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TARGET-MODERATOR-REFLECTOR SYSTEMS: COMPONENTS

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The presentations in these two sessions combined to give a varied programme covering several aspects of target station design. These included a new concept for a long pulse spallation source target station (F. Mezei), detailed work on moderator performance, both by experiment (N. Watanabe and Y. Kiyanagi) and Monte Carlo Simulation (G. Russell), a new approach for engineering solid methane moderators (T. Lucas), the cryogenic cooling system design for the ESS hydrogen moderators (K. Stendal) and the practical realisation for handling target station components constructed at SINQ (W. Wagner).

It is relatively rare for reactor engineers and physicists to address the problems of designing a spallation source. It was thus particularly welcome that the concept presented for a long pulse spallation target station arose from a deliberate collaboration with the reactor community. Starting with a typical large D2O tank which acted as moderator reflector and coolant the design incorporated rotating targets and small moderators in flux trap geometry to give a source capable of operating at high power with the prospect of high neutron fluxes. As shown in the presentation of coupled moderator neutronic calculations the incorporation of additional reflector components would then allow the pulse shape and intensity to be optimised.

The experimental work using the electron linac at Hokkaido university is aimed at developing high efficiency cryogenic moderators for spallation sources. The programme includes the study of the three classes of moderator those designed to produce the highest possible intensity beams of cold neutrons (regardless of pulse width), those for narrow neutron pulses with highest possible peak intensity and moderators cooled to extend the slowing down region to low energies. The experimental arrangement utilises an electron beam directed into a lead target as the primary neutron production mechanism. The performance of a wide variety of moderator assemblies in a graphite reflector has been studied by measuring both the intensity and pulse shape of the produced neutron beams at different wavelengths. In particular the work focuses on the effects of different arrangements of water premoderators, beam hole geometry in the reflector, decouplers and poisons. Detailed measurements showed that by a suitable choice of premoderator configuration combined with poisoning or decoupling the premoderator it is possible to get significant gains in intensity without sacrificing a good pulse shape. The coupled moderator studies measured the effects on intensity of different beam extraction geometries and the effect of adding a cooled beryllium reflector/filter. This is a unique experimental programme which is providing invaluable data for the spallation source community. It would be very desirable for the results to be used as benchmark data for the Monte Carlo simulation codes.

The Monte Carlo calculations presented were directed towards an understanding of the performance of coupled moderators on a long pulse spallation source. The effects on the pulse shape and intensity of reflector geometry and material and ortho to para hydrogen fraction were discussed. Of particular interest was way in which peak intensity and brightness could be adjusted by a suitable choice of geometry and material taking into account their effect on the decay time of the pulse. Also the calculations showed the gains possible by taking advantage of the spatial variation of flux across the moderator face. The calculations demonstrated the value to the moderator designer of the huge increase in computer power now available in modern workstations. Calculations to examine subtle effects (~ few per cent changes in intensity) which were not practical a few years ago are now a routine activity. The challenge remains to demonstrate the ability of the calculations to simulate the detail becoming available in the experimental data.

It is accepted that the best material for a cold moderator is solid methane. Operational experience, has shown that radiation damage to the methane is a formidable operational problem. The concept presented may allow the possibility of high power operation. The basic idea is to form the methane as solid pellets in a flow of liquid hydrogen which serves as the coolant. The pellets are formed in a continuous stream and removed after passage through the moderator volume. The solid methane is melted, purified and returned to the pellet source. There is a need for a detailed research and development programme to investigate this idea and solve the engineering problems which should not be underestimated. However, the prospect of solid methane as a high power cold moderator material is most exciting.

Use of liquid, or supercritical, hydrogen is the more conventional approach to providing cold moderators. The supply system required for the proposed ESS moderators was presented. The design was fully detailed and the options of a siphon system or a pumped loop considered. Layout considerations strongly favoured the latter approach. The scale of the systems for supplying 15 kW of cooling to each target station at 25 K and their complexity was clearly demonstrated including large compressor buildings, joint boxes and supplementary cooling to allow the source to run even if there were problems with the cryogenic plant.

In arriving at a practical operational design for a target station a vital consideration is the ability to insert and remove complex equipment on the target station especially when activated. The equipment design for this purpose for SINQ was presented. This included the equipment designed to handle moderator inserts, guide bundles and standard beam tubes. The equipment described (and seen operating in the tour of SINQ during the meeting) has to move tonnes of shielding with great precision and allow remote connection of services and flanges. The presentation clearly demonstrated the considerable technical challenge and high quality detailed mechanical engineering required to for this activity.