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References

Please number all references in the text in their order of appearance and compile the references at the end of the text. Examples of references:

- [1] Backert, W.-D.: Bonnet-less shut-off valves in water engineering, *Industriearmaturen* 4 (1996), No. 1, p. 18-20
- [2] Körting, J.: History of the German gas industry. Essen: Vulkan-Verlag, 1963
- [3] DIN EN 476, „General requirements on components for drains and sewers for gravity drainage systems“ (1997-08)
- [4] www.heat-processing.com; 14.07.2010

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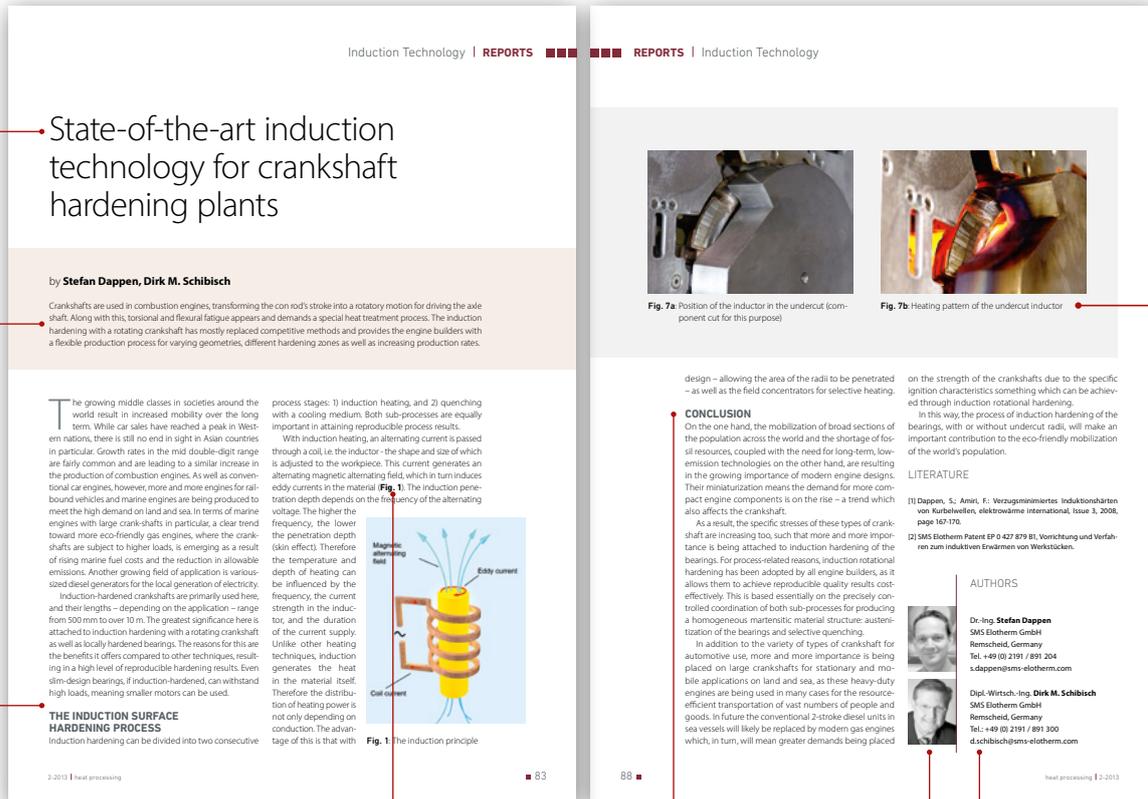
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Notes for Authors

At a glance



Title → State-of-the-art induction technology for crankshaft hardening plants

by **Stefan Dappen, Dirk M. Schibisch**

Abstract:
4-5 sentences,
max. 500
characters

Crankshafts are used in combustion engines, transforming the con rod's stroke into a rotary motion for driving the axle shaft. Along with this, torsional and flexural fatigue appears and demands a special heat treatment process. The induction hardening with a rotating crankshaft has mostly replaced competitive methods and provides the engine builders with a flexible production process for varying geometries, different hardening zones as well as increasing production rates.

The growing middle classes in societies around the world result in increased mobility over the long term. While car sales have reached a peak in Western nations, there is still no end in sight in Asian countries in particular. Growth rates in the mid double-digit range are fairly common and are leading to a similar increase in the production of combustion engines. As well as conventional car engines, however, more and more engines for rail-bound vehicles and marine engines are being produced to meet the high demand on land and sea. In terms of marine engines with large crankshafts in particular, a clear trend toward more eco-friendly gas engines, where the crankshafts are subject to higher loads, is emerging as a result of rising marine fuel costs and the reduction in allowable emissions. Another growing field of application is various-sized diesel generators for the local generation of electricity. Induction-hardened crankshafts are primarily used here, and their lengths – depending on the application – range from 500 mm to over 10 m. The greatest significance here is attached to induction hardening with a rotating crankshaft as well as locally hardened bearings. The reasons for this are the benefits it offers compared to other techniques, resulting in a high level of reproducible hardening results. Even slim-design bearings, if induction-hardened, can withstand high loads, meaning smaller motors can be used.

THE INDUCTION SURFACE HARDENING PROCESS
Induction hardening can be divided into two consecutive

process stages: 1) induction heating, and 2) quenching with a cooling medium. Both sub-processes are equally important in attaining reproducible process results.

With induction heating, an alternating current is passed through a coil, i.e. the inductor – the shape and size of which is adjusted to the workpiece. This current generates an alternating magnetic alternating field, which in turn induces eddy currents in the material **Fig. 1**. The induction penetration depth depends on the frequency of the alternating voltage. The higher the frequency, the lower the penetration depth (skin effect). Therefore the temperature and depth of heating can be influenced by the frequency, the current strength in the inductor, and the duration of the current supply. Unlike other heating techniques, induction generates the heat in the material itself. Therefore the distribution of heating power is not only depending on conduction. The advantage of this is that with

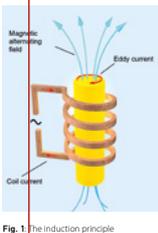


Fig. 1 The induction principle



Fig. 7a Position of the inductor in the undercut (component cut for this purpose)



Fig. 7b Heating pattern of the undercut inductor

Captions of figures and tables

design – allowing the area of the radii to be penetrated – as well as the field concentrators for selective heating.

CONCLUSION

On the one hand, the mobilization of broad sections of the population across the world and the shortage of fossil resources, coupled with the need for long-term, low-emission technologies on the other hand, are resulting in the growing importance of modern engine designs. Their miniaturization means the demand for more compact engine components is on the rise – a trend which also affects the crankshaft.

As a result, the specific stresses of these types of crankshaft are increasing too, such that more and more importance is being attached to induction hardening of the bearings. For process-related reasons, induction rotational hardening has been adopted by all engine builders, as it allows them to achieve reproducible quality results cost-effectively. This is based essentially on the precisely controlled coordination of both sub-processes for producing a homogeneous martensitic material structure: austenitization of the bearings and selective quenching.

In addition to the variety of types of crankshaft for automotive use, more and more importance is being placed on large crankshafts for stationary and mobile applications on land and sea, as these heavy-duty engines are being used in many cases for the resource-efficient transportation of vast numbers of people and goods. In future the conventional 2-stroke diesel units in sea vessels will likely be replaced by modern gas engines which, in turn, will mean greater demands being placed

on the strength of the crankshafts due to the specific ignition characteristics something which can be achieved through induction rotational hardening.

In this way, the process of induction hardening of the bearings, with or without undercut radii, will make an important contribution to the eco-friendly mobilization of the world's population.

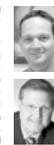
LITERATURE

- [1] Dappen, S., Amir, F.: Verzugsminimiertes Induktionshärten von Kurbelwellen, *elektrowärme international*, Issue 3, 2008, page 167-170.
- [2] SMS Elotherm Patent EP 0 427 875 B1, Vorrichtung und Verfahren zum induktiven Erwärmen von Werkstücken.

AUTHORS

Dr.-Ing. Stefan Dappen
SMS Elotherm GmbH
Remscheid, Germany
Tel. +49 (0) 2191 / 891 204
s.dappen@sms-elotherm.com

Dipl.-Wirtsch.-Ing. Dirk M. Schibisch
SMS Elotherm GmbH
Remscheid, Germany
Tel. +49 (0) 2191 / 891 300
d.schibisch@sms-elotherm.com



Marked image references

Conclusion at the end of the report

Photo Authors' details

Text, possibly figures and tables

Contact: Editorial department

Editor-in-Chief

Thomas Schneidewind
Tel.: 0201-82002-36
Fax: 0201-82002-40
t.schneidewind@vulkan-verlag.de

Managing Editor

Lena Langenkämper
Tel.: 0201-82002-15
Fax: 0201-82002-40
l.langenkaemper@vulkan-verlag.de

Address

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Advertising Sales

Maurice Kamp
Tel.: 0201-82002-57
m.kamp@vulkan-verlag.de

Subscription Services

Birgit Latzel
Tel.: 0201-82002-26
b.latzel@vulkan-verlag.de

Offprints

Monika Kull
Tel.: 0201-82002-16
m.kull@vulkan-verlag.de

Production

Nilofar Mokhtarzada
Tel.: 0201-82002-18
n.mokhtarzada@vulkan-verlag.de

Advertising Admin

Jutta Zierold
Tel.: 0201-82002-22
j.zierold@vulkan-verlag.de