Exam Date & Time: 09-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

MIT MPL and BLR - BTech I-III-V and VII Semester - End Semester Examination - Nov-Dec 2023

NON-NEWTONIAN FLOW IN THE PROCESS INDUSTRIES [CHE 4067]

Marks: 50 **Duration: 180 mins.**

Descriptive

Answer all the questions. Section Duration: 180 mins

* Answer all questions.
* Assume the missing data suitably.
* Write neatly and legibly.
* Give suitable examples wherever necessary.

1) Distinguish the different mathematical models used to represent the shear thickening fluid behaviour and their limitations (4)

2) Compare the concentric cylinder rheometer with parallel plate rheometer. (3)

3) Show that $(\tau_r/\tau_w) = (r/R)$ for circular pipe whose radius is R with assumptions (3)

4) Solve for flow behavior index of given non-Newtonian fluid where the shear stress vs shear rate data provided below. Assume the Yield shear stress is 43 Pa and flow consistency coefficient is 19.5 Pa s^n (5)

$\gamma(s^{-1})$	0.28	0.37	0.692	0.944	1.29	1.582	2.17	2.43
τ(Pa)	51.94	53.46	59.02	61.93	65.48	68.07	73.6	75.85

5) Explain the following flow regimes: disperse flow, slug flow with neat diagrams (3)

6) Bingham plastic fluid is flowing in 51.4 mm ID pipe with 0.15 m/s velocity with a density of 1030 kg/m^3 with a Reynolds number of 1300 & Headstrom number is 450000. Calculate the yield shear stress of Bingham fluid (2)

7) Examine the Ellis fluid model data of shear stress and rate of strain data obtained from an experiment and calculate Ellis fluid model parameter 'alpha'. Assume zero viscosity is 0.79 Pa.s and Tow 1/2 =20.3 Pa. (5)

$\gamma(s^{-1})$	5.57	7.02	8.83	14	17.62	22.2	27.9	35.2
τ(Pa)	3.79	4.6	5.55	8.11	9.65	11.5	13.5	16.05

8) Bingham plastic fluid is flowing in a pipe with velocity 0.15 m/s. The ID of pipe is 19 mm, fluid viscosity is 2 cP, density is 1200 kg/m^3 respectively. At particular shear stress of 100 Pa, the rate of shear is 9500 s^{-1}. What is the Headstrom number of this fluid. (2)

9) The rheological properties of a non-Newtonian fluid is approximated with power law model with a shear rate range of 20 to 180 s^{-1} with shear stress range of 30 and 220 Pa. Estimate the pressure drop where the fluid flow in a 50 mm diameter pipe with 250 m long when the centreline/ maximum velocity is 0.25 m/s (3)

10) Compare the average and superficial velocity of gas in gas-liquid flow (2)

11) A power fluid is flowing in between two parallel plates with flow behaviour index of 0.8 and fluid consistency index is 3 Pa.s^n. The two parallel plates are 10 mm apart, 10 cm width and a length of 100 m. Evaluate the pressure drop offered by these parallel plates when the flow rate is 300 liters/min and Calculate the maximum velocity with this flow rate. (4)

12) Non-Newtonian fluid is flowing down a wide inclined surface (The angle between the inclined surface and vertical wall is 15^0). The rheological properties of fluid are m=3 Pa.s^n, n=0.8 and density is 1050 kg/m^3. Calculate the film thickness if the film is moving with a maximum velocity of 0.01 m/s. Tabulate the v_z / $V_{z,max}$ vs y/H (0 to 1 range). (4)

13) Calculate the Reynolds number of the non-Newtonian fluid, flows in circular pipe with an internal diameter of 20 mm. The maximum velocity at center line is 1.2 m/s and the solution density is 1010 Kg/m^3. The consistency index and flow behavior index are 2 Pa s^n and 0.7. Calculate the maximum velocity with same Reynolds number if the fluid behaves as Newtonian fluid (3)

14) Compare the holdup of gas and liquid where volumetric flow rates of gas and liquid are 1:2 ratio flowing in a circular pipe. (2)

15) Air is injected into a horizontal pipe of 25.7 mm internal diameter carrying a non-Newtonian fluid of density 1300 kg/m^3. The rheological properties of fluid are m=4 Pa.s^n and n=0.9. The velocity of air and liquid are 0.5 and 0.35 m/s respectively. The air is introduced in the pipe with density of 1.4 kg/m^3 and viscosity of 1.8x10-5 Pa.s. The correction factor" J=0.575". Estimate the two-phase flow pressure drop in the pipe. (5)

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