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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

MAKEUP EXAMINATION – JAN 2023

Course Code: PET 228
Course Name: Workover and Stimulation
Program: B.Tech (PET)

Date: 27-JAN-2023
Time: 9.30 AM to 12.30 PM
Max Marks: 100
Weightage: 50%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Question paper consist of three parts, PART A, B & C
(iii) All questions are mandatory

Part A [Memory Recall Questions]

Answer the Question. Each question carries thirty marks. (1Qx 30M= 30M)

1. Answer the following question *[Each question carry 3 marks]*

I. Match the following

A. Control reservoir fluid	1. Packer
B. Tubing long life	2. Choke
C. Artificial lift	3. Blast Joint
D. Flow control	4. Expansion Joint
E. Casing tubing isolation	5. Side Pocket Mandrel
F. Tubing string movement	6. Liner

II. Find the correct statements

(a) Treatment size is primarily defined by the fracture height

(b) To simulate a short fracture to be created in a thick sandstone, the KGD model may be beneficial

(c) An appropriate fracture propagation model is selected for the formation characteristics and pressure behavior on the basis of in situ stresses and laboratory tests

(d) The maximum treatment pressure is expected to occur when the formation is broken down

(e) FCD value of 10 is required to ensure that the well inflow is not being limited by the fracture conductivity

III. Write any two advantage and one disadvantage of liner completion.

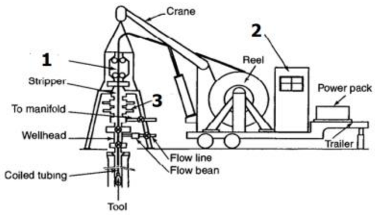
IV. What preflush is injected prior to injection of HF+HCl in clastic reservoir? How much volume of preflux is injected? Why HCl+HF is called Mud Acid?

V. Compared to wireline and slick line write three benefits of using Coiled Tubing.

VI. Mention any three application of Coil Tubing.

VII. __________type of completion can provide large wellbore radius, large wellbore radius improves Productivity Index and Inflow Performance whereas ______type completion can provide multi-zonal completion. However _____type of completion can lead to logging complications.

VIII. Identify 1, 2 & 3 from the diagram.



IX. Statement: Cased Hole Completion (CHC) can lead to reduction of productivity of the well

Assumption I: CHC lead to reduction of effective wellbore diameter

Assumption II: During CHC formation may damage

Assumption III: Long interval perforation is expensive

(a) Only Assumption I follows

(b) Both Assumptions I & III follow

(c) Both Assumptions I & II follow

(d) Assumption I, II & III follow

(e) Only Assumption II follows

(f) None of the Above

X. Write any one function of the following subsurface equipments (a) BLAST JOINT (b) SSSV (c) PUMP OUT PLUG (C.O.No. 1, 2, 3, 4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries ten marks. (4Qx10M=40M)

2. Well stimulation is a well intervention performed on an oil or gas well to increase production by improving the flow of hydrocarbons from the reservoir into the well bore. Hydro-fracturing and Matrix stimulation are two most favored method. With steady state, radial-flow equation show how these two method contribute to improve well productivity. (C.O.No. 2)[Comprehension]

3. Do as directed, (C.O.No. 3)[Comprehension]

(i) “TAML 2 and TAML 4 are two almost similar type of well TAML completion technique”-Write any two similarity between these two.

(ii) “The Inflow Performance of a Fracture Stimulated well is controlled by the dimensionless Fracture Conductivity”-Discuss in two points

(iii) “A completion design in which the reservoir fluids are produced through small-diameter casing is called Tubing Less completion”- Mention any two advantage of Tubing less cased hole completion.

(iv) “Consist of stripper (components with sealing elements) that provides a seal in dynamic phases (tubing being run in or pull out) and a stack of BOP”-What are the different type of BOPs available in CT unit.

(v) “Flow coupling are made to coupling OD (Outside Diameter) and Tubing ID (Internal Dia)”-Where do we install a flow coupling and what purpose it served?

4. In petroleum and natural gas extraction, a Christmas tree, or "tree", is an assembly of valves, casing spools, and fittings used to regulate the flow of pipes in an oil well, gas well, water injection well, water disposal well, gas injection well, condensate well, and other types of well. Draw a neat and clean block diagram of Christmas tree, label all its components. Also mention at least one function of each component.
(C.O.No. 1)[Comprehension]

5. “POTENTIAL FORMATION DAMAGE CAUSED BY MATRIX STIMULATION FLUIDS”-Justify the quoted sentence with five relevant points. (C.O.No. 4)[Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each question carries thirty marks. (1Qx30M=30M)

6. The need for well stimulation arises from either one of the following conditions: Formation permeability is inadequate to allow the well to produce at rates high enough for the timely recovery of investment in drilling and completing the well or the well has been completed in a formation having adequate permeability, but the formation near the wellbore has been damaged by the drilling or completion process. In the Fig 1, **Formation A represents** Sandstone with Porosity and Permeability 20% and 50 mD respectively. Pore pressure gradient 0.25 Psi/ft., **Formation B** represents Carbonate with Porosity and Permeability 15% and 36 mD respectively. Pore pressure gradient 0.28 Psi/ft., **Formation C** represents Shale with Porosity and Permeability 15% and 36 mD respectively. Pore pressure gradient 0.28 Psi/ft. Let’s assume Formation A, B & C depleted after 1 year, 1.5 year and 3 year respective. Now design a stimulation job for all three formation considering the following parameters,

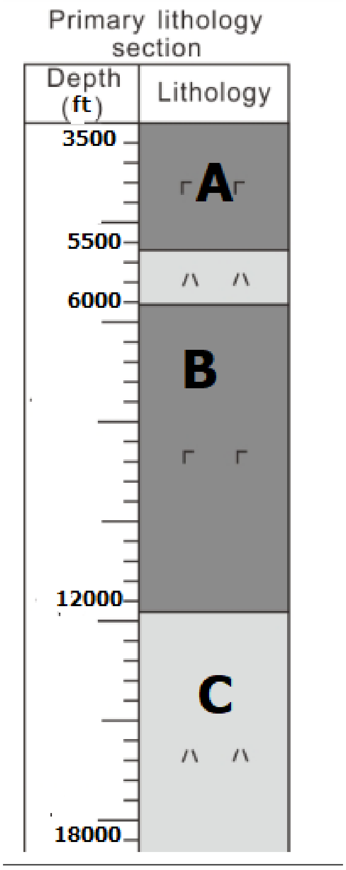


Fig 1

For the Sandstone (Density=169 pcf) formation containing 10 v% calcite, a 15 wt. % strength of the preflush should be injected ahead of the main acid to dissolve the carbonate minerals within the 1 ft. beyond a 0.328-ft radius wellbore. Specific gravity and viscosity of the acid solution are 1.07 and 1.5 cP respectively which is pumped down through a 2-in. inside diameter (ID) coil tubing. The formation fracture gradient is 0.7 psi/ft. Assuming a reservoir pressure of 4,000 PSi, drainage area radius of 1,000 ft., and a skin factor of 15, safety margin 300 psi.

Use 28 wt. % acid to propagate wormholes of 3 ft. from a 0.328-ft radius wellbore in a carbonate formation (specific gravity 2.71). The designed injection rate is 0.1 bbl. / min-ft., the diffusion coefficient is 10^{-9} m^2/sec, and the density of the 28% acid is 1.14 g/cc. In linear core floods, 1.5 pore volume is needed for wormhole breakthrough at the end of the core. Use any one of the available method for treatment design.

The average density of the overburden formation (above shale) is 165 lb/ft^3. Assume a tectonic stress of 2,000 Psi and a tensile strength of the sandstone of 1,000 Psi, Poison ratio= 0.45, Poro-elastic constant=0.72

Your treatment design must contain minimum preflush volume is required in terms of gallon per foot of pay zone, the maximum acid injection rate using safety margin 300 psi, the maximum expected surface injection pressure at the maximum injection rate and Maximum treatment pressure for Hydro fracturing job (in case you have opted for it).

[Refer to the equations given in the ANNEXURE-I]

(C.O.No. 4) [Application]

ANNEXURE-I

$$\beta = C_a \frac{\nu_m MW_m}{\nu_a MW_a},$$

where

β = gravimetric dissolving power of acid solution, lb_m mineral/lb_m solution
C_a = weight fraction of acid in the acid solution
ν_m = stoichiometry number of mineral
ν_a = stoichiometry number of acid
MW_m = molecular weight of mineral
MW_a = molecular weight of acid.

$$X = \beta \frac{\rho_a}{\rho_m},$$

where

X = volumetric dissolving power of acid solution, ft^3 mineral/ft^3 solution
ρ_a = density of acid, lb_m/ft^3
ρ_m = density of mineral, lb_m/ft^3

$$V_a = \frac{V_m}{X} + V_P + V_m,$$

where

V_a = the required minimum acid volume, ft^3
V_m = volume of minerals to be removed, ft^3
V_P = initial pore volume, ft^3

$$V_m = \pi\left(r_a^2 - r_w^2\right)(1-\phi)C_m,$$

$$V_P = \pi\left(r_a^2 - r_w^2\right)\phi,$$

where

r_a = radius of acid treatment, ft
r_w = radius of wellbore, ft
ϕ = porosity, fraction
C_m = mineral content, volume fraction.

$$q_{i,\max} = \frac{4.917 \times 10^{-6} kh\left(p_{bd} - \bar{p} - \Delta p_{sf}\right)}{\mu_a\left(\ln\frac{0.472 r_e}{r_w} + S\right)},$$

where

q_i = maximum injection rate, bbl/min
k = permeability of undamaged formation, md
h = thickness of pay zone to be treated, ft
p_{bd} = formation breakdown pressure, psia
$\bar{p}$ = reservoir pressure, psia
Δp_{sf} = safety margin, 200 to 500 psi
μ_a = viscosity of acid solution, cp
r_e = drainage radius, ft
r_w = wellbore radius, ft
S = skin factor, ft.

$$p_{si} = p_{wf} - \Delta p_h + \Delta p_f,$$

where

p_{si} = surface injection pressure, psia
p_{wf} = flowing bottom-hole pressure, psia
Δp_h = hydrostatic pressure drop, psia
Δp_f = frictional pressure drop, psia.

$$\Delta p_f = \frac{518\rho^{0.79} q^{1.79} \mu^{0.207}}{1{,}000 D^{4.79}} L,$$

where

ρ = density of fluid, g/cm^3
q = injection rate, bbl/min
μ = fluid viscosity, cp
D = tubing diameter, in.
L = tubing length, ft.

$$V_h = \frac{\pi \phi D^{2/3} q_h^{1/3} r_{wh}^{d_f}}{b N_{Ac}}$$

where

V_h = required acid volume per unit thickness of formation, m^3/m
ϕ = porosity, fraction
D = molecular diffusion coefficient, m^2/s
q_h = injection rate per unit thickness of formation, m^3/sec-m
r_{wh} = desired radius of wormhole penetration, m
d_f = 1.6, fractal dimension
b = 105×10^{-5} in SI units
N_{Ac} = acid capillary number, dimensionless,

where the acid capillary number is defined as

$$N_{Ac} = \frac{\phi \beta \gamma_a}{(1-\phi)\gamma_m},$$

$$p_{si} = p_{bd} - \Delta p_h + \Delta p_f,$$

where

p_{si} = surface injection pressure, psia
p_{bd} = formation breakdown pressure, psia
Δp_h = hydrostatic pressure drop, psia
Δp_f = frictional pressure drop, psia.

$$\Delta p_f = \frac{518\rho^{0.79} q^{1.79} \mu^{0.207}}{1{,}000 D^{4.79}} L,$$

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