Shot Peening of Fast and Electroheated Metals

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Several commercial alloys were fast heated and shot peened. Direct resistance heating (DRH) of wire samples was used as a fast heating technique in addition to exposure of some samples to high temperature before shot peening. Shot peening was performed using steel hamer and sink precooled to $0^{o}C$. SEM was used to study the shot peened specimens. Also a transient heat transfer method was used to evaluate the materials. The results showed that the fast electroheating and the fast mechanical impact during the shot peening process causes the reduction of grain size to about its quarter.This results in an improvement of the mechanical properties. The transient heat transfer data showed a variation in the signal measured (response to transient heat transfer after heat pulse). The shot peened materials showed higher signal level than those without shot peening. The variations in heat transfer characteristics may correlate to other properties such as the mechanical properties.

Background:

Shot peening technology is growing very fast due to its importance as a modification technique for surface characteristics and other benefits. Advances in heating and cooling technology are used for shot peening experimentation.

It may be well worth mentioning here that the subject of shot-peening is finding increasing interest throughout the world, and a series of international conferences is being organised (1). It is expected that this difficult subject will attract more and more attention due to its challenges and its importance. The objective of this work was to present a simple and economic technique for performing shot peening experiments on commercial and common alloys of importance in various fields of advanced technology.

Experimental Technique:

Test samples were electroheated using the direct resistance heating technique or furnace heating shown in Fig.1.The electroheated specimens were shot peened when melted due to DRH or after exposure to fast furnace heating . The peened samples were evaluated using metallographic techniqe (SEM). The response

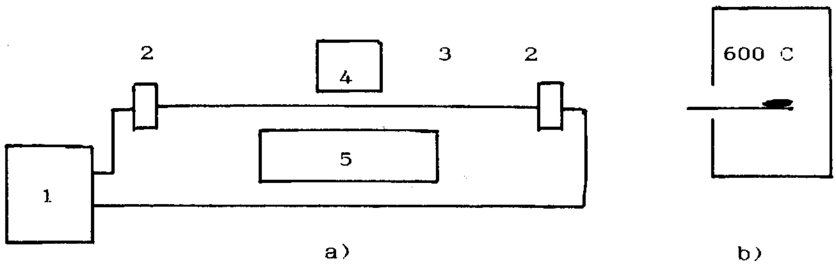


Fig.1: Experimental set-up

a) Direct Resistance Heating   b) Furnace Heating
1, DC power supply 2, Electrical Contacts
3, Test sample (wire) 4, Pre-Cooled steel hammer
5, Pre-cooled steel heat sink.

to heat pulse method was also used as a non-destructive test for the peened specimens. In this test a sensor head (thermistor or thermocouple) was pre-cooled to $0^{o}C$ before it is allowed to contact the shot peened surface which was at ambient temperature. The transient heat transfer was then monitored using a conventional mV chart recorder connected to the sensor thermocouple or thermistor wires. Details about this test is available elsewhere (2-3).

Results:

Fig.2 shows the response to transient heat transfer data for selected experiments.

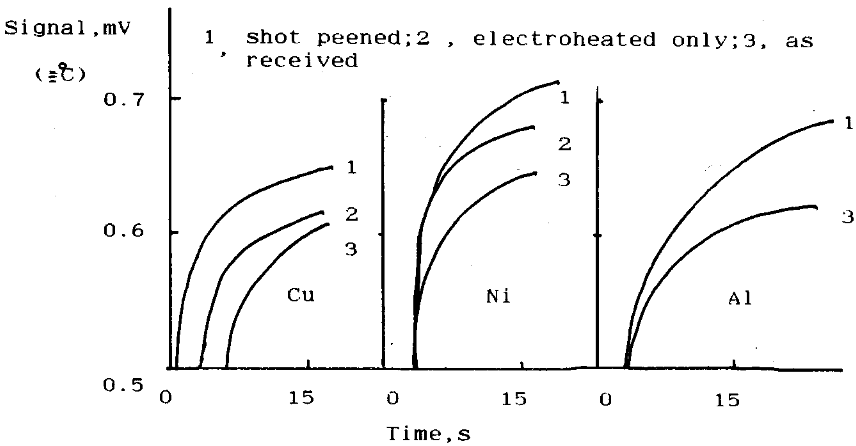


Fig.2. Response to heat pulse data of shot peened alloys.

The difference in transient heat conduction for various specimen shot peened is clear. It is known that shot peening improves heat transfer (4). The reported improvement was about 22% for heat exchanger brass and cupronickel tubes after the outer surface was shot peened. The variation in signal response to transient heat pulse for Ni was about 4% for both foamed and porous Ni specimens which may correlates to the physical characterstics of such materials particularly surface area.

Metallographic Observations:

Fig. 3-5 show the various forms of microstructure of selected copper specimens before and after shot peening. Crack initiation could be followed in the photos. The average grain size is reduced to about 25%. Fig.3 shows SEM details for Porous copper electrodeposited in presence of magnetic field(5).

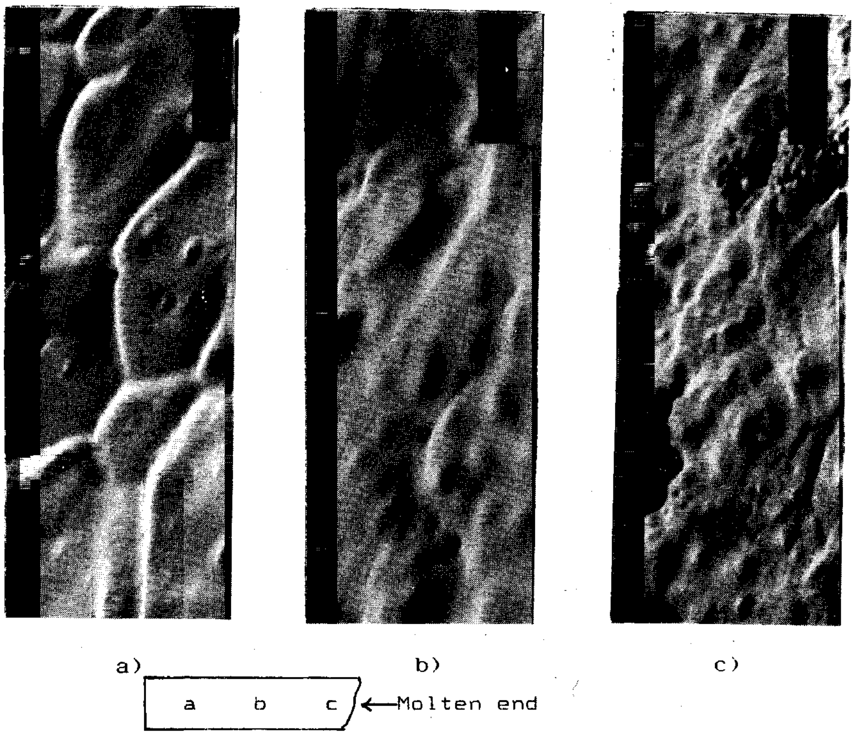
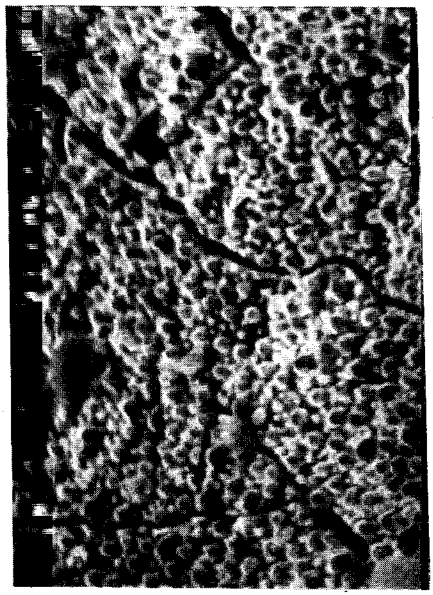
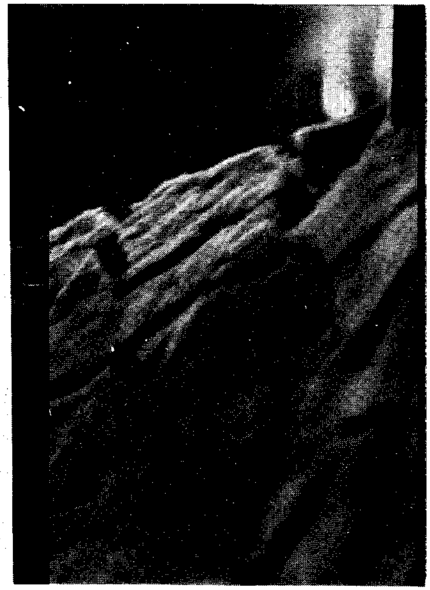


Fig.3: SEM of porous electroheated copper shot peened after melting.

It is clear that the grain size is smaller in the heat affected zone (HAZ), Fig.3a), than in the molten area (Fig.3c). The nature of the grains were of the equiaxed type despite their highly deformed level due to the mechanical impact. Fig.4. shows cracks formed on copper surface precoated with polyvinyl chloride (PVC) before shot peening. It seems that the presence of chloride in the polymer assisted the formation of stress corrosion cracking of copper.



a)



b)

c)

Fig.4: Stress corrosion cracking (SCC) of electroheated copper/PVC shot peened. Notice the initiation of crack from the PVC location spot (c).

The same finding was observed for furnace heated aluminium which was shot peened in contact with PVC. Pitting and stress corrosion cracking was noticed as shown in Fig.5.

a)

b)

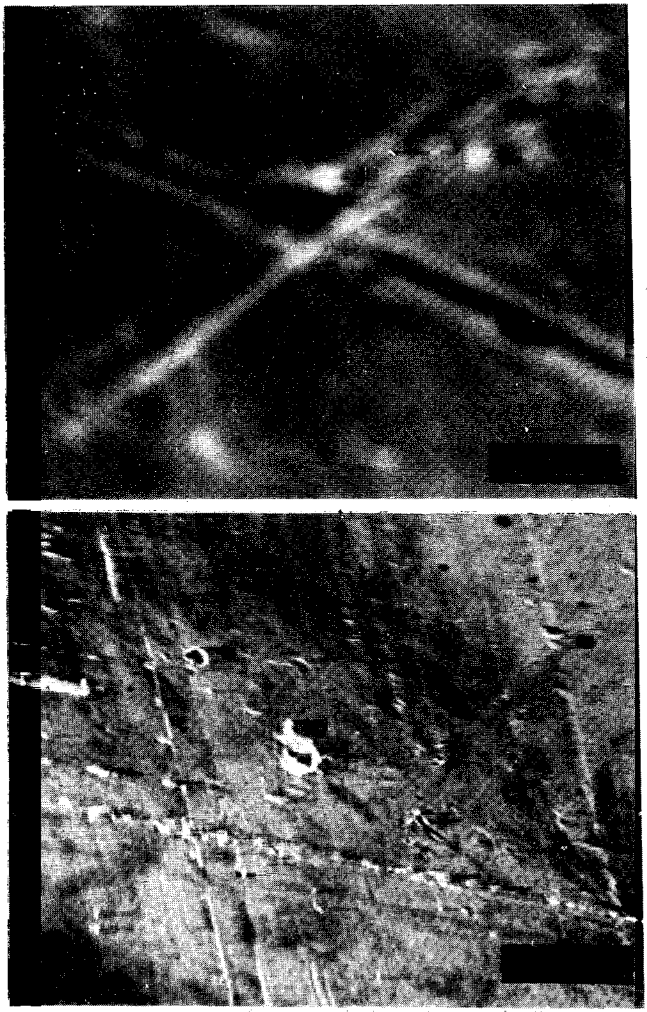


Fig.5. SEM of Aluminium specimen (furnace heated 600^{O}C 30s)shot peened in contact to PVC. Notice the SCC(a) and the pitting(b).

The situation was different when PVC was replaced by polyethylene (PE) as there was no stress corrosion cracking as shown in Fig.6 for DRH copper and Fig.7 for furnace heated aluminium. PE is not corrosive chemical as PVC is at high temperature.PVC decomposes at high temperature and releases the chloride ion which causes the stress corrosion cracking shown in Fig.4. and Fig.5.

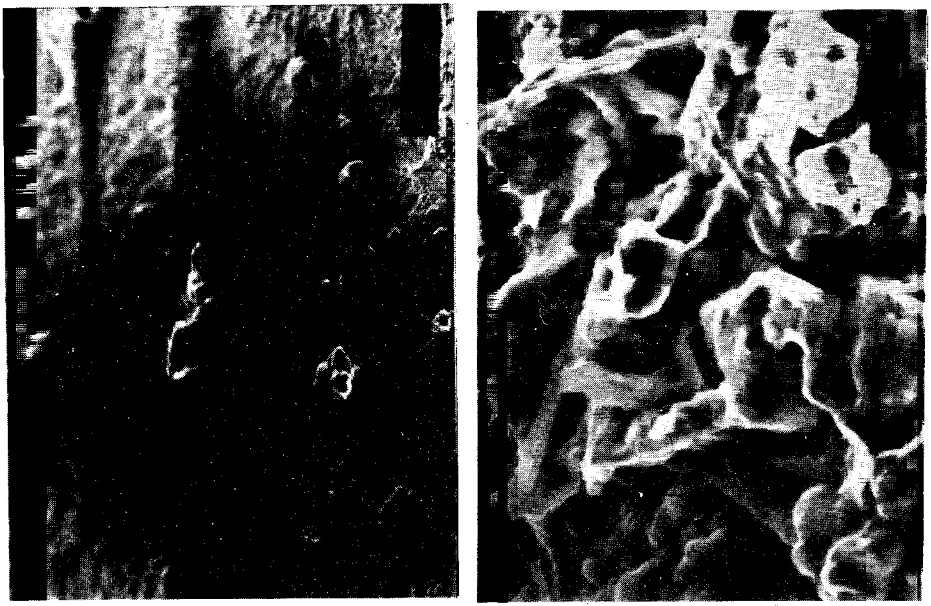


Fig.6: Shot peening of Aluminium precoated with PE coat.

Corss-section

Top View

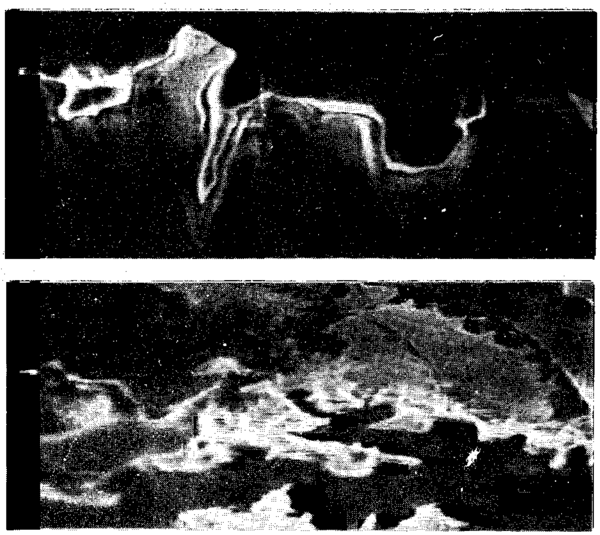


Fig.7 Shot Peening of Aluminium precoated with PE: No cracks.

Electroheating and shot peening of foamed Ni specimens showed the presence of microcracks in the areas cooled relatively at a faster rate as shown in Fig.8.

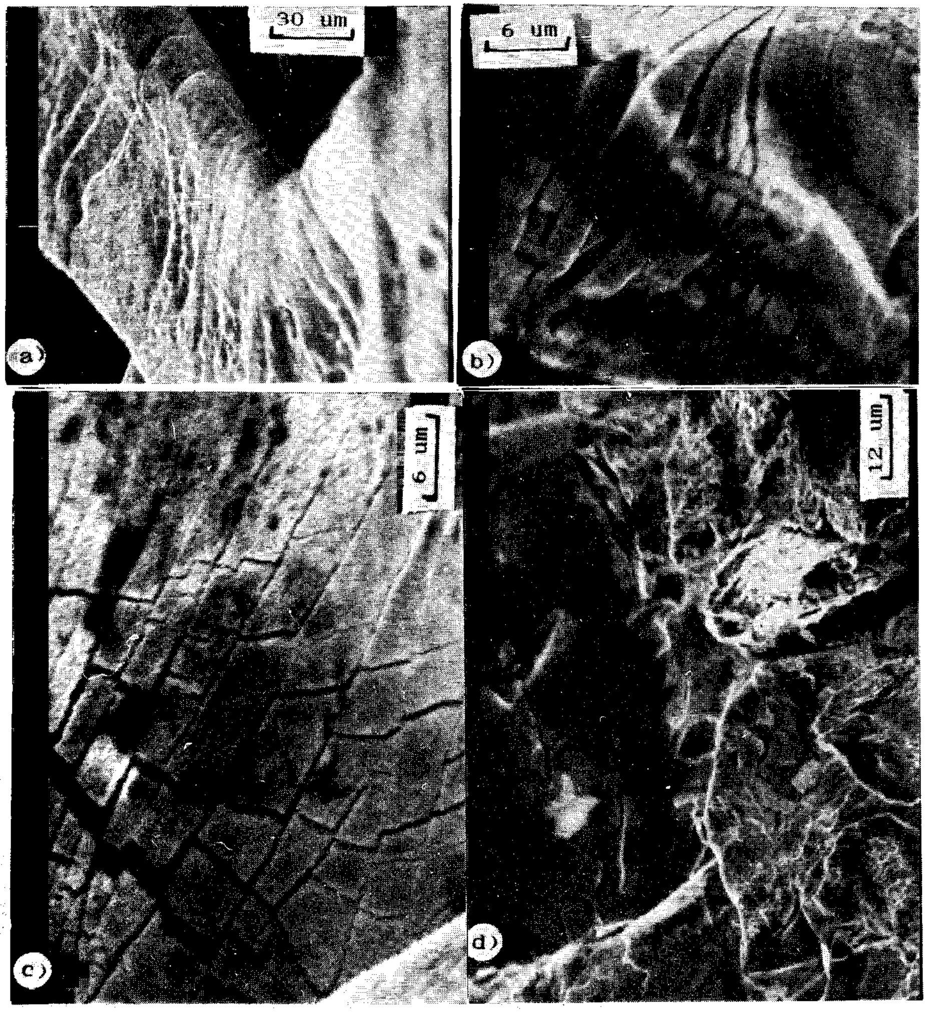


Fig.8. SEM of foamed Ni specimen shot peened in contact with PVC

a) At the centre
b) Outside (fast cooled) crack invitation
c) Mosaic structure cracks at 90^{o}
d) Minimum parallel cracks at highly deformed levels.

Shot peening of galvanized steel wire showed variations in microstructure as shown in Fig.9.

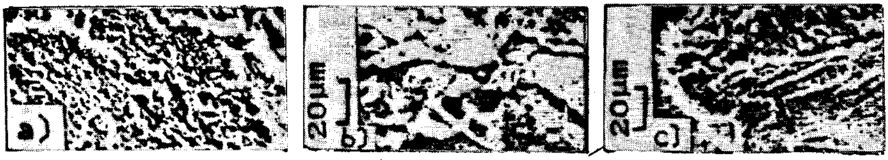


Fig.9 SEM micrograph of galvanized steel wire electroheated till melting and shot peened.
a) Rapidly solidified molten surface without shot peening; b)
b) Molten surface and shot peened c) Plastic deformation during shot peening
The heat affected zone is different from the molten shot peened zone.

Conclusions

1. Shot peening results in stress corrosion cracking if environmental conditions permit it such as the presence of Cl in (PVC) for Cu, Ni, Al specimens whether they were electroheated or furnace heated at high rate.

2. Size reduction of the metal grains is function of the local temperature profile at the shot peening process.

3. Polymeric materials such as polyethylene might be used for coating shot peened metal as a strong adhesion of the polymer to the substrate is produced. No stress corrosion is produced.

Acknowledgement:

Partial funding of Kuwait University and Can Reactor Materials, Inc. is acknowledged. The help of Mr. Rakan S. Al-Shamari and Mr. Mohammed S. Hassounah is appreciated.

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