Application broschure

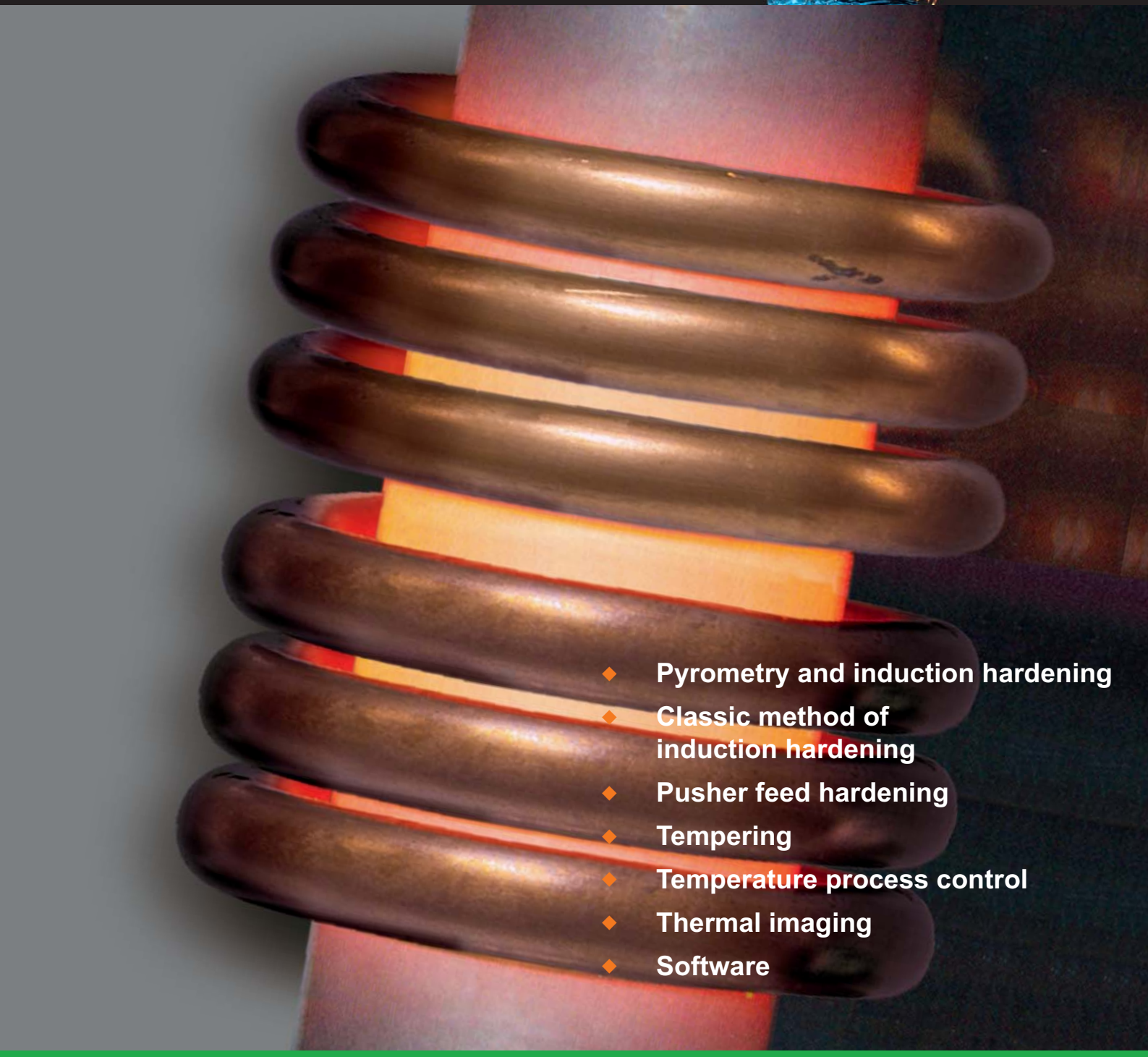
impac®
A LUMASENSE TECHNOLOGIES Company

Induction Hardening

certified ISO 9001:2000 IMPAC Infrared

Non contact measurement technology for induction hardening processes

-50°C  4000°C



- Pyrometry and induction hardening
- Classic method of induction hardening
- Pusher feed hardening
- Tempering
- Temperature process control
- Thermal imaging
- Software

IMPAC - Specialist in non-contact thermometry

A critical factor in induction hardening is the correct temperature. In particular the resulting quality and durability of parts are influenced significantly by the temperature before quenching.
A good knowledge of all aspects of induction hardening helps avoid the above mentioned problem. The temperature measurement is easily handled by precise temperature measurement equipment and the use of pyrometers for non-contact temperature measurement has been proven to be successful for induction hardening applications.

Pic. 1: Fixed IMPAC-pyrometer IS 140.

> Pyrometers enable the precise non-contact measurement of temperatures

Non-contact temperature measurement features the following advantages:

- Continuous monitoring of heating processes
- Continuous control of heating processes
- Very fast temperature measurement
- Measurement of very small objects
- Non-sensitive to electro-magnetic radiation
- Documentation of the measured values to monitor a defined quality standard

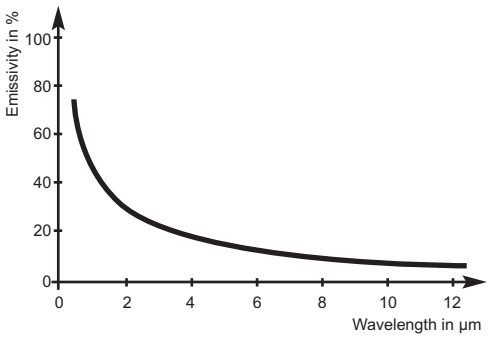
For induction hardening the capture of a temperature distribution of a larger area might be interesting. This can be achieved by using a line camera or thermal imaging camera.

Principles of pyrometry and induction hardening

In general, induction heating means hardening a surface of a part. Certain areas of a work piece are placed into an alternating electro-magnetic field (induction coil). This results in the rapid heating of the metal part to typically 900°C, followed by an immediate quenching process. The depth of penetration, consequently the thickness of the hardened layer, is determined by the power consumption and the frequency applied to the inductor.

Every body emits electro-magnetic radiation (infrared radiation) in a broad spectral range. A pyrometer uses this emitted radiation to assess the temperature of this body. Every material, however, radiates individually. The standard of this specification is called emissivity.

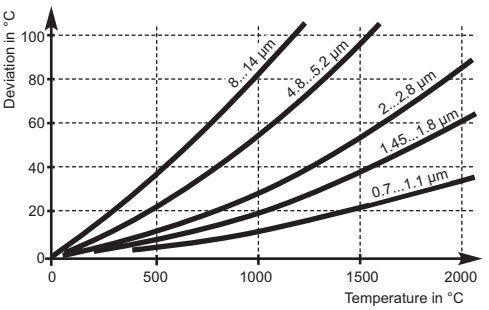
The emissivity of metal is dominant at short wavelengths and decreases at broad-band radiation. That is why metal should be measured by pyrometers working at short wavelengths.
The following graph shows the typical correlation (Wien's law):



Pic. 2: Correlation between wavelength and emissivity for metals.

> Metals should be measured at short wavelengths.

If this correlation is disregarded and the wrong type of pyrometer is used, the accuracy of the temperature measurement drops significantly.



Pic. 3: Measurement errors causes by incorrect selection of pyrometers. To demonstrate the temperature reading errors the emissivity was adjusted wrongly by 10%.

Pic. 3 shows five pyrometers detecting different wavelengths of the radiation emitted by a metal part. The pyrometer working at the shortest wavelength produces the smallest measurement errors.

The selection of the suitable pyrometer

The choice of the suitable pyrometer depends in general on various aspects:

- The pyrometer should be applicable for metals
- The measurement range of the pyrometer should cover the temperature range of the hardening process
- The spot size of the pyrometer should match at least the size of the target
- The measurement distance to the target selects the correct optic of the pyrometer
- The response time of the pyrometer should match the process speed

> IMPAC's product portfolio offers solutions for a multitude of measurement tasks.

Severe conditions motivate the use of so called ratio pyrometers or fibre optic pyrometers.
Ratio pyrometers are recommended for the following conditions:

- The spot size of the pyrometer is larger than the target
- The emissivity of the target changes during measurement
- The measurement is affected by ambient conditions e.g. airborne particles

Fibre optic pyrometers feature a small remote optical head, which is connected via a fibre optic cable to the transducer. The advantages of the fibre optic are as follows:

- Fibre optic and fibre optic cable are non-sensitive to electro-magnetic radiation
- The fibre optic can be installed directly onto the inductor and moves along with the inductor in the process
- The fibre optic can be used where the geometry does not allow standard sensors

Application: Classic process of hardening

In the classical process of hardening neither the inductor nor the target are moved while heating. Consequently it is quite easy to measure the temperature with a fixed standard pyrometer.

The following reason recommends the use of pyrometers:

To ensure the optimised hardening of the metal surface the part has to be heated rapidly for a defined period of time to the correct temperature. The resulting quality and durability of parts are influenced significantly by the temperature before being quenched.
For this application IMPAC pyrometers of type IS 5, IS 12, IS 140, IGA 5, IGA 12 and IGA 140 are best suited.
When confronted with severe conditions such as small targets, nfavourable atmospheres or electromagnetic fields the ratio pyrometers ISQ 5, ISQ 5-LO, ISR 12-LO and IGAR 12-LO offer solutions. These are available with or without fibre optic.

ISR 12-LO

IS 5

Pic. 4: IS 5: Standard pyrometer with fixed optics , ISR 12-LO: Ratio pyrometer with fibre-optic cable.

Application: Pusher feed hardening

In the pusher feed hardening process the inductor and quenching equipment is moved along the metal part.

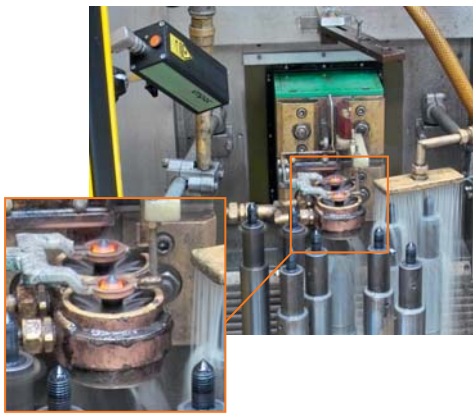
For some heating processes it is sufficient to measure the temperature of a metal part with a fixed pyrometer of type IS 5, IS 12, IS 140, IGA 5, IGA 12 or IGA 140. In this process the temperature is measured at one reference point of the metal part before the inductor hides it and disables the measurement. Please see example in pic. 5.

If the temperature needs to be measured by moving along the target the pyrometer can be mounted on the inductor. In most cases a fibre optic pyrometer IS 5-LO or IGA 5-LO is used for this situation. The optical head is small, lightweight and easy to mount.

For applications where there are target size, emissivity and atmospheric obscuration problems one of the ratio pyrometers ISQ 5-LO, ISR 12-LO or IGAR 12-LO should be used.

Application: Tempering

Induction hardening can leave parts in a potentially brittle condition, due to high surface tensions caused by the rapid heating process. To remove these tensions the parts go through a tempering process. This process requires the part to be heated up to a lower temperature and then be allowed to cool naturally.
For accurate temperature measurment the IMPAC IP 140 pyrometer is recommended.



Pic. 5: Pusher feed hardening of a special screw.

Advantages of IMPAC pyrometers

IMPAC is a specialist for all areas of non-contact temperature measurement and provides system solutions, solutions for industries and special solutions.
IMPAC pyrometers excel in following aspects:

- Highest quality standards
- Fast response time
- Accurate measurement
- Broad measurement ranges
- Precise measurement with negative influences of e.g. water vapour or dust
- Full digital signal conditioning
- Ease of use
- Automatic process control features

Type	Temperature range [°C]	Response time [ms]	Min. spot size [mm]	Optics	Display
Standard pyrometer					
IS 5	650 ... 3.000	2	0.5	fixed	–
IS 5-LO	650 ... 3.000	2	0.45	fibre optic	–
IS 12	550 ... 2.500	1	0.2	focusable	yes
IS 140	550 ... 3.300	1	0.35	focusable	–
IGA 5	250 ... 3.000	2	0.5	fixed	–
IGA 5-LO	300 ... 3.000	2	0.45	fibre optic	–
IGA 12	300 ... 1.800	1	0.2	focusable	yes
IGA 140	250 ... 2.500	1	0.35	focusable	–
IP 140	50 ... 1.300	1.5	0.25	focusable	–
Ratio pyrometer					
ISQ 5	600 ... 3.000	10	1.5	fixed	–
ISQ 5-LO	700 ... 2.500	10	0.45	fibre optic	–
ISR 12-LO	600 ... 3.300	2	0.45	fibre optic	yes
IGAR 12-LO	300 ... 2.200	2	0.45	fibre optic	yes

Pic. 6: IMPAC pyrometers stand for cutting edge quality in technology and workmanship.

For 50 years our customer base has benefited from consistent high quality, reliability and the attractive price-value ratio of IMPAC pyrometers.

Special solution: Automatic process control

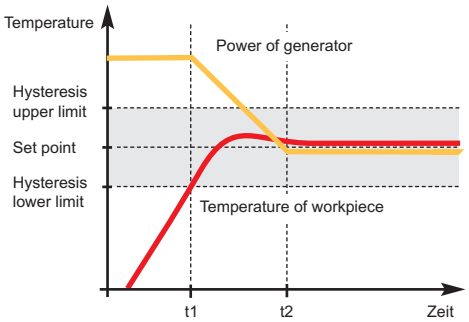
Of great importance for induction heat treating is the extremely short time it takes to get a metal part to the target temperature and to hold it constant. To control heating processes very fast controllers as well as pyrometers are required.

In order to meet this challenge, IMPAC has designed a digital indicator DA 6000-C with a high speed proportional controller for temperature control.

The DA 6000-C analyses the measured data of the pyrometer and controls the heating process. The proportional controller provides a very fast cycle time of 1 ms and ideally suited for induction heating applications.

Pic. 7: DA 6000-C

The following graph shows how this p-controller works. The desired set point and the width of the control span (hysteresis) is adjustable at the DA 6000-C. Moreover, the power of the generator can be controlled.



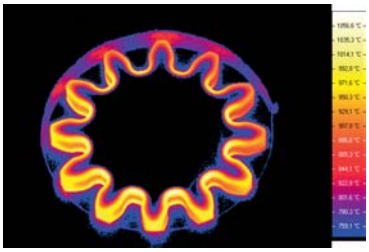
Pic. 8: Automatic temperature control using a proportional controller

Special solution: Thermal imaging

Besides single point measurement by pyrometers, IMPAC offers the measurement of temperature distribution in parts using portable thermal imagers.

Following applications have been identified:

- Optimisation of the magnetic field of an inductor by logging the temperature data of a target
- Optimisation of temperature gradients of e.g. a gear wheel between the tooth tip and tooth base (example in pic. 9)



Pic. 9: Thermal image of a gear wheel

- Detection of the optimal spot for a single point measurement by pyrometers
- Logging of image sequences at high speed e.g. 60 Hz for later analysis of individual frames (pictures)
- Check if targets which have been heated up in parallel show identical temperature patterns

Special solution: Software

IMPAC offers software for visualisation, data-logging and analysis for various products.

InfraWin: *InfraWin* is the standard software shipped with all digital pyrometers from IMPAC. Additionally to visualisation, data-logging and analysis all parameters can be adjusted by software.

All IMPAC pyrometers utilise the Universal Pyrometer Protocol (UPP®). This enables the seamless integration of pyrometers into existing user software.

MultiTemp: *MultiTemp* is software for combining the data-logging of several pyrometers. Temperatures are visualised, logged and can be analysed from a central computer. Also all parameters of all attached pyrometers are adjustable.

For additional customer specific software requests IMPAC systems will provide individual solutions.

Individual application solutions:

Our experienced staff will answer your questions and provide individual solutions based on our technologies.

Additional information can be found on our website with regards to data sheets, application brochures, news etc. or ask us directly at IMPAC.

IMPAC Infrared GmbH
Temperature Measurement
Kleyerstraße 90
D-60326 Frankfurt/Main
Telefon: +49 (0)69 / 9 73 73 - 0
Telefax: +49 (0)69 / 9 73 73 - 167
www.impacinfrared.com
info@impacinfrared.com

IT2H8