INFRARED THERMOGRAPHY IN MONITORING OF LASER WELDING

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Goal :

The inflence of depth of penetration on surface temperature distribution behind melt pool in the case of butt laser welding of steel pieces of flat geometry.

The depth of penetration is the fuction of :

- power of laser beam
- defocusing of laser beam

This information is importanat in the control of the quality of weld produced with laser welding.

THE COURSE OF RESEARCH :

1. The experimental part

The registration of temperatures on the weld seam behind the weld pool of flat carbone steel samples of different thicknesses with the IR camera
and
measurement of the absorbed laser power for :

- variable laser power + the laser spot on the surface of the detail
- variable position of the laser spot (defocussing) + constant laser power

2. The theoretical part

The modelling of temperatures by means of a specially constructed thermal conduction model of laser welding in function of both measured absorbed laser power and measured depth of penetration.

3. The comparative analysis of experimental and theoretical results.

4. Proposal of an two-points control system of weld quality.

♦

For the sake of simplicity, the butt welding was replaced with simple remelting of homogeneous samples.

Defocusing

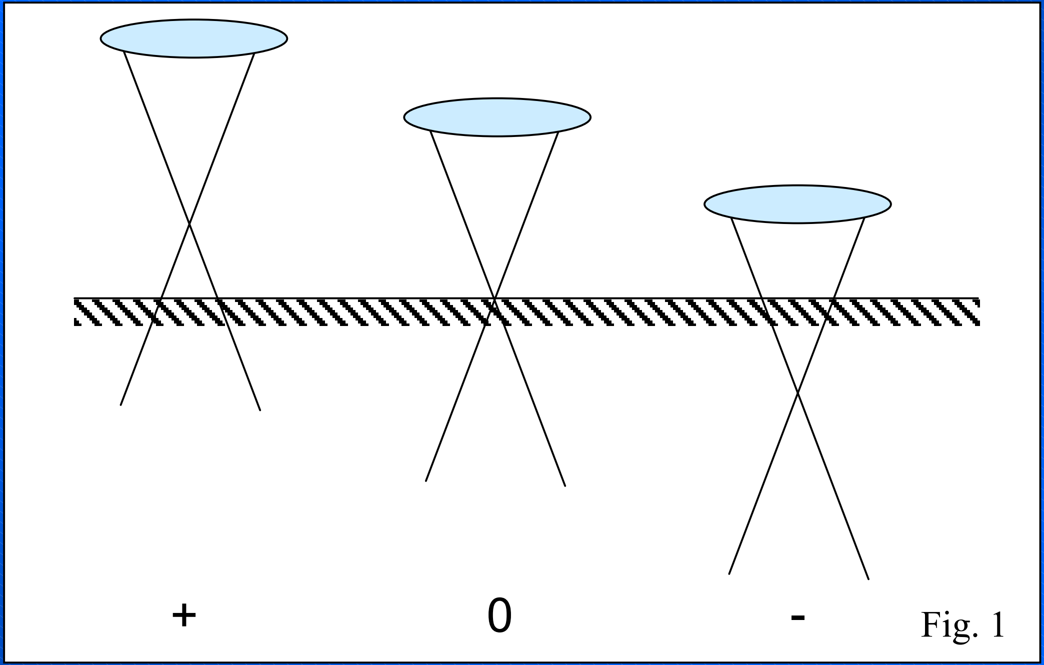


Fig. 1

EXPERIMENTAL SET-UP
IR Thermography

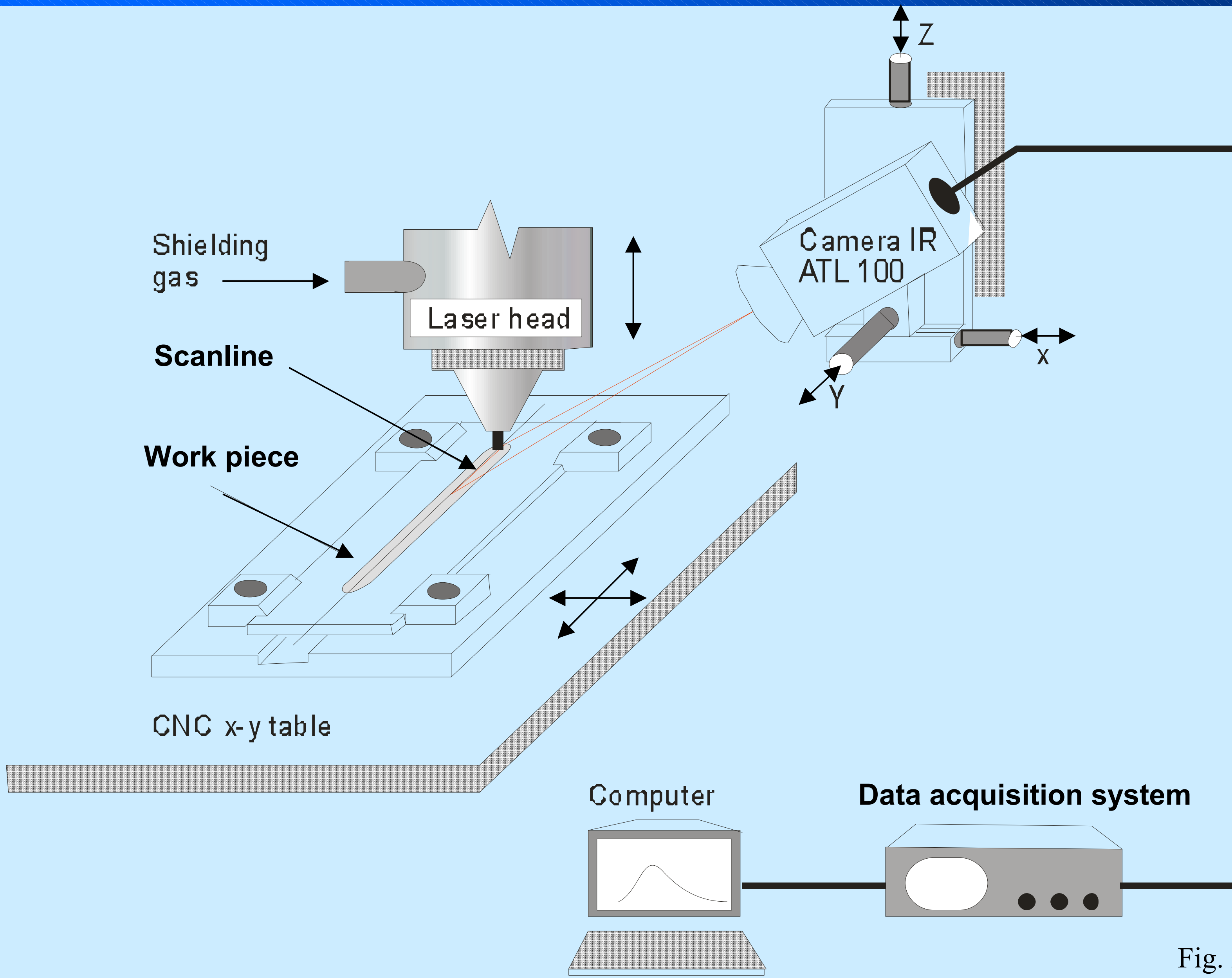


Fig. 2

EXPERIMENTAL SET-UP
absorbed laser power measurements

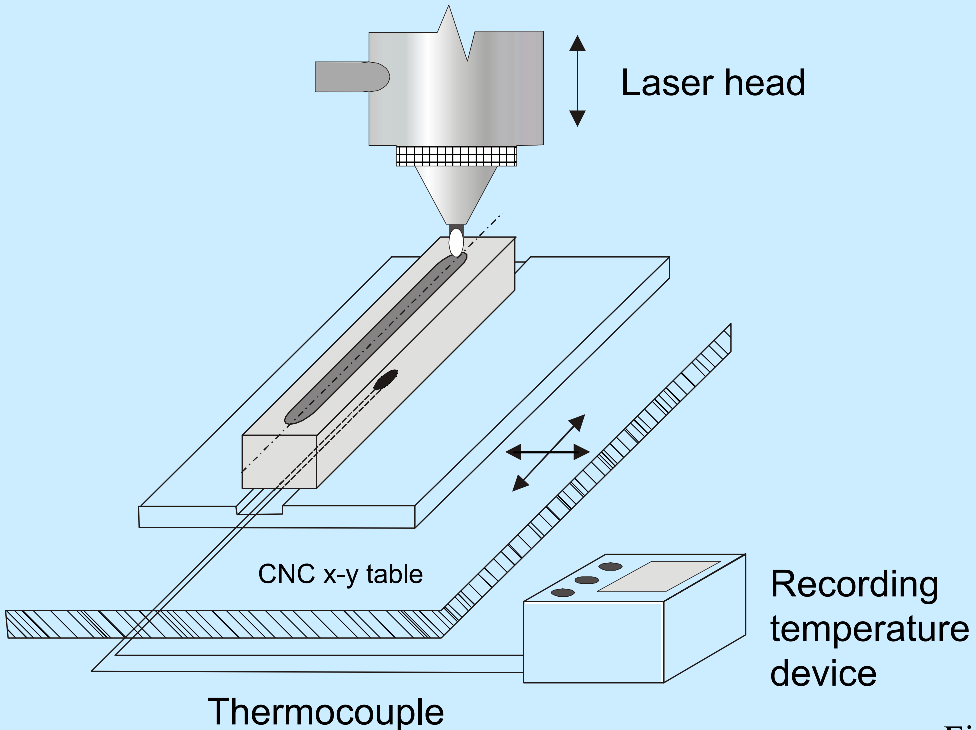


Fig. 3

LASER BEAM WELDING MODEL

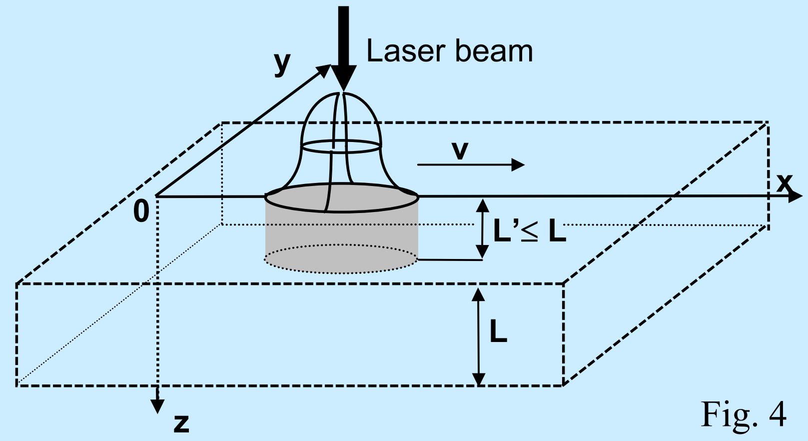


Fig. 4

Conduction Heat Equation :

Three-dimensional + Linear + with Heat Source Term

Heat source term :

- Gaussian in X, Y
- uniform in L'≤ L
- moving with a speed v in X direction
- releasing power P_a

Boundary conditions : - heat transfer coefficient constant on the both surfaces

Initial condition : - work piece at uniform temperature of 20 °C

WELDING OF FLAT SHEETS

SHEET 0.7 mm OF THICKNESS

Temperatures on the weld surface

Temperatures observed with IR thermography

In function of the distance from laser beam in steady state.

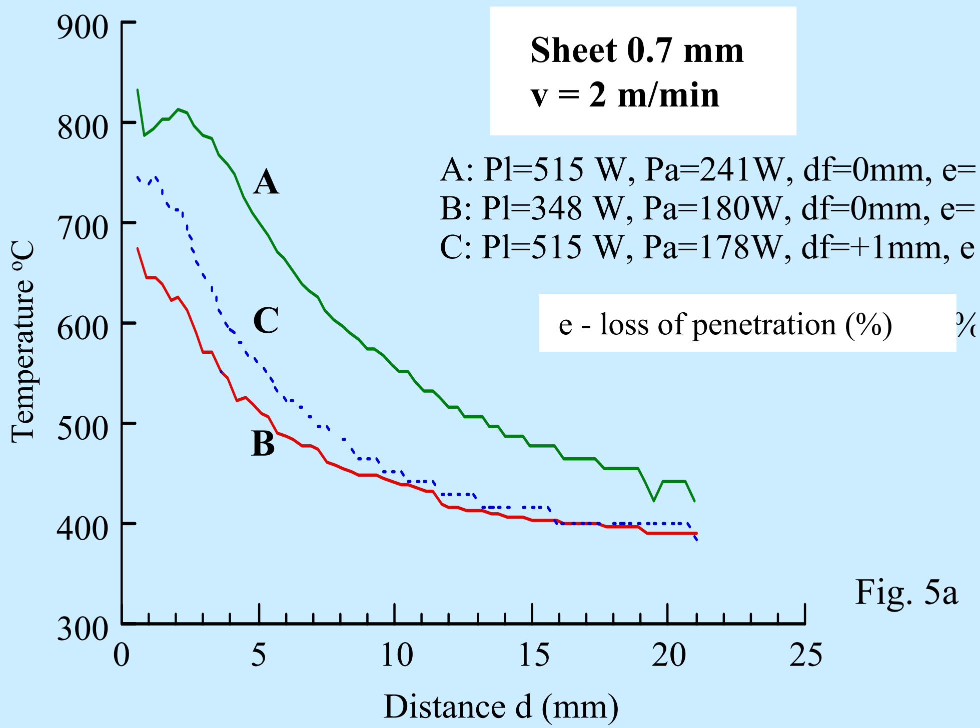


Fig. 5a

Temperatures calculeted with analytical model

In function of the distance from laser beam in steady state.

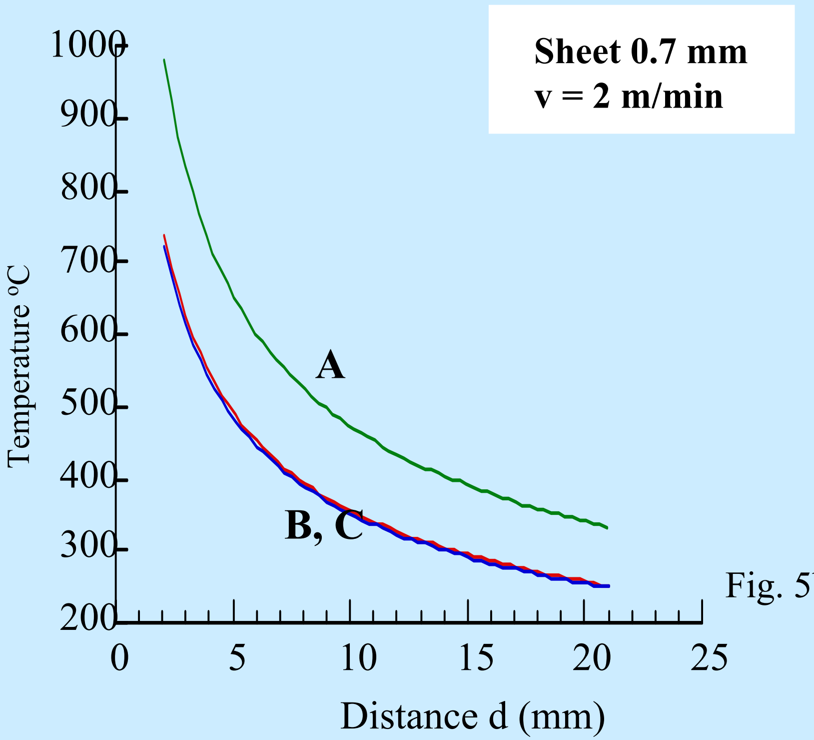


Fig. 5b

WELDING OF FLAT SHEETS

SHEET 3 mm OF THICKNESS

Temperatures on the weld surface

Temperatures observed by IR thermographie

In function of the distance from laser beam in steady-state.

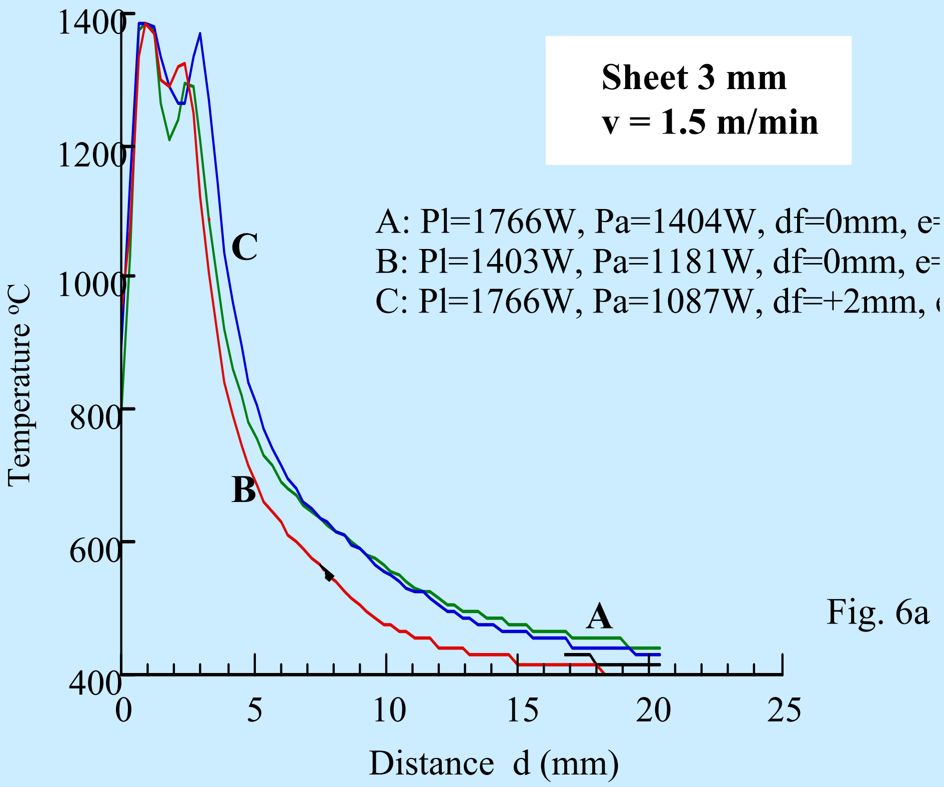


Fig. 6a

Temperatures calculeted by analytical model

In function of the distance from laser beam in steady-state.

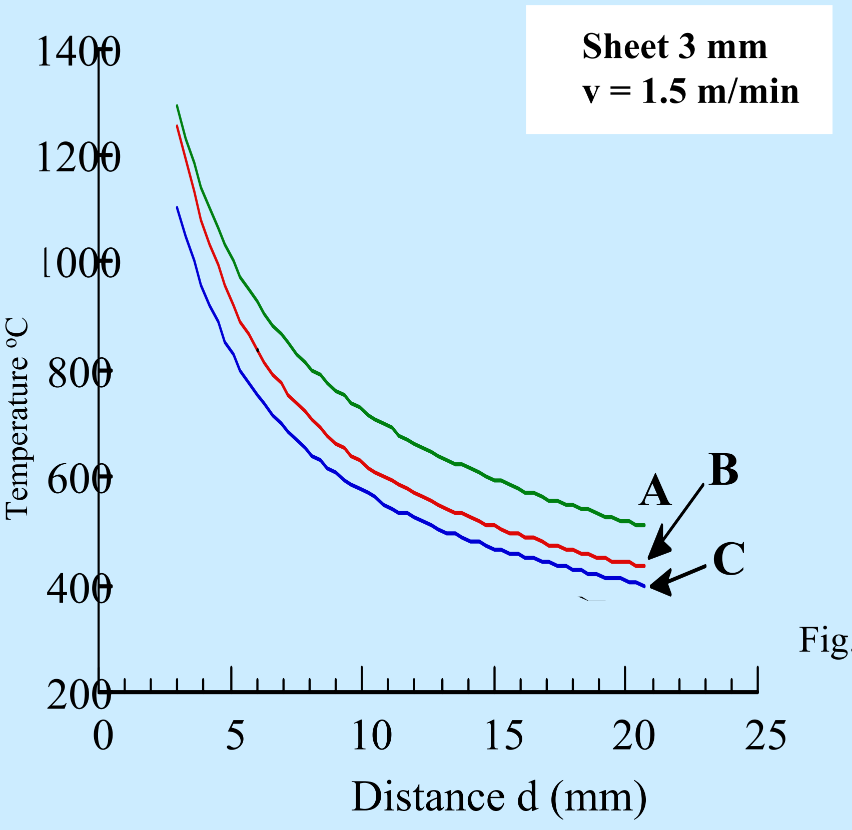


Fig. 6b

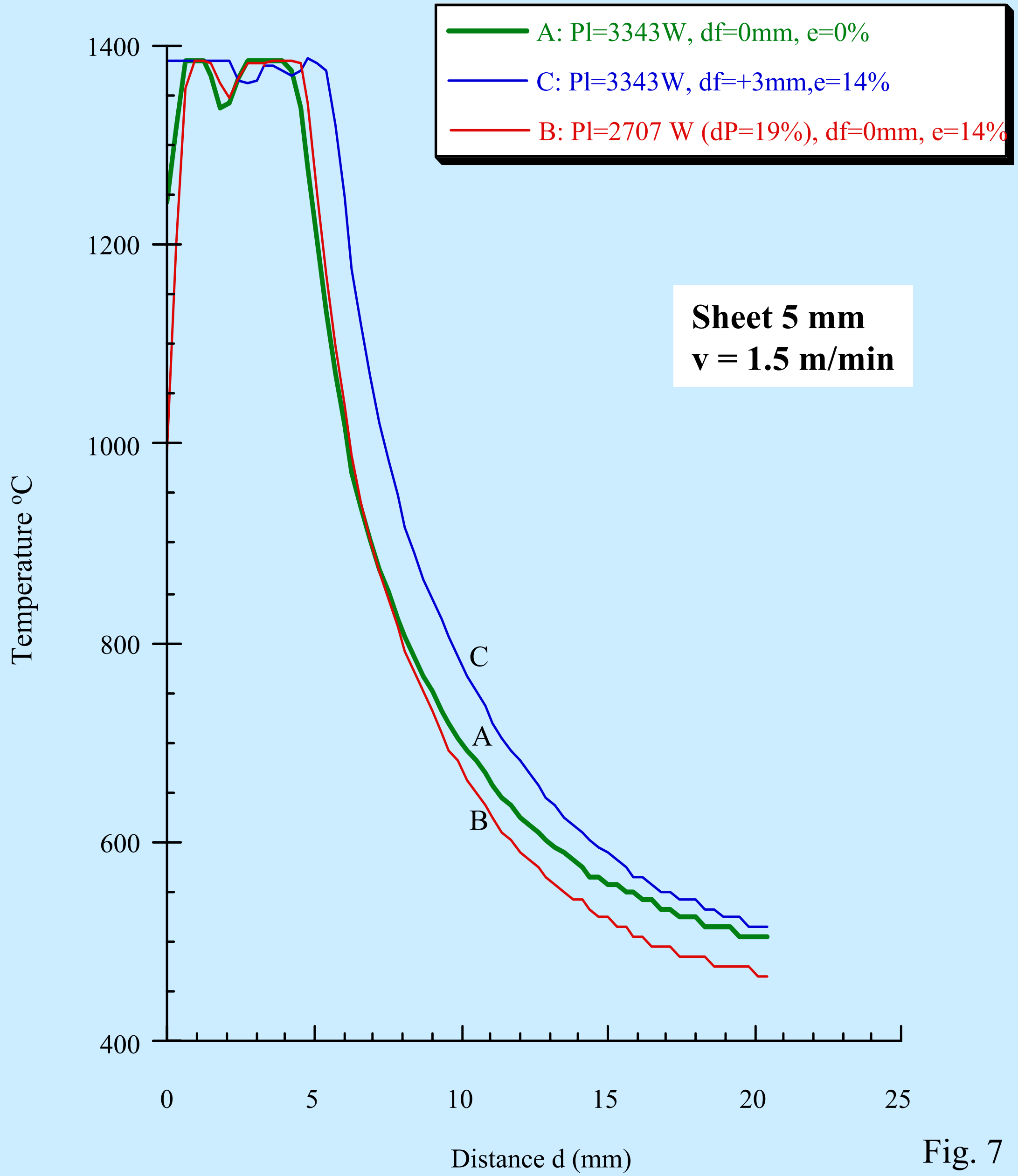


Fig. 7

WELDING OF FLAT SHEETS

SHEET 5 mm OF THICKNESS

THE SAME LACK OF PENETRATION

DUE TO :

- LOSS OF LASER POWER
- DEFOCUSING

WELDING OF FLAT SHEETS

SHEET 3 mm OF THICKNESS

Temperature difference

between optimal welding conditions and welding with incomplete penetration of 20 %.

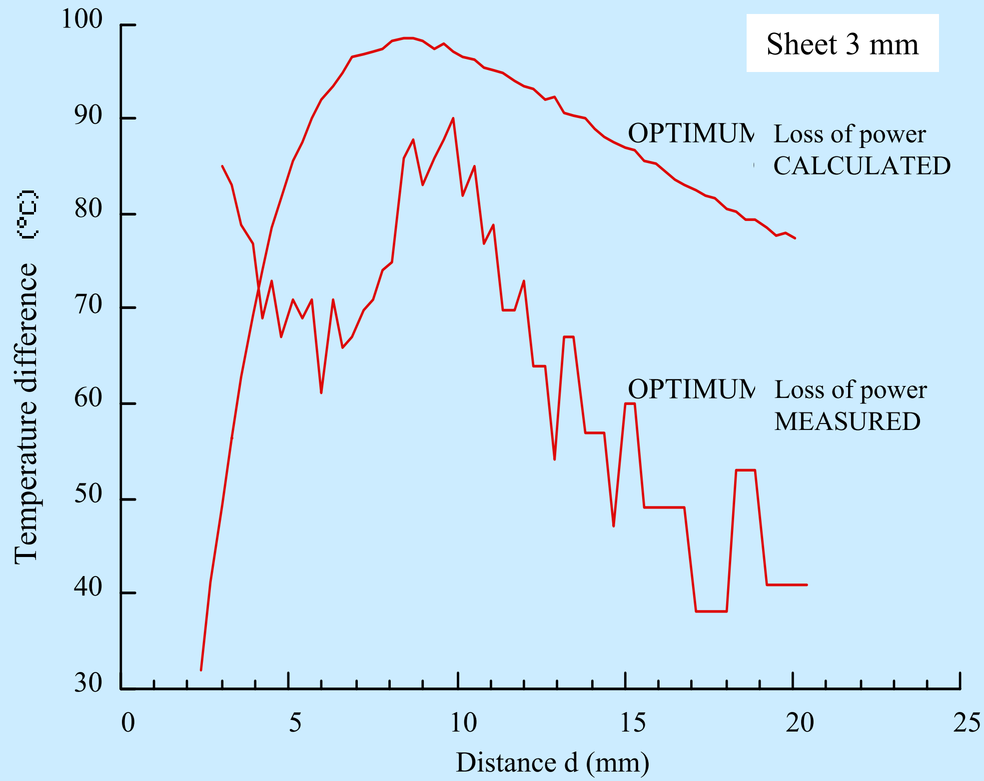
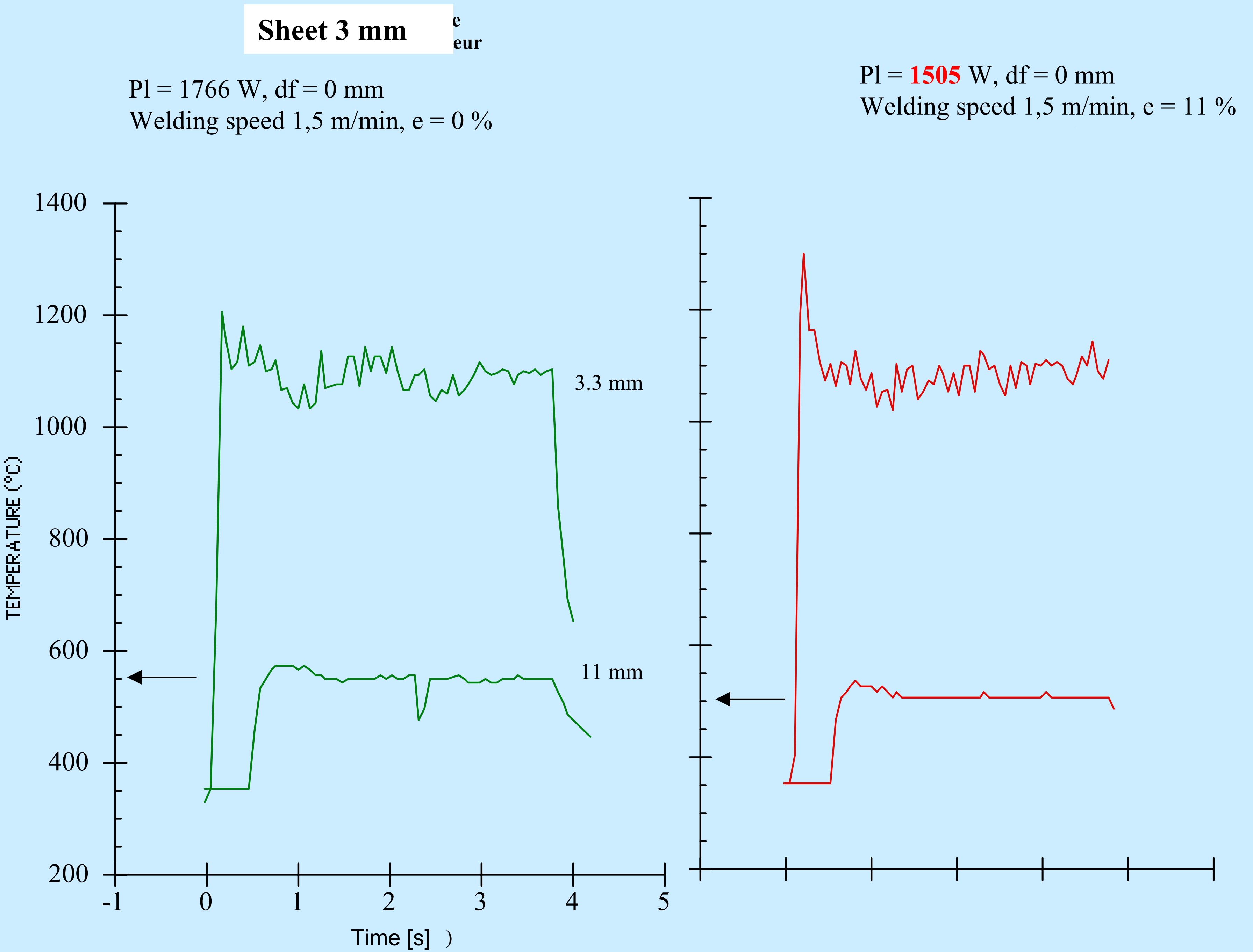


Fig. 8



Sheet 3 mm
e
eur
Pl = 1766 W, df = 0 mm
Welding speed 1,5 m/min, e = 0 %
Pl = 1505 W, df = 0 mm
Welding speed 1,5 m/min, e = 11 %
1400
1200
1000
800
600
400
200
TEMPERATURE (°C)
3.3 mm
11 mm
-1
0
1
2
3
4
5
Time [s])

Fig. 9

Sheet 3 mm

Pl = 1766 W, df = 0 mm
Welding speed 1,5 m/min,   e = 0 %

Pl = 1766 W, df = +2 mm
Welding speed 1,5 m/min, e = 12 %

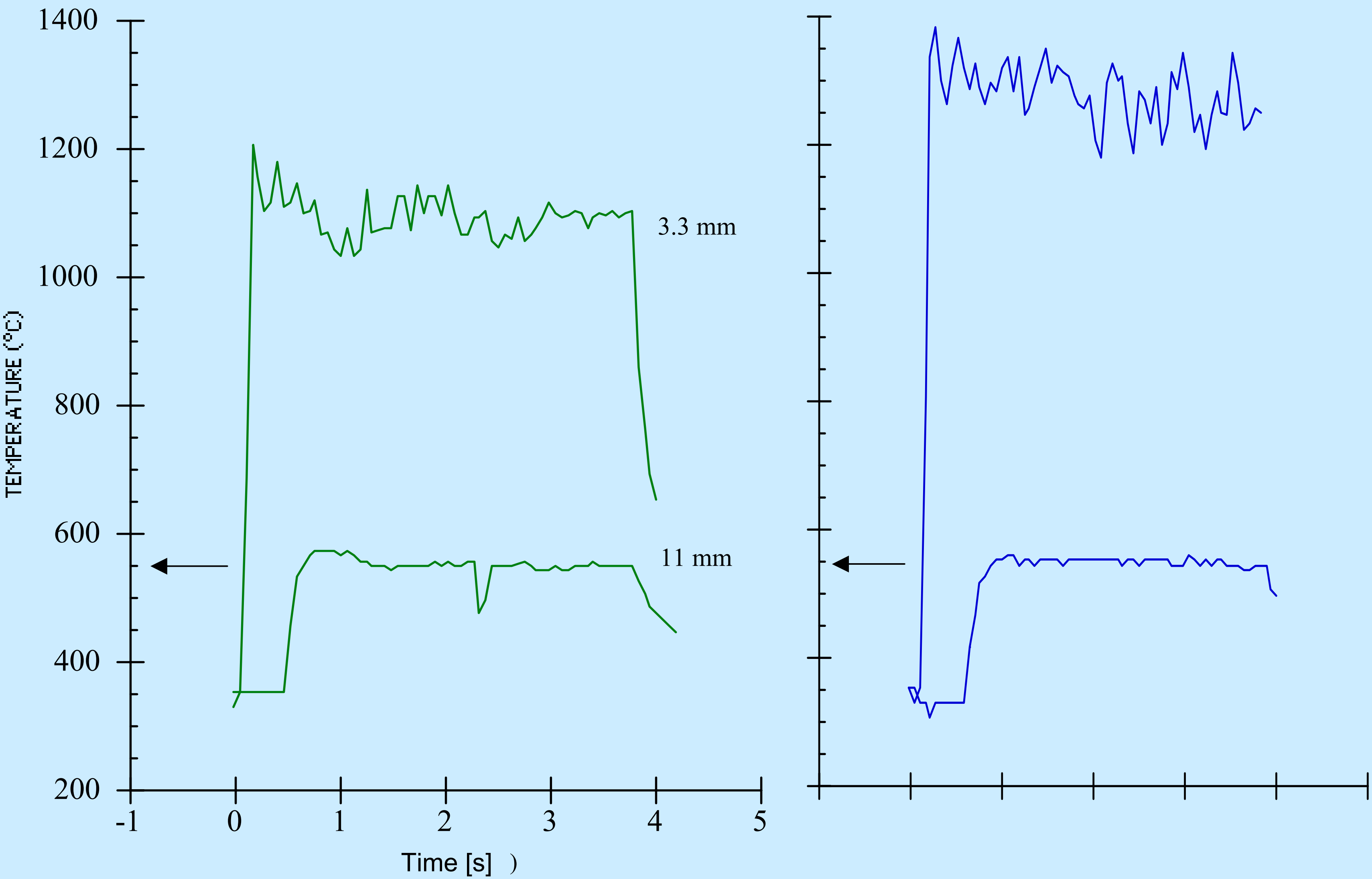


Fig. 10

Sheet 3 mm

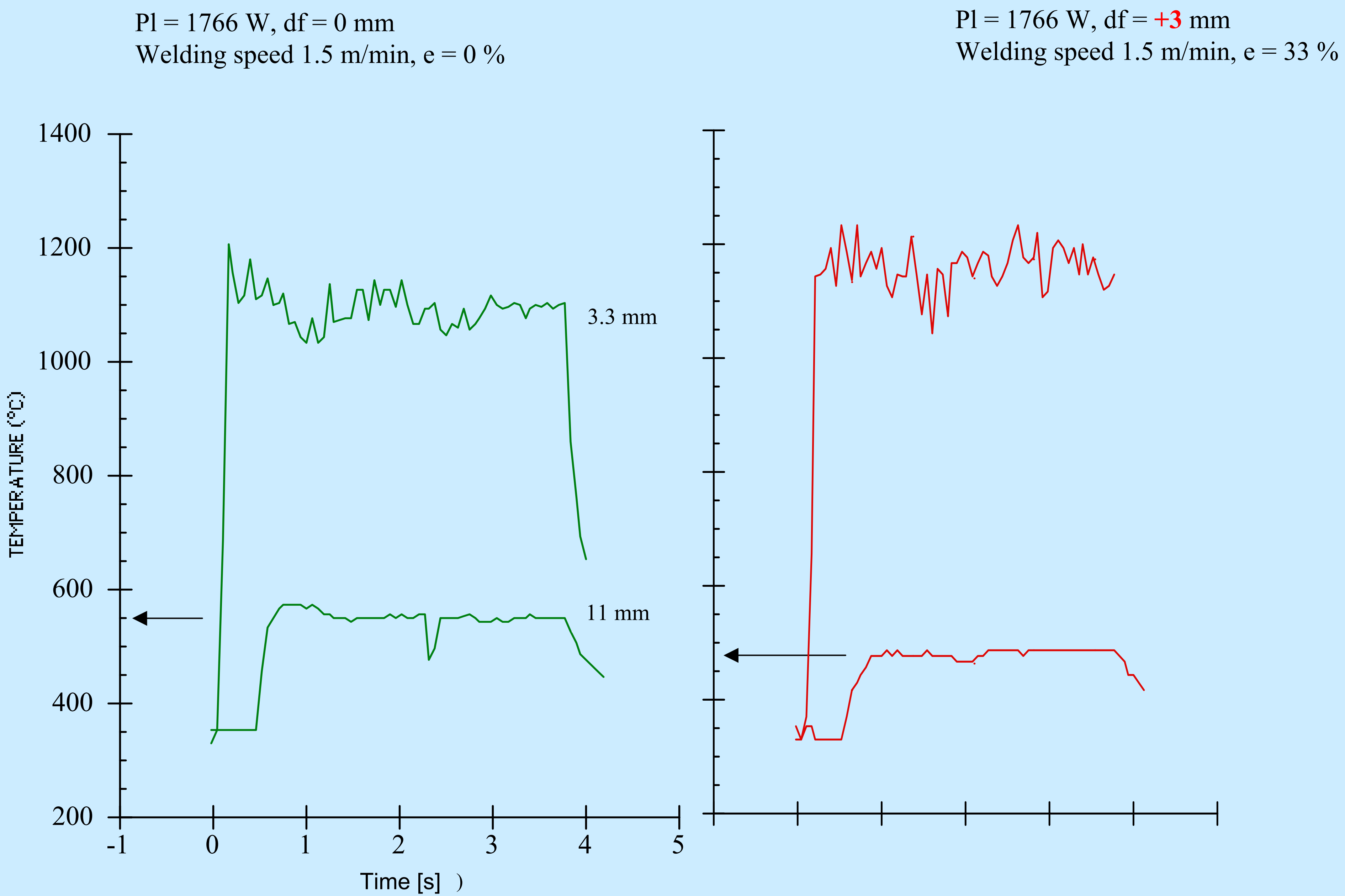


Fig. 11

Proposal of
TWO-POINT CONTROL SYSTEM OF LASER WELDING QUALITY

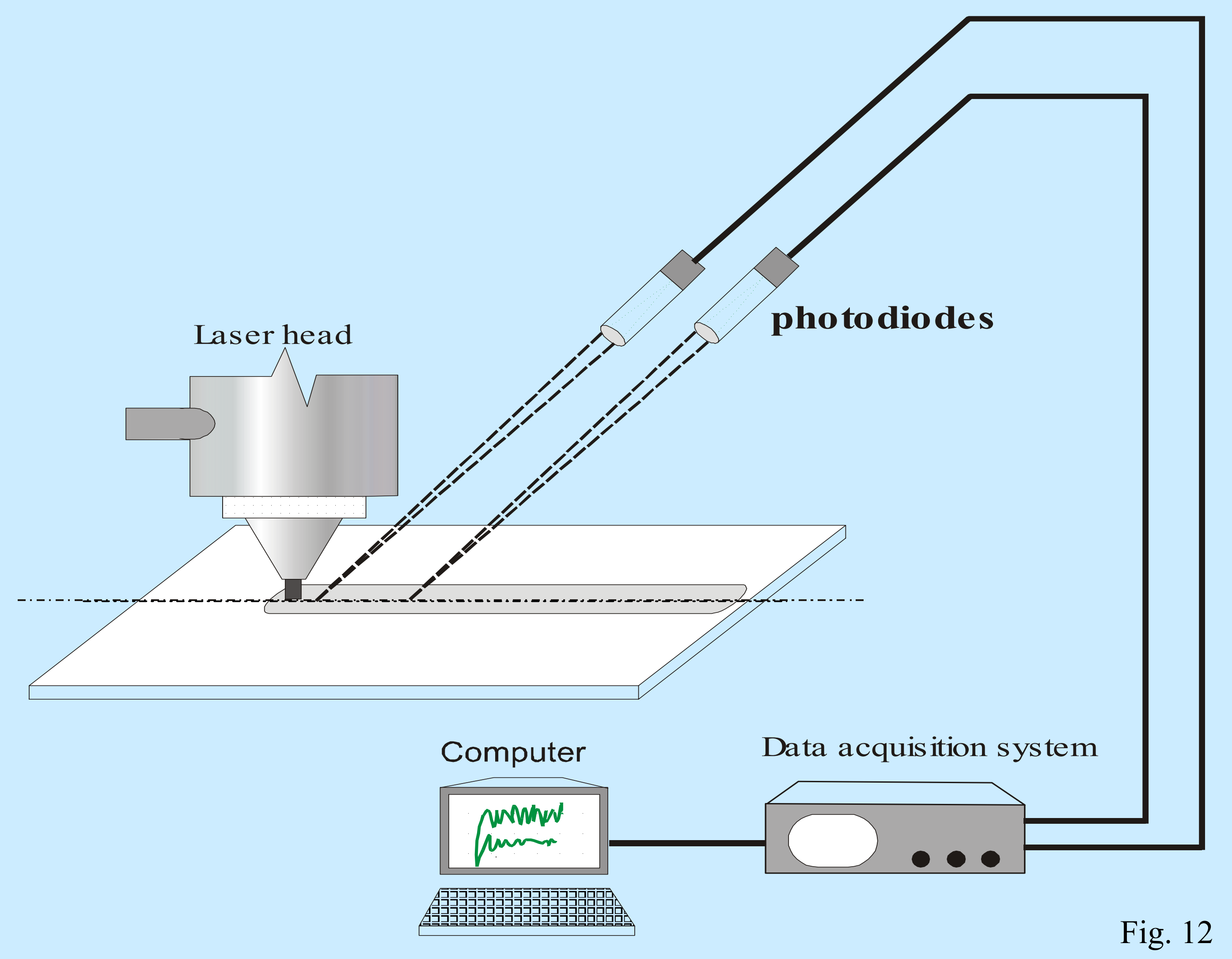


Fig. 12