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REDUCTION OF NOISE FROM INDUCTION FURNACES

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INTRODUCTION

In steelworks and foundries induction furnaces are used for melting scrap. Medium frequency crucible furnaces (HFD) produce a strong tone at double the electrical frequency, or between about 600 Hz and 900 Hz. The sound pressure level can often reach 85 - 90 dB at the fundamental frequency in the 1 000 Hz octave band. Clearly some sort of hearing protection is required. Here we will describe this noise and how it is generated, and which noise reduction steps have been developed and tested with what results. This is the result of a noise reduction project financed by the Swedish Work Environment Fund between April 1980 and April 1983.

FURNACE DESIGN

The scrap is heated in the center of the furnace. A thick refractory insulates the melt from the electrical coil which conducts the electrical current for generating the magnetic field. The magnetic field induces eddy currents in the scrap and melt which result in heat for melting the scrap. Outside the electrical coil are magnetic yokes which return the magnetic field to the scrap and prevent it from heating other parts of the furnace. The magnetic yokes provide mechanical stiffness and backing for the coil and refractory as well.

NOISE CHARACTERISTICS

The figure shows third octave band spectra measured at four meters distance from the center of the furnace at different times during meltdown of the scrap. In addition to the fundamental tone at about 800 Hz there are overtones at 1600 Hz, 2400 Hz, etc. In modern installations using thyristor frequency converters the frequency of the tone increases somewhat during meltdown because the temperature of the scrap passes the Curie point, reducing the inductance of the furnace and increasing the resonance frequency of the furnace-capacitor resonator.

NOISE GENERATION

Clearly it is the tone which must be reduced in strength in the noise reduction work. When the magnetic field oscillates with a frequency of about 800 Hz the coil, melt and magnetic yokes act as a large electromagnet, and very large forces are generated between them. Thus the magnetic yokes, coil, refractory and scrap/melt vibrate in time with the magnetic field, and the vibrations generate air-borne sound. The vibrations are transmitted to all parts of the furnace, of course. The vibration amplitudes can be calculated starting from the magnetic field strengths, and the theoretical results for all parts of the furnace agree with the measured ones to within a few dB. Then using radiation efficiencies and areas the noise radiation and noise levels can be calculated, and good agreement is again obtained. This is described in references 1 - 4.

NOISE REDUCTION

Front plates. A large part of the noise generated by a furnace is radiated downwards and into the work area of the furnace. A way of reducing this noise is to mount front plates in front of the furnace and sound absorbers on the sides of the furnace pit behind the front plates. The front plates must be mounted on the concrete foundations around the furnace, and not on the furnace itself, to avoid vibrations in the plates with consequent radiation. The noise reduction achieved with these plates is 10 - 12 dB in front of the furnace, a satisfactory result.

Noise reduction housings. On the platform level the noise level is determined by radiation from the platform itself and from the furnace opening (scrap/melt and refractory), when there is no exhaust hood. It is possible to vibration isolate the platform and reduce the noise in that way, but the value of this step is limited to a few dB because of radiation from the furnace opening.

Another way of reducing the noise is to mount noise reduction housings over the furnaces. We have evaluated the effect of two such housings installed in 1975 and which have functioned satisfactorily since then. The noise reduction is about 10 dB. These housings require a special charging system as electromagnets suspended from above cannot be used to charge the furnaces. Here a system of trucks on rails is used. In addition to reducing the noise levels these housings provide an effective means of evacuating the exhaust gases from the furnace and reduce the risks involved with possible explosions in the furnace melt. It is quite possible that more such systems will be installed in the future.

Design changes. Based on our noise generation model we have developed some proposals for changes in the design of medium frequency crucible furnaces which could result in lower noise levels. One such idea is to vibration isolate the platform from the furnace to reduce vibrations and radiation. A way of doing this is to divide the platform along its center through the spout and mount the two halves on hinges at the sides of the furnace pit. This would require a rather thorough redesign of the mechanical construction of the furnace.

A further method is to change the furnace frequency. Reduction of the furnace frequency is not expected to have any real effect on the A-weighted sound pressure level, while increasing the frequency can have such an effect under certain conditions. Theoretically we find that the vibration level should decrease by about 6 dB per frequency doubling. On the other hand, the radiation factors of the various radiating surfaces are expected to increase somewhat. This increase is at most about two dB except for the furnace platform, where the radiation efficiency could increase by 8 or 9 dB. However, this increase can be avoided by vibration isolating the platform as above. Then increasing the frequency of the furnace could reduce the noise level. However, this is expected to increase the cost of the electrical installation. These and other ideas are currently under evaluation.

REFERENCES

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[3] D H McQueen, G Lundmark and J Svensson, "Reduction of noise from induction furnaces III Evaluations" Scandinavian Journal of Metallurgy 11, 309-312 (1982).

[4] J Svensson, "Rangordning av ljudkällor genom intensitetsmätningar", paper presented at Nordisk Akustisk Sällskapet NAS-82, Stockholm 16 - 18 August 1982 (in Swedish).

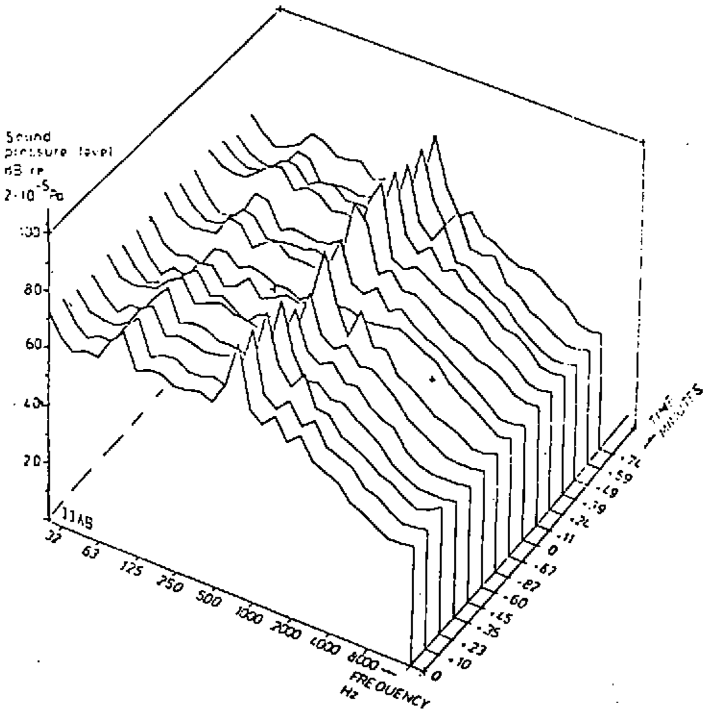

Figure showing third octave band analyses of noise from an induction furnace measured on the furnace platform during two meltdowns.