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Present Status of KENS

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The KENS pulsed neutron source was firstly constructed in 1980 with both of the thermal neutron moderator (H2O moderator at 300K) and the cold neutron moderator (solid methane moderator at 20 K). Since 1980, it has been operated with a 20 Hz-proton beam of 500 MeV and 2-6 μA. In 1998, absolute measurements of the neutron fluxes were made at various neutron beam lines by a gold foil activation method as well as a fission detector. It suggested that the sub-cadmium neutron flux of the cold neutron moderator was about 30% of the nominal design value although the epi-thermal neutron fluxes (E > 0.5 eV; cadmium cut-off energy) were nearly equal to the nominal value. It had been considered that the flux reduction below 0.5 eV was caused by a part of cadmium-liner in the neutron beam line. In November and December in 1998, by the direct inspection, the swelling of the cadmium-liner was found in the neutron beam line. We seriously discussed several methods to repair the liner. Since it was very difficult to repair the liner under the high radiation level and possible hazards due to chemical poisoning of beryllium compounds, we decided to replace the whole target-moderator-reflector assembly (TMRA) by a fully new one. In order to obtain better neutronic performances, such as the source intensity, the pulse width of thermal neutron beam while saving on the fabrication cost, so much neutronic calculations were performed by using the Monte Carlo radiation transport code system LCS-2.7 developed at LANL. Proton and higher energy neutron behaviors were calculated with the LAHET code. The neutron behavior below 20 MeV was calculated with the HMCNP code modified from the MCNP/4A code and with the neutron cross sections based on the ENDF/B-V. Based on the calculation results, a composite reflector with graphite and beryllium was proposed, which makes it possible to recover the cold-neutron source intensity within 90% of the nominal value of the old KENS (the reflector in the old KENS was made of beryllium) and to save the fabrication cost. The total amount of beryllium in the new KENS was only 34.8 kg (about 200 kg in the old KENS).

A 0.3 mm-thick gadolinium-plate was put in the center plane of the ambient-temperature moderator, in order to make a thermal neutron pulse sharper in the energy region below 100 meV. The new KENS can give a faster decay of the pulse and a smaller FWHM than the old KENS. 0.5 mm cadmium plates were adopted as the de-coupler in the cold moderator, and the

B_4C de-coupler plates were used for the thermal neutron moderator. The de-coupling energy was determined taking into account the neutron pulse shape over a wide energy range from 10 meV - 10 eV. Finally, the de-coupling energy was determined to be 100 eV for the B_4C de-coupler plates between the ambient moderator and the target, and 50 eV for B_4C de-coupler plates in the other parts. These values are fairly smaller than those of the old KENS (488 eV and 95 eV, respectively). Furthermore, the tantalum-clad tungsten target was successfully fabricated by the HIP method and installed instead of the old tantalum target. This can increase the neutron intensity by about 20 %.

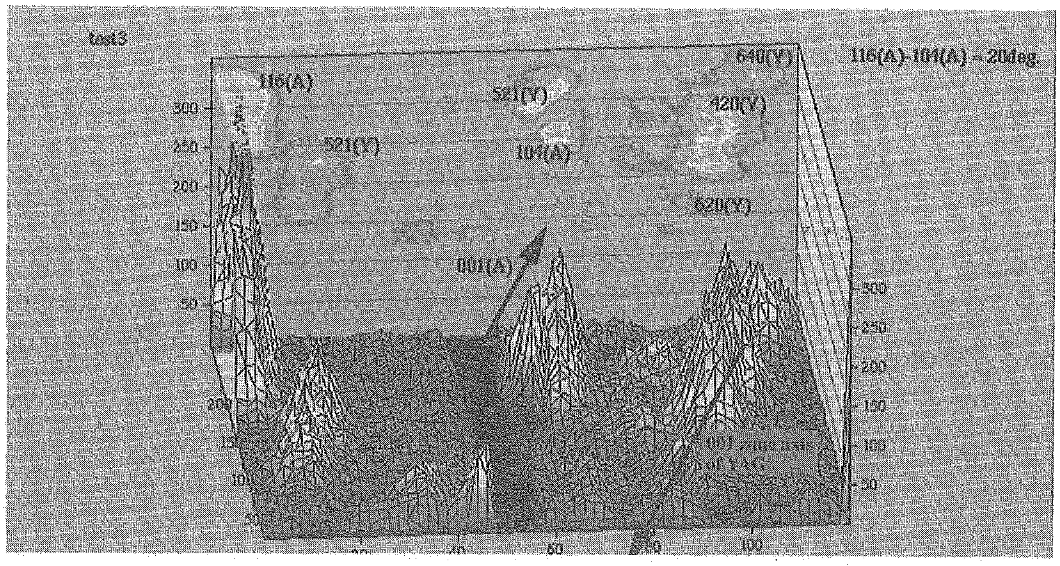
The actual replacement of the TMRA has been made during August 31 to September 21. The neutron pulse beams from the new TMRA were ejected on November 1, 2000. Just after November 1, the neutron spectra of the thermal and the cold neutron beams were measured. The measured spectra well agreed with those calculated values, and it was confirmed that the KENS cold source was perfectly recovered by this renewal. The performance of the thermal moderator was prominently improved by using gadolinium poisoning, which provided a higher peak intensity and sharper pulse beam. In the 21st century, we will construct new MW-class pulsed neutron sources. In these design works, the neutronic calculation codes are indispensable. The KENS-renewal works indicates how accurate those codes are in the actual system. From this point of view, the works in KENS was very important.

The primary flight path of the chopper spectrometer (INC) in KENS is 8.2 m, and the secondary path is 2.5 m for low angles and 1.3 m for high angles. A guide tube with NiC/Ti-super-mirrors was recently installed in the primary flight path. The guide tube is a straight guide with a cross section of 8 cm x 8 cm and a length of 4 m, and located between the shutter and the Fermi chopper. In the wave-number (Q) dependence of the neutron reflectivity from the super-mirror used in the present assembling, the reflectivity shows more than 90% at Q = 0.063Å^{-1} near to the critical point. We assembled super-mirror pieces with a typical coating area of 8 cm x 20 cm (thickness of glass is 2 mm or 5 mm) into a guide tube with a square cross section. The tolerance of the glass substrate was ± 0.05 mm, and the SUS frames were manufactured with a typical tolerance of ± 0.05 mm or ± 0.1 mm. Consequently, the super-mirrors were assembled into a guide tube with a parallelism of ± 0.7 mrad between the right and left mirrors and ± 0.4 mrad between the upper and lower mirrors in a SUS frame section of 40 cm with respect to the neutron beam line. We also performed a Monte-Carlo calculation to evaluate the intensity gain for installing the guide tube. It indicated that the guide tube is effective at neutron energies less than approximately 80 meV, a gain factor of 3 can be expected at 20 meV and of 6 at 10 meV. The actual installation has been done in the summer, 2000, in the same period of the KENS source renewal. The performance of INC was drastically improved. A huge intensity gain at low energies due to installing the super-mirror guide tube and a gain of factor 2 at high energies due to changing the characteristics of the neutron source were observed without any increase in the background noise. The observed gain of the guide tube was in very good agreement with a calculation. This, for the first time, demonstrated the effectiveness of a super-mirror guide tube for higher energy neutrons than cold neutrons for which a guide tube has been known to be effective. Moreover, the poisoning of the ambient-temperature H_2O moderator provided INC more symmetric energy resolution function as well as an increase in the peak intensity in the TOF spectra. The present construction resulted in a great improvement concerning all aspects of the performance.

A new neutron reflectometer (ARISA) with vertical scattering-plane geometry for studying free surface was installed at a thermal neutron port viewing an ambient-temperature water moderator at KENS. ARISA is a unique reflectomer using thermal neutrons at a pulsed spallation neutron source as well as the first neutron reflectometer with vertical scattering-plane geometry in Japan. An inner iron collimator with two beam holes and a neutron beam-line shield were installed to minimize high-energy neutrons directly coming from the neutron-target due to the shield loss produced by beam holes themselves. The inner collimator makes two independent downward beam holes with different angles, 0° - 0.47° and 1.4°. The neutron beam-line shield has function of an additional beam-shutter as well. The designed specifications for the covered range of neutron momentum transfer, q_z, in the vertical direction are 0.008 $Å^{-1}$ - 0.61 $Å^{-1}$ and 0.008 $Å^{-1}$ - 2.8 $Å^{-1}$ for liquid and solid samples, respectively, using the neutrons with 0.5 Å – 4 Å wavelengths.

On Oct 2, 2000, Memorandum of Understanding for the KENS/IPNS Collaboration was assigned, with the spirit modeled by the previous agreement of KENS/ISIS (1996) and KENS/Lujan Center (1998). We expect to realize international collaboration between KENS and IPNS on four areas: neutron moderator/target system, instrumentation/devices, and software development and sciences. Those are keys of the MW-class pulsed neutron source facility which US and Japan will realize at the beginning of the 21st century.

On KENS existing instruments, several developments and useful trials were done. One of those is a residual stress measurement with TOF method. Residual stresses are responsible for unexpected destruction of structures due to fatigue failures or stress corrosion cracking. In industries such as nuclear reactors and aerospaces, failures of components are unacceptable. In these cases finite element calculation has been utilized widely, but the reliability of the calculations cannot be examined easily by direct measurements of stress distribution deep within the components. Neutrons evidently penetrate deep into the components, and then have the potential for a major break through in this field when a next-generation pulsed source are realized. However, only several pulsed instruments for this purpose currently exist world-wide. Therefore, basic studies on TOF strain diffractometers for various kind of applications are indispensable for designing strain diffractometers in the future project. In this study, neutron residual strain measurements were carried out in the unidirectionally solidified $Al_2O_3/Y_3Al_5O_{12}$(YAG) composites (See figure). Polycrystal Al_2O_3, polycrystal YAG and polycrystal Al_2O_3/YAG were also measured for a comparison. The neutron diffraction data were collected with a high resolution diffractometer *Sirius* at the neutron science laboratory (KENS) in the high energy accelerator research organization (KEK). As a result of the comparison of the diffraction peak, YAG phase in the composite Al_2O_3/YAG was compressional state while Al_2O_3 phase in tensile state.



TOF data for each pixel are also stored. From this data together with TOF data, orientation relation of the two phases and strains of both phases are precisely determined.

The KENS has delivered 500 MeV protons to the Neutron Science Laboratory and Meson Science Laboratory as well as to the Proton Medical Research Center (University of Tsukuba). However, at July , 2000, the proton Medical Research Center in KEK was shut down because the center had already constructed the dedicated accelerator inside of the University. The total operation time in FY1999 was about 5500 hours. Figure shows the history of the average beam intensity delivered to the neutron and meson experiments.