(1) STEAM TURBINE NOISE

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Introduction

The Central Electricity Board, in common with many other users of large plant installations, has an exceptional duty to its workers and the public to limit the emission of noise. The large time scale between design and commissioning together with many years of uninterrupted operation demand the use of the latest noise control techniques and an unusual degree of foresight.

Noise control costs for a 1000 MW power station may be as much as £1,000,000 and clearly expenditure of this nature must be supported by a very careful noise control design. In particular there must be a careful balance of the contribution of sources to match the internal and external requirements, with careful placing of noise control to enable maximum utilisation of existing structures.

Steam and Gas Turbines are shown to be the most powerful continuous noise sources in their respective installations and it is important to know both the acoustic power radiated by their sources and their near field noise levels to enable solutions to be provided to meet the requirements related to public annoyance and hearing conservation. Because of the difference in size and thermodynamic cycle used in the two types of turbine slightly different approaches must be made to the methods used in noise control.

The steam turbine is often considered to be that large piece of equipment sitting in the middle of a turbine hall, which is only an assembly of fixed and rotating blades in a pressure vessel, whereas in reality the total plant complement of a power station; boiler, feed pumps, fan, cooling system etc. provide the thermodynamic cycle which is the steam turbine. This plant is widespread over a large area and to some extent the minor noise sources can be considered in a piecemeal way but unfortunately very seldom in acoustic isolation. The sheer size and power requirements prevent acoustic assessment in an ideal acoustic environment.

The gas turbine presents a different set of problems because the working fluid is different and the thermodynamic cycle is satisfied by one compact plant assembly rated at no more than 50 MW. Acoustic assessment of noise radiation and the application of noise control is relatively simple compared with the steam turbine.

1. <u>Steam Turbines</u>

Contemporary steam turbines in the CEGB are of 500-660 MW capacity, with from 2-5 units grouped to form a power station.

Much work has been done in providing broad assessments of near field noise levels of power station plant for hearing conservation purposes. To a lesser degree work has also been carried out to provide assessments of the radiation patterns of plant and hence the acoustic power radiated, particularly from the turbo-generator assembly, to enable a more precise balance of noise control to be achieved. The greatest difficulties encountered in this work are the sheer size of the plant and our inability to run individual items at representative loads. However the information now available does enable sensible and consistent acoustic design procedures to be adopted which will progressively lead to some economy and a better feedback of useful data. Some of the more important aspects of our investigations which are the basis of our noise control precedures are:-

(a) The turbine generator assembly (turbo-generator) is the most powerful continuously operating noise source in a power station and at low frequencies provides the major contribution to internal and external noise levels.

(b) The surface noise levels of the turbo-generator at mid and high frequencies are no more onerous than many other plant items in a power station when considered in relation to the hearing conservation problem. However with the reduction of noise from these smaller sources these surface noise levels will become more significant in our noise control programme.

(c) In the short term it can be assumed that no large reduction of the basic noise source in a turbo-generator can be achieved due to the thermodynamic and mechanical restraints in design needed to achieve economic operation.

(d) Within the plant building the sound field is complex and cannot for example be considered to have a bulk room constant. Although small spaces between machines may be considered as reverberant there is a considerable decay in the noise level along the major axis of the building of the noise from a single source (of the order of 6 dB per doubling of distance)

(e) The turbo-generator is a very large area source and it is seldom possible to find a point within the building where propogation from any one turbo-generator can be seen to diverge at a rate of more than 3 dB per doubling of distance, with all turbo-generators running. In fact the sound level 'A' varies by little more than 1-2 dB over the whole turbine hall area beyond about 2-3 metres from machine casings with all plant operating.

(f) In areas of the power station remote from the turbo-generators the many other sources tend to maintain a uniform spatial noise level. However with well designed auxiliary plant the space average sound levels in an oil fired boiler house tend to be some 5 dB below turbine hall sound levels.

(g) Relationships between turbo-generator capacity and acoustic power have not yet been established. Average surface sound levels tend to obey the laws; Sound level A = $2 \log_{10}$ MW + 85 to $SL_A = 7 \log_{10}$ MW + 80 depending on the section of the turbo-alternator considered. The space average turbine hall sound level A relationship is found to be approx: $SL_A = 82 + 3.5 \log_{10}$ MW.

(h) Large variations in noise level are only found very close to plant casings becoming rapidly less at distance greater than 1 metre because of the multi source condition and the radiation of support structures and interconnecting pipework etc.

Noise Control

Careful consideration of our objectives and the present knowledge of plant noise radiation and operational aspects indicate that simple "bulk noise control" will not lead to a satisfactory progressive reduction of internal or external noise levels and that it is necessary to deal with each source or sub-source in a detailed way. The noise control of the turbo-generator will mainly rely upon the improvement of casing transmission loss by modification to the thermal cleading or by the addition of secondary casings, with enclosures used only where operational or maintenance access will be negligable. Detailed consideration must be given to improvements in vibration isolation. The prime objectives in employing these methods are that operational and maintenance practices should not be disrupted and that the detailed methods used may be more easily introduced progressively into original equipment design. On particular parts of the plant it can already be seen that small changes in mechanical design may provide some improvement; the practices described above of course will enable the significance of these changes to be objectively assessed.

Bulk noise control may be suitable for some ancillary plant in "factory type" installations but in the power industry personnel are only present to operate and maintain the plant and for these functions close access is required. An analogy may be that the power station worker is located under the bonnet of a car, the bonnet being the power station building.

Having declared a policy for noise control of course we have to depart from it in the short term to meet the immediate requirements for near field noise levels and we are actively dealing with the near field noise level from much of our secondary plant by screening and partial enclosure. This practice may continue for some time since the acoustic power radiated from this type of plant is small. Also much of the secondary plant does not require close access and where it does remote indication is a simpler proposition.

Research projects are being undertaken to look in detail at noise from primary plant and its sub-sources by careful narrow band analysis of existing data. Consideration is also being given to the use of measuring techniques employing local noise excluding chambers with controlled internal propagation characteristics.

The policy described of course means that the work to be undertaken will require very close co-operation with the turbo-generator and power station design engineers. If notice is to be taken of our recommendation for any basic plant modifications the case has to be very well supported by technical evidence considered in relation to the overall plant noise emission. All of this will mean much hard and labourious work.