Testing and evaluation of velocity selector control system of small angle neutron scattering spectrometer

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Abstract. Testing and evaluation of velocity selector control system of small angle neutron scattering (SANS) spectrometer has been done. It applied a unit of speed control variable AC, Optidrive Invertek Drives. This system is designed to be manually controlled and computerized. To control the Optidrive in manual mode, it can be done by keypad on the unit. The Optidrives can be controlled using computer by connecting the unit into a computer via USB port and OptiTools Studio software. Optidrive Invertek Drives need alternative current (AC) voltage one phase 220 volt with three phase out 220 volt. This out voltage is used as voltage source for moving the motor of disk in SANS neutron velocity selector. The speed of the disk in SANS neutron velocity selector is changed by adjusting the frequency from the Optidrive Invertek Drives. The numbers of speed of the disk determine the neutron wavelength passed through SANS neutron velocity selector. It is observed that every increasing frequency of 1 Hz, it will increase the disk speed by 59.929 rpm. The calibration that has been done for this system using silver behenate, obtain wavelength of the neutrons dependent to the disk speed. They are 3.10, 3.09, 3.41, 3.76, 4.23, 4.71, and 5.39 Å for disk speed 6500, 6000, 5500, 5000, 4500, 4000, and 3500 rpm respectively.

1. Introduction
The Center for Science and Technology of Advanced Materials (PSTBM) BATAN has mission on doing research and development in science of nuclear industry and advanced materials based on nuclear technology. The other top mission of PSTBM BATAN is to do research and development in utilization of neutron beam technology [1]. In order to reach its mission, PSTBM BATAN manages Neutron Scattering Laboratory with 8 instrument based neutron beam technology. Small angle neutron scattering spectrometer (SANS) is one of the instruments for characterizing the advanced materials in nano scale [2].

SANS uses a neutron velocity selector (NVS) as its neutron monochromator. The NVS of SANS BATAN is a multidisc rotor type from Mirrotron [3]. The SANS BATAN has been commissioned since 1992. For these almost three decades, the NVS of SANS BATAN has good performance until last year the NVS control system was broken. The reparation of the NVS control system needs a replacement with other control system type.

Optidrive Invertek is a drive which can move motor and be controlled by computer. This drive is used to replace the old NVS control system. The aim of this work is to test and evaluate the Optidrive Invertek as NVS control system.
2. Materials and methods

2.1. Instrumentations

Optidrive Invertek Driver is connected to computer via USB port. This drive is controlled by OptiTools Studio software, which adjusting the frequency to move the disk motor of the NVS. The dist speed is determined by tachometer.

2.2. Materials

Silver behenate is applied to test and evaluate of the Optidrive Invertek drive performance. Silver behenate [CH$_3$(CH$_2$)$_2$COOAg] is surfactant powder which has been known for calibrating small angle scattering instrument. Silver behenate is silver salt with long hydrocarbon chain. In powder, silver behenate has lamellar structure with lattice d$_{001}$=58,378 Å [4]. Silver behenate is purchased from Alfa Aesar, Johnson Matthey Company [5].

2.3. Test and evaluation

Silver behenate was placed in the aluminium cell. An empty aluminium cell was used as the background. The detector of SANS was set at 1.5 m from the sample. The collimation is set at 4m with pinhole configuration is 000654. The disk speed of NVS is varied as 3500, 4000, 4500, 5000, 5500, 6000 and 6500 rpm. The silver behenate is exposed by neutron beam for about 6 hours for each disk speed variation. The wavelength assumption for this test is 3.9 Å for all variations.

3. Result and discussion

Initial parameter, determined by Optidrive Invertek drives, is electrical frequency. The value of the electrical frequency, sent from the Optidrive Invertek to NVS, is correlated to the disk speed of the NVS. Therefore, to adjust the disk speed of the NVS, the correlation of the frequency to the disk speed should be characterized. The characterization is conducted by varying the frequency with 0.1 Hz interval. For each frequency, the disk speed of the NVS is observed. The electrical scheme of this system was describe in figure 1. Meanwhile the display of the OptiTools Studio is showed in figure 2.

![Figure 1](image1.png)

**Figure 1.** Scheme of the connection of OptiDrive Invertek with the computer and neutron velocity selector.
The result of the correlation between the frequencies with the disk speed is shown in figure 3. It is obtained that the correlation between them is perfectly linear. This result gives a confirmation that the Optidrive Invertek drives has good performance.
The result of the evaluation of the performance of Optidrive Invertek drives uses silver behenate are showed in figure 4. The first peak seems to be shifted to the low q as the disk speed increase. This shifting of the first peak position due to the first assumption of wavelength is determined to be 3.9 Å for all disk speed variation.

In small angle scattering, as it is elastic scattering, the momentum transfer will be \( q = (4\pi \sin \theta / \lambda) \) [6]. Determining the assumption of wavelength, the first peak of silver behenate will appear in a certain \( q \) (q assumption). The lamellar structure of the powder silver will appear as an order peaks, with the first peak at \( q = 0.1086\text{Å}^{-1} \) (q real) for \( d_{001} \) of silver behenate.

![Graphs showing the effect of disk speed on the first peak of silver behenate](image)

- Disk speed MVS = 3500 RPM
- Disk speed MVS = 4000 RPM
- Disk speed MVS = 4500 RPM
- Disk speed MVS = 5000 RPM
- Disk speed MVS = 5500 RPM
- Disk speed MVS = 6000 RPM
Since $4\pi \sin \theta$, in this case is a constant value, the relation between the momentum transfer and wavelength assumption with momentum transfer and wavelength real will be

$$q_1 \lambda_1 = q_2 \lambda_2$$

where $q_1$ and $\lambda_1$ are momentum transfer and neutron wavelength assumption, meanwhile $q_2$ and $\lambda_2$ are momentum transfer and neutron real, respectively.

Varying the speed disk and calculate the momentum transfer of the first peak, it is now can be determined the real wavelength pass through NVS. The result is showed in table 1.

**Table 1.** The real wavelength related to the disk speed.

| Disk speed (rpm) | $\lambda$ (Å) |
|------------------|---------------|
| 3500             | 5.39          |
| 4000             | 4.71          |
| 4500             | 4.23          |
| 5000             | 3.76          |
| 5500             | 3.41          |
| 6000             | 3.09          |
| 6500             | 3.10          |

The correlation between wavelength and disk speed, moved by Optidrive Invertek drives, have similar value to the previous system. It is indicated that the Optidrive Invertek drives has good performance to move the disk motor of the NVS as monochromator in SANS instrument.

**4. Conclusion**

The replacement of NVS control system in SANS BATAN with Optidrive Invertek drives has shown a good performance. The testing and evaluation, using silver behenate in many disk speeds, obtain similar result to the previous control system. The linearity of the correlation of frequency and disk speed ensure the stability of the performance of this NVS control system.

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