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Abstract:

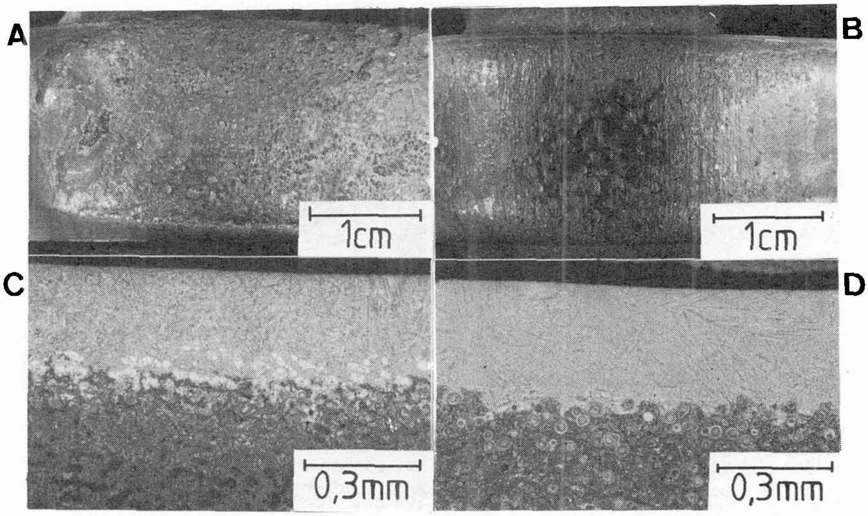
Laser melting of cast iron under well defined conditions. The laser conditions have been calculated using an mathematical model and optimized to large melting depth. The only variables during laser melting were the intensity (W/cm^2) and the feedrate (duration time).

Introduction:

Using a CO_2-Laser the surface of cast iron can be melted in a well defined manner /1-4/. A calculation-model was developed which simulates the heating conditions during the laser treatment as an aid for the correct choice of laser parameters. Two cast iron samples have been melted, using the calculated laser conditions.

Experimental:

In the computational modell a one dimensional heat conduction is assumed. A necessary condition for this calculation is that the plane of the laser beam has to be much larger than the melting depth. An absorption of 30% has been measured calorimetrically.



A,B - views of the surface of a laser melted camshaft
microstructure of the ledeburitic surface produced with
C(A) - a laser intensity of $3.60 \cdot 10^3$ W/cm^2
D(B) - a laser intensity of $4.25 \cdot 10^3$ W/cm^2

Fig. 1 shows the temperature distribution during the heating and quenching periods, presuming a constant laser intensity of $3,6 \cdot 10^3$ W/cm^2 and a heating time of 1 second.

Using the temperature distribution in the surface (Fig. 1c) the melting depth can be read off. Using to the cooling curves (Fig. 1b, 1d) the temperature gradient and the quenching rate can be read off. With these calculations it is possible to get information about the resulting microstructure, especially about the ledeburitic microstructure obtained i.e. about the formation of martensite in the heat affected zone.

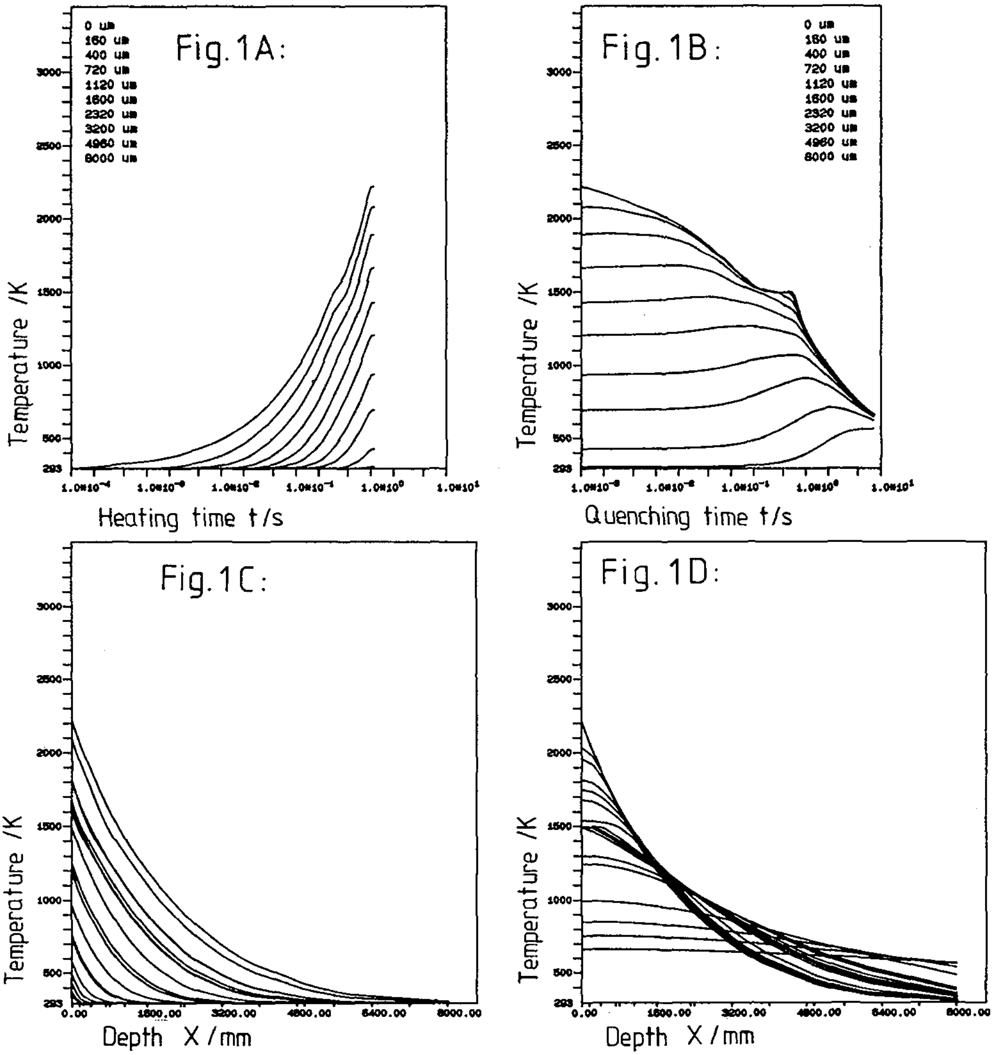


Fig. 1: Temperature distribution at various distances from the surface for various heating times under constant laser conditions.

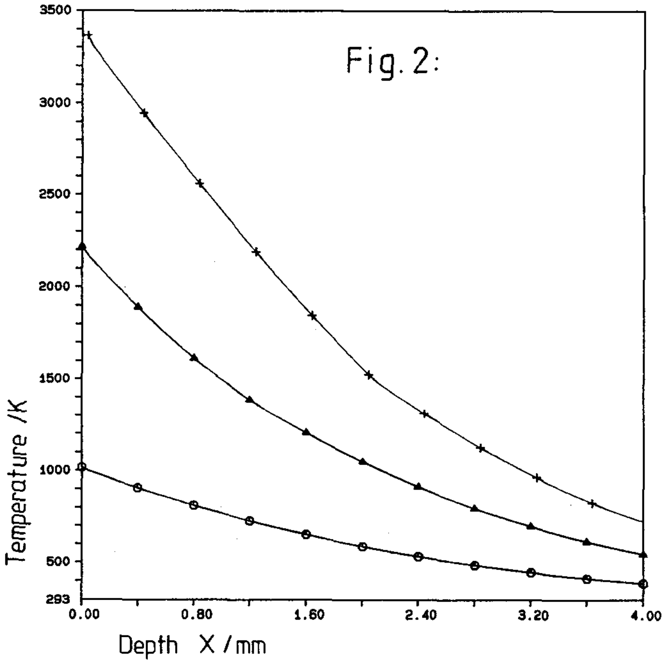


Fig. 2: Surface temperature as a function of laser intensity (I) melted depth (md) vaporized depth (vd)

*P=6000W;D=10mm;v=1cm/s
I=7639W/cm^2;t=1s;
md=2.04mm;vd=0,04mm

▲P=3000W;D=10mm;v=1cm/s
I=3820W/cm^2;t=1s;
md=0.96mm;vd=0mm

○P=1000W;D=10mm;v=1cm/s
I=1273W/cm^2;t=1s;
md=0.00mm;vd=0mm

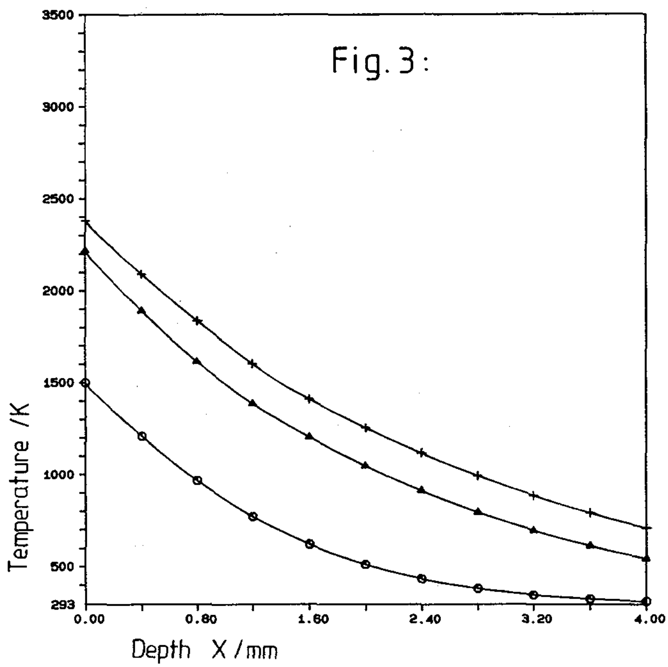


Fig. 3: Surface temperature as a function of the heating time with constant laser intensity.

*P=6000W;D=15mm;v=1cm/s
I=3395W/cm^2;t=1.5s;
md=1.4mm;vd=0.0mm

▲P=3000W;D=10mm;v=1cm/s
I=3820W/cm^2;t=1.0s;
md=0.96mm;vd=0.0mm

○P=3000W;D=10mm;v=3cm/s
I=3820W/cm^2;t=0.3333s;
md=0mm;vd=0.0mm

Experimental and theoretical results show good agreement. With increasing temperature gradient a finer microstructure is obtained.

Conclusions

A computational model for the calculation of heat conduction during a laser treatment has been instalated. With the aid of this model it was possible to chose the necessary laser conditions to get the wanted melting depth and microstructure. It was shown that a good agreement between theoretical and practical results could be obtained.

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