pavilion facet edge of a brilliant-cut diamond. Darkfield illumination. 34x.

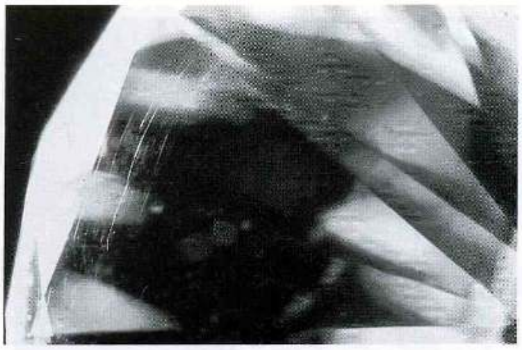

Fig. 6. Arc-shaped scratches on the table of a brilliant-cut diamond viewed from the pavilion side. Darkfield illumination. 17x.

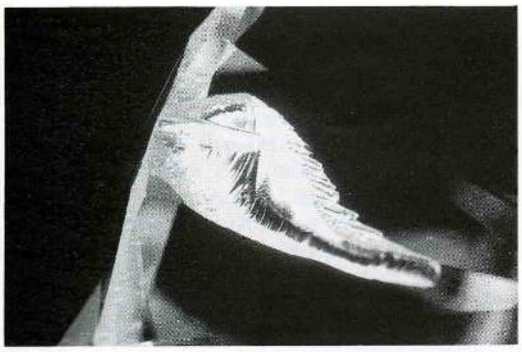

Fig. 7. Complex cataract breakage in the pavilion of a brilliant-cut diamond, generated by shock impact from the crown side on to the girdle zone. Darkfield illumination. 17x.

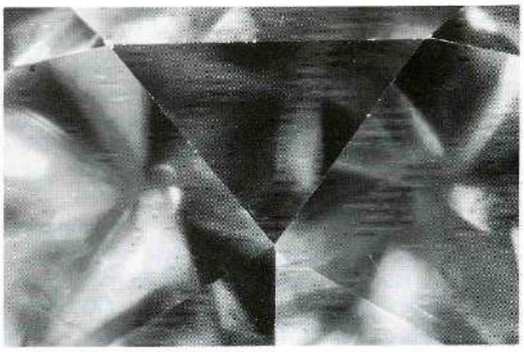

Fig. 8. Wear marks in the form of small shallow bruises on the edges and corners of a star facet and a fine scratch on an adjacent main facet. Darkfield illumination. 22x.

Damage during wear

Several types of blemishes are observed on mounted diamonds. The most widespread damage originates from knocking the set diamond against other objects. They consist of small, but loupe-visible, bruises and percussion cracks. They appear on edges and corners around the table and the crown facets. These wear marks demonstrate clearly that diamonds are slightly sensitive to the influence of shocks (Figures 8 and 9).

Larger breakages in the girdle region also occur, particularly on big diamonds with a very thin girdle (e.g. on old-cut diamonds). These cases, however, are less frequent than generally assumed in the jewellery trade. Stone settings with widely separated prongs favour the formation of such fractures. While ordinary percussion cracks effect a reduction of the clarity grade of loupe-clean stones only, larger fractures may easily lower a VS and even an SI clarity grade.

Further damage develops when a solitaire ring is worn next to a diamond-studded eternity ring. Since the ring on the neighbouring finger may rotate, it usually scratches the solitaire diamond at two opposite places according to how the ring has been placed on the finger. Rough, whitish abrasion marks result from this. They are also occasionally of fissure-like character.

Bruises and percussion cracks on the pavilion side of set diamonds are probably not the result of wearing jewellery. The pavilion is protected by the mounting and the finger. These blemishes are not recent and usually have been produced in the diamond factory, as mentioned earlier. Scratches may occur whenever diamonds touch, not only on stones in a lot but also in the mounted state, for example in the jewellery box.

Damage in repairing and transforming diamond jewellery

According to the introductory statements, superficial burn marks are produced under the goldsmith's torch if the mounted diamond has not been sufficiently degreased. The borate coating then cannot offer complete protection and burn marks are the consequences (Figure 10).

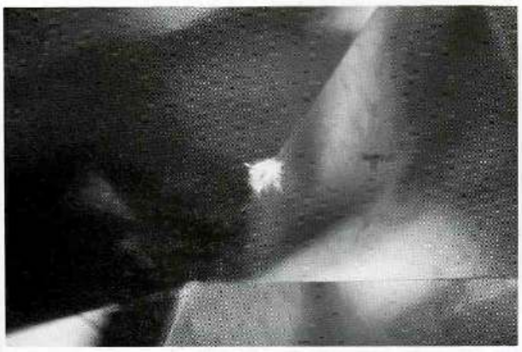

Fig. 9. Bruise on a table edge accompanied by fairly deep percussion cracks, radiating out to both sides of the facet edge. Darkfield illumination. 34x.

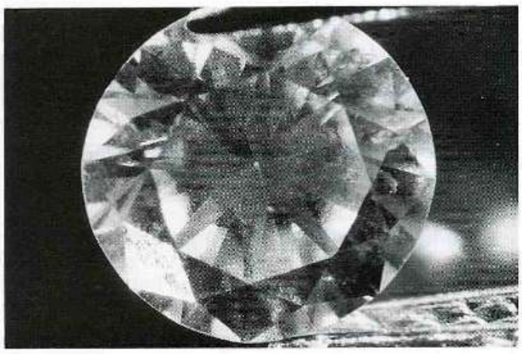

Fig. 10. Brilliant-cut diamond with whitish surface due to extensive burning. Brilliance grossly reduced. Darkfield illumination. 13x.

Repair of damaged diamonds

Most of the blemishes listed here can be removed with minor weight loss by a carefully executed repolishing operation. Damages of considerable depth demand a more complete recutting of the stone and cost more than just a few points of weight. Buying loupe-clean diamonds with weights like 1.00 ct is not recommended, for the simple reason that even a slight touch up of such a stone will decrease its weight below the critical limit.

The skills of a specialized diamond cutter are needed for a successful repolishing operation. He does not treat diamonds like the hardest material in the world but works gently and cautiously as if handling raw eggs. If this approach would take hold and prevail in all diamond workshops, a much larger portion of loupe-clean diamonds would reach the market.

In the damaged state, diamonds are mainly graded between VVS 1 and SI 2 if they do not contain any internal characteristics other than new cracks. SSEF clarity grading always assesses the possibility of improving the stone and a corresponding recommendation for repolishing, plus a precise sketch for the specialized cutter are provided. Thus, the repolishing operation finally raises such stones up to the clarity level which they could have had from the beginning or which they once possessed.

If, apart from the clarity, the cut can be ameliorated in the same operation, the recommendation for repolishing includes a comment for the cutter with respect to symmetry, polish, girdle or culet.

Conclusion

It can be stated that a precise microscopic examination of damage on cut diamonds in certain cases enables the recognition of the causes. The SSEF Laboratory has been in a position to carry out this type of analysis for many years. Insurance companies and other interested parties have regularly made use of this service.

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