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***Short Communication***

# Establishing correlations between different spindle and rpm for viscosity determination

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## Abstract

*A non-Newtonian fluid is one that does not obey Newton's law of viscosity. Determination of viscosity of pharmaceutical formulation like cream, paste, gel, lotion, highly viscous formulation is very important evaluation parameter. Ostwald's viscometer could not be used for those liquids or material which shows non Newtonian flow. Viscosity of these material can be determine by Rotational viscometer. The aim of this study was to check the viscosity with different spindle no. and rpm and check their correlation. In study viscous glycerine and different spindle no 2, 3 and 4 were used. Results of viscosity in mPa.s were found to be 1392±8 (6 rpm), 978±4 (12 rpm), 760±9 (30 rpm), 539±6 (60 rpm) for spindle II, 3767±13 (6 rpm), 2332±18 (12 rpm), 1445±13 (30 rpm), 900±14 (60 rpm) for spindle III, and 17210±13 (6 rpm), 9659±19 (12 rpm), 4833±14 (30 rpm), 4080±12 (60 rpm) for spindle IV. A result shown that viscosity is also not only depends on type of spindle no. which is used for study but also rpm of spindle. So selection spindle no and rpm are crucial step during viscosity study.*

**Keywords:** Brookefield's viscometer, Rheology, Torque, Viscosity.

## Introduction

Liquids and fluids possess flow properties termed rheology. Viscosity is the essential factor that describes the flow property of liquid and is related to the resistance offered by the particles to maintain the flow of liquid. In simple words, viscosity is defined as the resistance offered to the flow or movement of liquid[1]. Viscosity is the resistance of fluid that is provided by internal friction between layers. Attractive forces between the molecules of fluid responsible for internal friction. Therefore, the fluid process moves faster than the adjacent slower process. Therefore the average molecular velocity of fast moving process decreases due to the presence of adjacent slow moving process.

Therefore, intermolecular cohesion increases the viscosity of the liquid. Torque is a measure of the force that can rotate an object about an axis. Forces are what cause objects to accelerate in linear kinematics. The axis around which an object rotates is called the axis of rotation. But in gases, this is due to the diffusion of gas molecules. Newton reported viscosity as a quantitative study by calculating the relation between the rate of flow ($\gamma$) and applied stress ($\sigma$). According to Newton, on increasing applied stress over liquid, the flow rate also increases and vice versa. Hence, they are directly proportional to each other[2].

The rate of shear can be defined as the derivative of velocity related to the distance moved in the direction of flow and can be related to the difference in shear-strain ratio towards the direction of flow[3]. Rotational viscometer is the instrument used to measure the flow properties of liquids having simple shearing motion[4]. Motion is related to the friction force between two infinite parallel layers of a liquid system. In this system, one layer or plate is kept constant whereas another plate remains in constant movement over the first layer[5]. In the present study we have studied how the viscosity of liquid change with change of rpm and spindle no. Also in study correlation was established between rpm and spindle no.

**Factors Affecting Viscosity[6-8]:** There are number of factors on which viscosity is depends.

**Effect of temperature:** The viscosity of the liquid id inversely proportional to temperature, as temperature of fluids is increases viscosity of fluid is decreases. It is due to decrease in cohesiveness of molecules due to increasing of kinetic energy when temperature is increases.

**Effect of pressure:** The viscosity of liquids also depends on pressure. Except water as the pressure increases the viscosity also increases. While viscosity is partially independent on pressure in case of gases. But viscosity of water is decrease when we increase the pressure.

**Effect of density:** Density of liquid may affect the viscosity of liquid. The viscosity of liquid will increase rapidly with increasing the density. Viscous (i.e. highly dense) liquids such as glycerine, honey and coal tar have a higher viscosity compared to lower viscous liquid (low dense).

## Materials and methods

Rotational viscometer (Model No. LMDV 60), beaker, sample (glycerine).


**Figure-1:** Rotational viscometer (Model No. LMDV 60).

**Methods:** Brookfield type Rotational viscometer Model No. LMDV 60 (Figure-1) was used for the determination of viscosity. All the parameters needed for viscosity determination were set in the viscometer screen by selecting the required parameter. A sufficient sample whose viscosity is to be measured is poured into the beaker up to the dipping mark of the Spindle. The viscosity of the given sample was measured using different spindle numbers and different rpm. Temperature for all experiments was maintained at constant (26.8$^{o}$C)[9]. All the experiments were repeated for three times.

## Results and discussion

The viscosity of any liquid depends on the type of spindle (spindle number) used and the rpm of the spindle. Results shown for the same sample value of viscosity changed when either spindle number or rpm changed at a constant temperature. In table number 1 values of viscosity at different rpm are given when spindle number 2 was used likewise in Table-2 and 3 spindle numbers 3 and 4 were used respectively and values were observed at different rpm. Table-4 shows the comparative study of viscosity at different rpm concerning different spindle no. Figure-2, 3, and 4 shows the graphical representation speed of the different spindle and the value of viscosity. In all observations as the rpm increased value of viscosity as well as % torque was increased.

**Table-1:** Effect of rpm on spindle No. 2.

| rpm | Viscosity (mPa.s) | % Torque (dyn.cm) |
|---|---|---|
| 6 | 1392±8 | 27.9±0.7 |
| 12 | 978±4 | 39.2±0.4 |
| 30 | 760±9 | 76.0±0.5 |
| 60 | 539±6 | 107±0.8 |

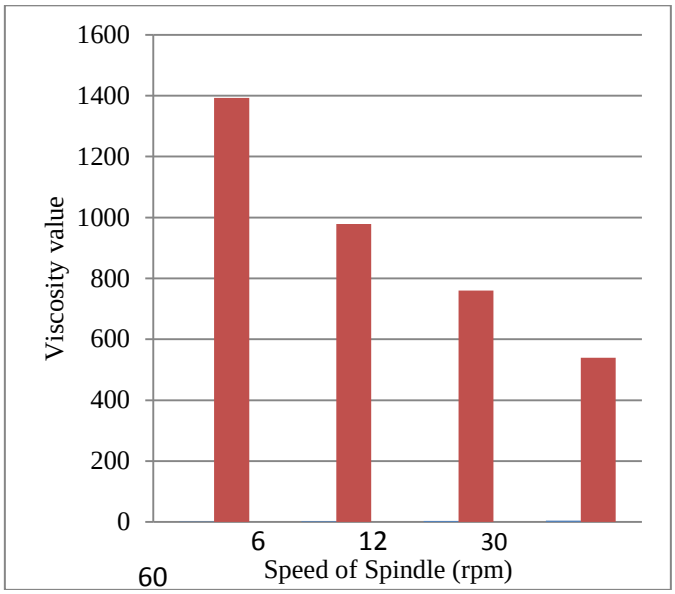


**Figure-2:** Bar graph representation of the speed of spindle (no. 2) and viscosity.

**Table-2:** Effect of rpm on spindle no. 3.

| rpm | Viscosity (mPa.s) | % Torque (dyn.cm) |
|---|---|---|
| 6 | 3767±13 | 18.8±0.6 |
| 12 | 2332±18 | 23.3±0.4 |
| 30 | 1445±13 | 36.5±0.3 |
| 60 | 900±14 | 45.0±0.5 |

**Table-3:** Affect of rpm on spindle no. 4.

| rpm | Viscosity (mPa.s) | % Torque (dyn.cm) |
|---|---|---|
| 6 | 17210±13 | 17.2±0.4 |
| 12 | 9659±19 | 19.3±0.5 |
| 30 | 4833±14 | 24.2±0.9 |
| 60 | 4080±12 | 40.8±0.4 |

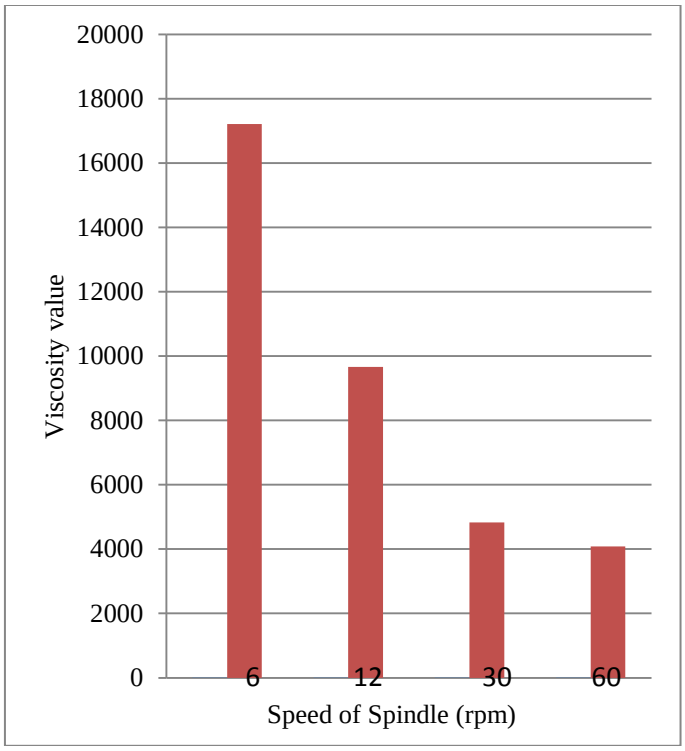


**Figure-3:** Bar graph representation of speed of spindle (no. 3) and viscosity.

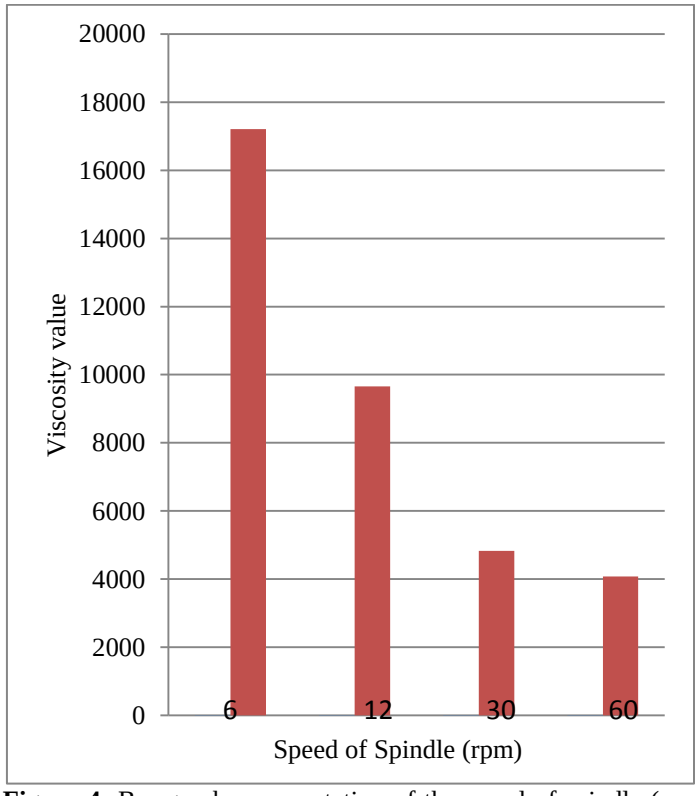


**Figure-4:** Bar graph representation of the speed of spindle (no. 4) and viscosity.

**Table-4:** Comparative study of viscosity at different rpm concerning different spindle no.

| Spindle No. | Viscosity (mPa.s) | | | |
|---|---|---|---|---|
| | 6 rpm | 12 rpm | 30rpm | 60rpm |
| II | 1392±8 | 978±4 | 760±9 | 539±6 |
| III | 3767±13 | 2332±18 | 1445±13 | 900±14 |
| IV | 17210±13 | 9659±19 | 4833±14 | 4080±12 |

## Conclusion

The selection of a spindle for the determination of viscosity is a very crucial aspect during the study of the rheology of liquid. It may be also depends on the spindle no. and speed of the spindle. The researcher should use the same spindle for the determination of the viscosity of the standard and test samples. The temperature should always maintain constant during the study.

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