Department of education and science of Ukraine
NATIONAL TECHNICAL UNIVERSITY
"DNIPRO UNIVERSITY OF TECHNOLOGIES"

METHODICAL GUIDELINES

to implementation of course project from discipline
"Well Drilling (Oil & Gas)"
for the students of speciality
185 Oil and gas engineering and technologies

Dnipro
DUT
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Manager

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Arrival

A course project is independent work of students of speciality 185 Oil and gas engineering and technologies and has for an object fixing of knowledge purchased at investigation of discipline of "Holing on oil and gas".

At implementation and guard of course project a student must show ability to use the purchased knowledge for the decision of concrete engineerings tasks from a ground the inspected technical decisions at the level of modern achievements of theory and practice.

In a project it must be taking of access borehole is foreseen to the budgeted depth with the minimum charges of time, money and goods at absolute assurance of the hazard of borings works engineering, conservation of mineral resources and environment.

Knowledge and ability is purchased at implementation of this course project is sound intermediate preparation to implementation the students of CCT.

Authority of implementation of course project

A course project is executed in a 8th semester in dates conditioned by a dean's office and department.

A course project is individual. An initial document for implementation of course project is a task for implementation of course construction, which seems to every student the director of project. Task, after the inspected geometry necessarily includes a geological drill core on an access borehole, depth diameter of operating column predetermined well.

Theme of course project: "Project of technology of the borehole drilling in ___ m depth on ________________ an area".

A student executes a course project according to the approved calendar table, the concrete dates of implementation of separate divisions are indicated in which. The director of project gives consultations from a course construction accordingly of the approved card of consultations. Before implementation of every next division of project a student begins after coordination with the director of the got decisions from a previous division. A course project is checked up by a director and is on the defensive before the committee of department, which proposes a final assessment.

Table of contents and volume of course project

A course project consists of calculation-explanatory message and graphic addition.

A ground over the inspected technical, technological and other decisions is brought in an explanatory message. Her care must answer the calls of methodical guidelines from a course construction and in general case must consist of divisions, stated below.

Arrival

1. Geological and technical drilling conditions.
2. Determination and ground of well design.
3. Boring method.
4. Determination of drill bits.
5. Drill string.
6. Determination of boring behavior.
7. Washing of access borehole.
8. Determination of drill rig, rope hoist and hoist system.

At the beginning of explanatory message place a title page, task on implementation of course project, care with the directive of all divisions. At the end of explanatory message an author puts the signature and brings a bill over of the used literature.

A volume of explanatory message of course project is within the limits of 25-35 pages of the handwritten text. Graphic addition shows by itself geological and technical outfit on the projected borehole drilling is executed on the sheet of grid of A1.

1 Geological and technical drilling conditions

In this division a geological drill core is described on an access borehole, the lithologic attribute of geological horizons is added. Cited data from mechanical and abradant rock, extent of reservoir pressures and breakdown pressures characteristics. The belts of the expected complications are described.

2 Determinations and ground of well design

A well design it is recommended to design in such consequence:

it is determination of count of the borings casings and their landing depths;

it is determination of types of the borings casings;

it is a construction of diameters of the borings casings and bore bits under every column;

it is a ground of bands of backfill of every column.

For determination of count of the borings casings and their landing depth at first build the combined card of change of formation pressure and breakdown pressure gradients after a hole depth. On his base the first reference variant of well (table. 1) design is designed.

The eventual variant of decision about the count of the borings casings and their landing depth is accepted after the evaluation of geological-and-technical conditions of boring taking into account possible complications, to experience of construction of access boreholes on this deposit.

Determination of classes of the borings casings (continuous, sectional, "butts") is conducted also on the basis of evaluation of geological-and-technical conditions of boring and minimization of charges of goods and time on fastening of access borehole.

Table 1

Combined card of pressures and well design

Depth of bottom boundary, m	Pressure, NPa/m gradient		Combined card of pressure	Well design
	Reservoir	Розриву		

The diameter of operating column is conditioned by a task on a course project. Determination of bands of backfill of every boring casing is executed on the basis of operating instructional and methodical goods. The constructions of diameters of the borings casings and bits conduct on next methods.

Choose the diameters of the borings casings and bits, height of lift of slurry solvent. The diameters of the borings casings and bits choose from below upstairs, beginning from an operating column.

The diameter of bore bit under an operating column is delineated after equation

$$Д_д^э = Д_м + 2\delta$$

where $Д_м$ is an external diameter of clutch of casings column; δ it is an extent of clearance between a clutch and walls of access borehole.

The extent of clearance δ depends on a diameter and as casings, behavior of wall and her bending, extent of exit connections from under pad device of previous column. In dependence on the diameter of the borings casings next values δ (table. 2) are recommended.

Table 2

The recommended clearances are between a clutch and walls of access borehole

External casing, mm size	114-127	140-168	178-245	273-299	324-351	377 and more
Clearance, mm	5-15	10-15	10-30	15-30	20-40	25-50

Knowing the calculation extent of $Д_д$, delineate the nearest greater value of diameter of bit after state standard.

Delineate the bore diameter of the previous boring casing, coming from that a difference between the bore diameter of previous column and bit diameter must be a 6-8 mm, so

$$Д_в = Д_д + (6 \div 8)$$

After it set on tables the external diameter of previous column and diameter of bond clutches to her.

Knowing the diameter of previous column, delineate on the higher brought methods over the diameter of bore bit under this column.

By such method conduct calculations while will not reach to the mine conductor.

The diameter of conductor is chosen to such, that difference between his external diameter and diameter of bore bit under surface casing was a 50-100 mm

It is necessary to remember at implementation of this division, that a well design largely delineates the capability of leading to of access borehole to the budgeted depth and predetermines her cost.

In a complete class a well design over is brought as a table and table.

3 Methods of boring

For determination and ground of boring method in the different bands of access borehole it is necessary to take into account her construction, learn the geological-and-technical conditions of construction of access boreholes and conduct the evaluation of technical and economic coefficients of access boreholes drill-in on given and nearby areas. A basal criterion at determination of boring method a minimum prime price is considered a 1 m of deepening.

Except for it is necessary to take into account and on that the rotor method of boring it is recommended to use then, when a hole depth exceeds a 3500 m; a diameter of bit is a less than 190,5 mm; temperature of bottom hole more than 140 (C; freeze-ins and wearing out, possible use of the aerated circulating fluid are expected in an access borehole; air and carrier gas; drill bit is with the air-tight backing.

The sphere of the use of downhole turbine motor drilling mainly are access boreholes in a less than 3500 m depth and diameter a more than 190,5 mm; with the temperature of bottomhole less than 140 (C; boring of the aslope-directed and horizontal access boreholes; in the conditions of the limited duties on a bit, at the use of diamond bits.

4 Determinations of drill bits

Determination of classes of borings bits on the stage of construction is conducted by such two methods:

1) on mechanical and abradant rock characteristics;

2) from industrial data.

For determination as a bit on the first method for the drilling-out of concrete breed which contains layers with different mechanical characteristics, it is necessary to estimate the category of hardness and abrasivity of all layers, find them weighted average calculation values for all layer of breed and to inflict on the qualifying table of pair compliances of categories of hardness and abrasivity which over is brought in literature [5].

At the use of the second method it is necessary to have industrial information (cards of bits working out) from boring not less than 5-6 access boreholes on this area. Processing this information compare trip speed and prime price of one meter and choose the optimal class of bit for every band.

For the oriented determination as borings bits depending on mechanical and abradant characteristics it is possible to avail to the table. 3 [1].

Table 3

Recommendations are in relation to determination of drill bits

Class of bit	Drill bits			
	roller cone	two- and trilobate	multiblade hard-alloy blade-cutting	diamond
M	II – III/II – III	I – II/I – II	I – II/I – II	II – III/I – II
MЗ	III – IV/IV – V	–	–	–
MC	III – IV/III – IV	II – III/I – II	III – IV/I – II	III – IV/II – III
MCЗ	IV – V/V – VI	–	–	–
C	III – IV/IV – V	–	IV – V/II – III	IV – V/II – III
CЗ	IV – V/V – VI	–	–	–
CENTURY	IV/IV – V	–	V – VI/II – III	V – VI/III – IV
T	V – VI/IV – V	–	VI – VII/III – IV	VI – VII/III – IV
TЗ	VI – VII/V – VI	–	–	–
TK	V – VI/V – VI	–	–	–
TKЗ	VI – VII/VI – VII	–	–	–
K	VI – VII/VII – VIII	–	–	–
OK	VII – VIII/VIII – IX	–	–	–

5 The drill string

In this division it is necessary:

- to choose the diameters of collars and pipe drills;
- to choose BTA;
- to define necessary length and arrangement of collars;
- to define the construction of drill string.

The transferred questions are examined coming from drilling conditions under an operating column.

<u>Determination of diameters of collars and pipe drills</u>

At determination of diameters of collars and pipe drills take into account the recommended ratio by the diameters of bits, collars and pipe drills (table. 4)

Except for it, choose the diameters of borings and collars drills so that such correlations were maintained

$$\frac{d_{ОБТ}}{D_д} = 0,75 - 0,85 \text{ at } D_д < 295,3 \text{ mm};$$

$$\frac{d_{ОБТ}}{D_д} = 0{,}65 - 0{,}75 \text{ at } D_д > 295{,}3 \text{ mm};$$

$$\frac{d_{бт}}{d_{ОБТ}} = 0{,}75 - 0{,}80,$$

where $d_{ОБТ}$, $D_д$, $d_{бт}$ – accordingly diameter of collars, bit and pipe drills.

Table 4

Recommended ratio by the diameters of bits, collars and pipe drills

Diameter of bit, mm	External diameter, mm	
	collars	pipe drills
120,6	95/89	73
139,7; 146	120/108	89
151	120; 133/108	89; 101,6
165,1	133; 146/120	101,6; 114,3
190,5	159/146	114,3
215,9	178/159	127
244,5	203/178	139,7
269,9	219; 229/203	139,7
295,3; 320	229; 245; 254/219; 229	139,7
349,2	245; 254/229; 245	139,7
393,7 and anymore	273; 299/254; 273	139,7; 168,3

Note. The brought recommended correlations over of diameters of bits and collars for normal (numerator) and for the complicated (denominator) drilling conditions.

If it is not succeeded to survive the indicated ratio by the diameters of borings and collars, then arrangement of collars is done by stepped.

Determination of BTA

A bottomhole assembly is designed taking into account the contour of barrel by access boreholes and inclinations of breeds to hole deviation. For vertical holes it mainly one or two calibrators, one or two collars (balanced, square or corkscrew) of maximally possible diameter, equalizer and farther collars of the designed diameter [1].

For single-stage arrangement necessary length of collars is delineated as

$$l_{ОБТ} = \frac{KC_д - G}{q_{ОБТ}\left(1 - \frac{\rho_{пр}}{\rho_м}\right)},$$

where К is a coefficient of reserve, К=1,20-1,25; Сд is abutment, Н; $\rho_п$р is flushing liquid, kg/of $м^3$ density; (a m is density of metal, kg/of $м^3$; $q_{ОБТ}$ is weight a 1 m of collars, Н/of m; G is weight of bottomhole motor, Н.

The got length of collars is broken in a greater flank to the extent, what multiple to length of candle. If arrangement of collars must be stepped, then a bottom (first) degree is done long ((=a 0,7-0,8). Diameter of the second degree of collars is chosen on one or two diameters less first.

For two-stage arrangement of collars

$$l_{ОБТ} = \frac{KC_{д}}{\left[\lambda q_1 + (1-\lambda) q_2\right]\left(1 - \frac{\rho_{пр}}{\rho_{м}}\right)},$$

where q1 is weight a 1 m of the first degree of collars, H/of m; q_2 is weight a 1 m of the second degree of collars, H/

Length of collars must be checked for a fastness from the function of own weight. For this purpose delineate critical length of collars after equation

$$l_{ОБТ}^{кр} = 1{,}94\sqrt{\frac{EI}{q_{ОБТ}}},$$

where E is the module of elasticity of material (to steel), H/of м2; I is a moment of inertia at a bend-over, $м^4$

$$I = \frac{\pi}{64}\left(d_з^4 - d_в^4\right),$$

where $d_з$, $d_в$ – according to external and domestic diameter of collars

If $l_{ОБТ} \geq l_{ОБТ}^{кр}$, then for warning of possible borehole crookedness it is necessary to foresee plugging in arrangement of collars of centralizing attachments. The habitat of determination of centralizers, spacing interval between them and their diameter, delineate according to recommendations [1, table. 4.29, 4.30].

Above collars it is recommended to place the overbite batch of pipe drills. For this purpose mainly choose pipe from steel of bank of endurance capability of "Д" with the most depth of wall and long a 250-300 m [2].

Construction of drill string

At definition of construction of drill string accept, that a drill string has a single-stage construction, id est at an identical external diameter consists of a few sections which differ one from other long, in thick walls and by the bank of endurance capability. For the first section accept the pipe drills of bank of endurance capability of "Д" with the minimum depth of wall.

Length of the first section is delineated from the clause of possible tensions of tensile

$$l_1 = \frac{Q_р - k\left(G_{убт} + G_{нк} + G\right)\left(1 - {}^{\rho_{пр}}\!/_{\rho_{м}}\right) - \left(P_д + P_т\right)F_к}{kq_{бт}\left(1 - {}^{\rho_{пр}}\!/_{\rho_{м}}\right)},$$

where $Q_р$ is a duty which stretches, that is assumed, for the pipe of bottom section, H; k is a coefficient considering effect of friction (accepted 1,15); $G_{ОБТ}$ is weight of collars, N; $G_{УБТ}$ is weight of overbite batch, H; G is weight of bottomhole motor and bit, H; $P_д$, $P_т$ is a bit pressure drop and vane borer, Pa; $F_к$ is an area of communicating channel of duct; $q_{бт}$ is weight a 1 m of drill string, N.

In turn

$$Q_p = \frac{\sigma_{тр} F_{тр}}{n},$$

where $\sigma_{тр}$ is a bound of fluidity of material of pipe, Pa; $F_{тр}$ is an area of intercept of pipe, m^2; n is an assurance coefficient, accepted by even 1,3.

A bound over of fluidity of material of pipe is brought in a table. 5.

Table 5

Bound of fluidity of material of pipe

Bank of endurance capability of steel	Д	К	Е	Л	М	Р	Т
Bound of fluidity of material of pipe $\sigma_{тр}$, MPa	380	500	550	650	750	900	1000

If a drill string is made from the pipe of one diameter, but different after a depth walls or different banks of endurance capability, then such column will consist of a few sections. From the point of view of decrease of cost of column for a bottom section pipe are accepted with the minimum depth of wall and the banks of endurance capability of Д. became

For a multi-section column length of the first (from below) section is already certain higher, and length of the second section

$$l_2 = \frac{Q_{p2} - Q_{p1}}{K q_{бт2} \left(1 - \rho_{пр} / \rho_м\right)},$$

where Q_{p1} and Q_{p2} is load capacities which stretch, for the pipe of the first and second section, H; $q_{бт2}$ is weight of 1 m pipe of the second section, H.

A calculation is conducted until total length of sections plus length of collars will not exceed the depth predetermined well. If all pipe will be sorted out on the depth of wall, and total length of sections will be less hole depth, then a next section is accepted from steel of higher bank of endurance capability.

At the end of division the erected table (table. 6) and graphic image of construction of drill string is pointed.

Table 6

Construction of drill string

Coefficients	Number of section from below upwards				
	collars	1	2	3	4
External diameter of pipe, mm					
Depth of wall, mm					
Bank of endurance capability of material of pipe					
Length of section, m					
Weight a 1 m, kN/m					
Weight of all section, kN					
Gross weight, kN					

6 Determination of boring behavior

1. Abutment is on the bit of $C_Д$.

Duty on a bit it is possible to define two methods, going out volumetric rock destruction

a) after a specific duty

$$C_д = c_п D_д ,$$

where $c_п$ is a specific duty on a 1 m of diameter (table. 7), H/of m; Dд is a diameter of bit

Table 7

A specific duty is for the different classes of bits

Class of bit	Tricone bit				
	M	MC	C	T	К
$c_п \cdot 10^5$, H/m	<2	2-5	5-10	10-15	>15
Class of bit	Blade		Millings	Diamond and "INM"	Singlecone bit
	twoblade	trilobate			
$c_п \cdot 10^5$, H/m	3-5,7	1,3-1,5	4-6	1,5-3,3	6-8

б) after hardness of breeds and by an area interference

$$C_д = k_п p_ш F_к ,$$

where $k_п$ is a coefficient which takes into account rock ($k_п$ = 0,7-0,8 for porous grounds (sandstones, crumbling burrs, aleurites) and $k_п$ = 1,0-1,2 – for continuous breeds) characteristics; $p_ш$ is hardness of breed after a stamp at atmospheric pressure, Pa; $F_к$ is an area of interference of teeth of bit with a breed, m^2 (table. 8).

Table 8

Pin area of bits

Class of bit	Pin area of bits, mm^2, diameter, mm										
	188,9	190,5	214,3	215,9	242,1	267,5	269,9	292,9	295,3	318,0	391,7
Blade bits											
ЗЛГ	245	-	269	-	295	315	-	350	-	385	450
ДСГ ЗЛГ	-	-	-	-	265	290	-	315	-	350	425
HORN	-	-	-	-	-	-	-	290	-	310	-
ПЛД	180	-	205	-	235	250	-	275	-	285	360
Diamond bits											
ДРСТ1	190	-	215	-	-	-	-	-	-	-	-
ДРСТ2	210	-	235	-	-	-	-	-	-	-	-
ДРТ1	200	-	225	-	-	-	-	-	-	-	-
АИ	220	-	255	-	-	-	-	-	-	-	-
ДК	190	-	215	-	240	265	-	-	-	-	-
ДУС	150	-	180	-	-	-	-	-	-	-	-
ДИ	210	-	235	-	-	-	-	-	-	-	-
ДЛ	160	-	185	-	-	240	-	-	-	-	-
ИСМ	162	-	190	-	215	230	-	260	-	280	350
Roller-cone bit											
M	-	169	-	195	-	-	245	-	270	-	-
M3	-	-	-	202	-	-	-	-	-	-	-
MC3	-	162	-	-	-	-	-	-	255	-	-
C	-	221	-	250	-	-	280	-	330	-	-
MC	-	179	-	220	-	-	-	-	305	-	-
C3	-	180	-	-	-	-	210	-	317	-	-
T	-	210	-	233	-	-	305	-	352	-	-
T3	-	150	-	-	-	-	220	-	241	-	-
К	-	125	-	153	-	-	-	-	190	-	-

The designed abutment on a bit must not exceed possible (calibration certificate) for this type and size of bit [$C^{д}$] (table. 9)

$$C_{д} \le [C_{д}].$$

2. Frequency of rotation of bit.

For roller-cone bits frequency of rotation is delineated after equation

$$n_{д} = \frac{d_{ш}}{t_{min} D_{д} Z},$$

where $n_{д}$ is frequency of rotation of bit, c^{-1}; $d_{ш}$ is a diameter of cone, m; t_{min} – minimum necessary time of interference of tooth of bit with a breed, $t_{min} = (3^{-8})\cdot 10^{-3}$ c; Z is a maximal count of teeth on the peripheral crown of cone (table. 9).

Table 9

A count of teeth is on a peripheral crown but a load capacity is on tricone bits

Bit	Load capacity, kN	A count of teeth is on a peripheral crown, pieces	Bit	Load capacity, kN	A count of teeth is on a peripheral crown, pieces
Ш93, 0Т-ЦА	40	14	Ш215, 9ТКЗ-ГВ	250	18
Ш98, 4С-ЦА	50	13	Ш215, 9ТКЗ-ГНУ	250	18
Ш98, 4Т-ЦА	50	15	Ш215, 9К-ГНУ	250	19
Ш98, 4ОК-ЦА	50	15	Ш215, 9К-ПВ	250	19
Ш112, 0Т-ЦВ	60	15	Ш215, 9ОК-ПВ	250	19
Ш120, 6С-ЦА	60	13	Ш244, 5Т-ЦВ	320	23
Ш120, 6Т-ЦА	60	15	Ш244, 5Т-ПВ	320	23
Ш132, 0С-ЦВ	70	16	Ш244, 5ТК-ЦВ	320	21
Ш132, 0Т-ЦВ	70	17	Ш244, 5ТК-ПВ	320	21
Ш132, 0К-ЦВ	70	20	Ш244, 5ОК-ПВ	320	21
Ш139, 7С-ЦВ	100	17	Ш269, 9М-ГНУ	350	13
Ш139, 7Т-ЦВ	100	20	Ш269, 9С-ГВ	350	19
Ш146, 0Т-ЦВ	120	21	Ш269, 9С-ГНУ	350	19
Ш146, 0ОК-ЦВ	120	15	Ш269, 9СЗ-ГН	350	19
Ш151, 0С-ЦВ	120	19	Ш269, 9СЗ-ГНУ	350	19
Ш151, 0Т-ЦВ	120	20	Ш269, 9СТ-ЦВ	350	18
Ш151, 0К-ЦВ	120	21	Ш269, 9СТ-ГН	350	18
Ш165, 1С-ЦВ	150	14	Ш269, 9Т-ЦВ	350	25
Ш165, 1Т-ЦВ	150	19	Ш269, 9ТЗ-ЦВ	350	25
Ш190, 5М-ГВ	200	10	Ш269, 9ТК-ЦВ	350	24
Ш190, 5МС-ГВ	200	13	Ш269, 9К-ЦВ	350	19
Ш190, 5МСЗ-ГВ	200	15	Ш269, 9ОК-ПВ	350	21
Ш190, 5МСЗ-ГАУ	200	18	Ш295, 3МСЗ-ГНУ	400	15
Ш190, 5С-ЦВ	200	18	Ш295, 3МС-ГВ	400	15
Ш190, 5С-ГН	200	18	Ш295, 3Т-ЦВ	400	24
Ш190, 5С-ГВ	200	18	Ш295, 3ТЗ-ЦВ	400	24
Ш190, 5СЗ-ГВ	200	19	Ш295, 3ТК-ЦВ	400	26
Ш190, 5Т-ЦВ	200	21	Ш295, 3К-ЦВ	400	24
Ш190, 5ТЗ-ЦВ	200	20	Ш320С-ГВ	450	19

Ш190, 5ТК-ЦВ	200	15	Ш320ОК-ПВ	450	22
Ш190, 5ТКЗ-ЦВ	200	22	Ш349, 2М-ЦВ	450	17
Ш190, 5К-ГНУ	200	24	Ш349, 2М-ГВ	450	17
Ш215, 9М-ГВ	250	11	Ш349, 2С-ЦВ	450	24
Ш215, 9М-ГАУ	250	11	Ш349, 2С-ГВ	450	24
Ш215, 9МЗ-ГВ	250	11	Ш349, 2Т-ЦВ	450	28
Ш215, 9МС-ГВ	250	11	Ш393, 7М-ЦВ	470	12
Ш215, 9С-ГВ	250	16	Ш393, 7М-ГВ	470	12
Ш215, 9С-ГН	250	17	Ш393, 7С-ЦВ	470	24
Ш215, 9СЗ-ГВ	250	18	Ш393, 7С-ГВ	470	24
Ш215, 9СЗ-ГН	250	18	Ш393, 7Т-ЦВ	470	35
Ш215, 9Т-ЦВ	250	18	Д445С-ЦВ	500	31
Ш215, 9ТКЗ-ЦВ	250	18	Д490С-ЦВ	500	32

For diamond, blade and "INM" bits frequency of rotation is delineated after equation

$$n = \frac{60V_д}{\pi D_д},$$

where $V_д$ is possible inline speed of rotation, which is delineated from the terms of abrasive damage and heating of bit, $V_д$=3-5 m/s.

After the calculation of frequency of rotation actual frequency of rotation is chosen going out the attribute of rotor in this air drill.

3. Expense of circulating fluid.

Flushing expense fluid is chosen on two terms

а) from the clause of the bottomhole cleaning from the drilled rock

$$Q_1 = q_0 F_{виб},$$

where Q1 is an expense of circulating fluid, м3/с; q0 is a specific expense of circulating fluid, m^3/c on 1 m^2 of bottomhole (q_0=0,35-0,5 – at a rotor and electrical bottomhole drilling; q_0=0,5-0,7 – at boring fluid bottomhole drives); $F_{виб}$ is an area of bottom hole, m^2;

б) from the clause of hauling of the core boring in circular space

$$Q_2 = V_{min} F_{кп}$$

where V_{min} – minimum possible rate of movement of circulating fluid in circular space (in rocky breeds V_{min}= 0,7-1,0 m/s; in soft V_{min}=1,0-1,4 m/s; at boring of large-break bits V_{min}=0,3-0,5 m/s).

From the designed values choose most, what is then fitted with the technical attribute of air drill. For an actual cost take on a nearest greater value of expense of Q and value of pressure fit to her

At the end of division the erected table over of characteristics of boring behavior is brought for all bands of access borehole.

7 Washing of access borehole

Ground of flushing liquid density

Flushing liquid density is delineated for every band of compatible drilling conditions after equation

$$\rho_{пр} = \frac{\alpha P_{пл}}{gH};$$

where $P_{пл}$ – reservoir pressure in the band of access borehole for which is delineated $\rho_{пр}$, Pa; g is an acceleration of earthly gravitation, m/s^2; H is a depth of bottom boundary of band of access borehole, m; (it is a normative coefficient which concordantly to the calls of codes of conduct of borings works delineates the supply of pressure in an access borehole above reservoir (to the table. 10).

Table 10

Value of normative coefficient α

Depth of hole H, m	<1200	1200-2500	>2500
α	1,10-1,15	1,05-1,10	1,04-1,07

Hydraulic calculation

Resistance heads of pressure in the components of circulation collection [6]

$$P = P_т + P_{кп} + P_з + P_{ОБТ} + P_{кпОБТ} + P_{обв} + P_д,$$

where P is total resistance heads of pressure in circulation collection, Pa; $P_т$ are pressure drops in pipe drills, Pas; $P_{кп}$ are pressure drops in a drill-pipe annuity, by Pa; $P_з$ are pressure drops in locks and clutches, Pas; $P_{ОБТ}$ are pressure drops in collars, Pa; $P_{кпОБТ}$ are pressure drops in circular space after collars, Pa; $P_{обв}$ are pressure drops in surface strapping (to the chimney, boring hose, kelly, swivel), Pa; Pд are pressure drops in a bit, Pa.

For definition of pressure drops in pipe and circular space it is necessary to define behavior of motion, depending on which choose those or other calculation equations. For this purpose delineate actual Re and critical $Re_{кр}$.

$$Re = \frac{\rho_{пр} V d_г}{\eta_{пр}},$$

where $\rho_{пр}$ is flushing liquid, kg/of м^3 density; V is a rate of movement of circulating fluid, m/s; $d_г$ is a hydraulic diameter, which equals a pipe bore $d_в$ or difference of diameters $d_г = D_c - d_з$ for circular space, m; D_c is a borehole, m diameter; $d_з$ is an external diameter of drill string, m; $\rho_{пр}$ is dynamic viscidity of circulating fluid, Pa·s

$$\eta_{пр} = 0{,}033 \cdot 10^{-3} \rho_{пр} - 0{,}022;$$

$$Re_{кр} = 2100 + 7{,}3 He^{0{,}58},$$

where He is a criterion of Hellstrom;

$$He = \frac{\rho_{пр} \tau_0 d_г^2}{\eta_{пр}^2},$$

where t_0 is dynamic tension of change, Pa.

$$\tau_0 = 8{,}5 \cdot 10^{-3} \rho_{пр} - 7.$$

If Re<Re$_{кр}$ – behavior of motion is laminar.

If Re>Re$_{кр}$ – behavior of motion is turbulent.

$$V = \frac{Q}{F},$$

where F is an area of cross-sectional area cut, m^2

for pipe $F = \frac{\pi}{4} d_в^2$; for circular space $F = \frac{\pi}{4}\left(D_c^2 - d_з^2\right)$.

At laminar to behavior of motion of pressure drop in pipe drills and circular space delineate after such equations:

$$p_т = \frac{4\tau_0 l}{\beta_т d_в};$$

$$p_{кп} = \frac{4\tau_0 l}{\beta_{кп}\left(D_c - d_з\right)},$$

where l is length of joints of borings pipes of identical diameter of $d_в$, $d_з$, D_c;

$\beta_т$, $\beta_{кп}$ – accordingly coefficients which can be found after the card (Fig. 1) preliminary finding the characteristic of Saint-Venant Sen for pipe and circular space

$$Sen = \frac{\tau_0 d_г}{\eta_{пл} V}.$$

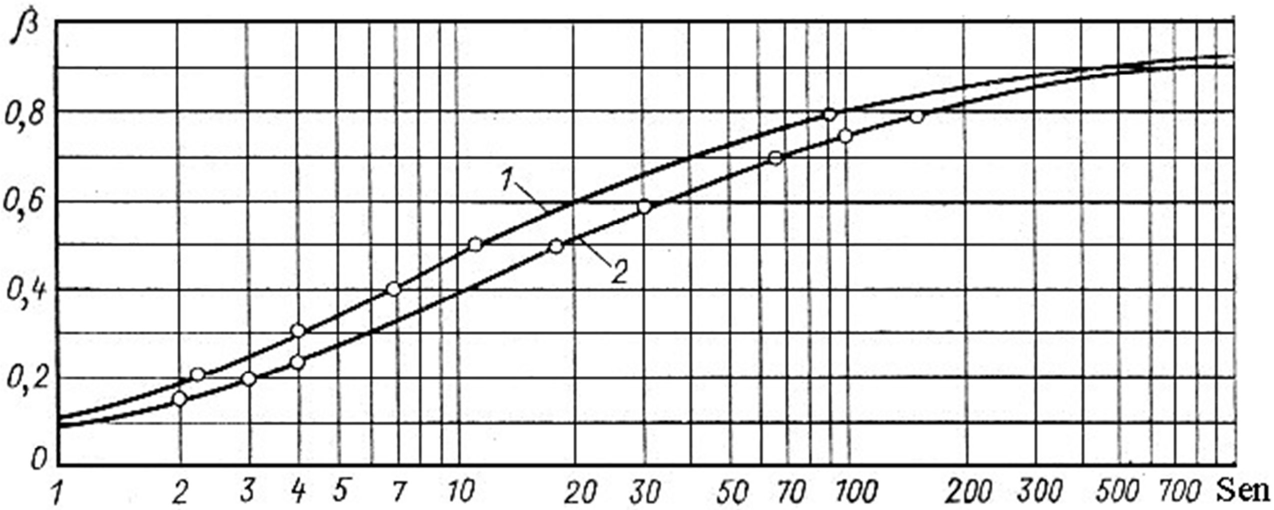

Figure 1. Dependence to the coefficient β from to the characteristic of Saint-Venant Sen:

1 – for the pipe (of т; 2 – for circular space (of кп

At turbulent behavior of motion of pressure drop in pipe drills and circular space delineate after equation of Darcy-Weisbach

$$P = \lambda \frac{V^2}{2} \frac{\rho_{пр}}{d_г} l,$$

where λ is a coefficient of wall friction

for pipe

$$\lambda_т = 0{,}1\left(1{,}46\frac{\Delta}{d_d} + \frac{110}{Re}\right)^{0{,}25};$$

for circular space

$$\lambda_т = 0{,}106\left(1{,}46\frac{\Delta}{D_c - d_з} + \frac{110}{Re}\right)^{0{,}25},$$

where Δ is a roughness of pipe ($\Delta=3\cdot10^{-4}$ m – for walls pipe and the cased departments of hole annuity; $\Delta=3\cdot10^{-3}$ m – for the uncased departments of hole annuity).

Like find pressure drops in collars ($P_{ОБТ}$) and circular space after collars (Pкпcollars).

Pressure drops in locks delineate Bordeaux-Carnot after equation

$$P_з = \xi\rho_{пр}\frac{V^2}{2}i,$$

where ξ is a coefficient of domestic resistance head; V is an average rate of movement of fluid in pipe or in uncress part of circular space, m/s; and is a count of locks.

$$\xi = k_{пк}\left(\frac{F}{F_{пк}} - 1\right),$$

where $k_{пк}$ = 2 is the experienced coefficient which takes into account the characteristics of geometry of domestic resistance head in a communicating channel; F is an cross-sectional area of channel of pipe or uncress part of circular space, m^2; $F_{пк}$ is the least area of cut of communicating channel in a lock, m^2.

$$i = \frac{l}{l_т},$$

where l is length of pipe drills of identical diameter; $l_т$ is length of one duct.

Pressure drops in surface strapping find after equation

$$P_{обв} = (\lambda_c + \lambda_{бш} + \lambda_в + \lambda_{вт})\rho_{пр}Q^2,$$

where λ_c, $\lambda_{бш}$, $\lambda_в$, $\lambda_{вт}$ – accordingly coefficients of wall frictions in a chimney, boring hose, swivel, and anchorwoman to the duct, a value over of which is brought in a table. 11.

Table 11

Coefficient of wall frictions of components of strapping

Component of strapping	Passage diameter, mm	Diameter of communicating channel, mm	λ_i, m^{-4}
Chimney	114		$3{,}4\cdot10^5$
	140		$1{,}1\cdot10^5$
	168		$0{,}4\cdot10^5$
Drill hose		38	$38\cdot10^5$
		76	$1{,}2\cdot10^5$
		80	$0{,}93\cdot10^5$
		90	$0{,}52\cdot10^5$
		102	$0{,}3\cdot10^5$
Drive-head carriage		32	$27\cdot10^5$
		75	$0{,}9\cdot10^5$

		80	$0,7 \cdot 10^5$
		90	$0,44 \cdot 10^5$
		100	$0,3 \cdot 10^5$
An anchorwoman is a duct	65	32	$11 \cdot 10^5$
	80	40	$7 \cdot 10^5$
	112	74	$1,8 \cdot 10^5$
	140	85	$0,9 \cdot 10^5$
	155	100	$0,4 \cdot 10^5$

Reserve of pressure, which can be realized in a bit, is delineated as a difference between pressure which develops a pump (or pumps) at the select diameter of boxes, and sum of drop, in circulation collection.

$$P_д = b_р P_н - \sum P_i ,$$

where Pд is reserve of pressure, which can be realized in a bit; $b_р$ =0,75-0,8 is a coefficient, which takes into account that the protracted working pressure of blowing of borings pumps must be, in obedience to the codes of conduct of borings works, less than calibration certificate on 20-25 %; Pн is pressure, which develops a pump, Pa; ΣPi are pressure drops in pipe drills, circular space, locks, collars, circular space after collars, strapping.

By value $P_д$ must be set capability of the use of jet effect at boring of this band of access borehole.

For this purpose delineate the rate of movement of fluid in the flushing holes of bit after equation

$$V_д = \mu_д \sqrt{\frac{2P_д}{\rho_{пр}}} ,$$

where (д is a coefficient of expense, values over of which are brought in a table. 12.

Table 12

A coefficient of expense is for different geometries of finals

Geometry finals	Cylindrical boring	Boring from by the beveled entrance	Y fissure	Finals are for the jet bits
Coefficient of expense	0,64-0,66	0,8-0,9	0,7-0,75	0,9-0,95

If the got value of speed exceeds a 80 m/of c, then it means that band which is examined it is possible to bore with the use of jet bits.

It is necessary to bear in a mind, that a pressure decrease which works in the finals of jet bit must not exceed some maximum value of $P_{кр}$, which is conditioned by both the endurance capability of structural components of bit and capability of start of vane borer. In calculations accept $P_{кр}$≤of 12-13 MPa.

Therefore pick up such values of $V_д$ and $P_д$, that such terms were executed:

$$V_д \geq 80 \text{ m/s};$$

$$P_д < P_{кр} .$$

At implementation of these terms delineate the total area of finals of $f_д$ of jet bit after equation

$$f_д = \frac{Q}{V_д}$$

On the extent of $f_д$ pick up the diameters of finals of jet bit after equation

$$d_н = \sqrt{\frac{4f_д}{\pi n}},$$

where dн is a diameter of final, m; n is a count of finals.

If the value of speed does not exceed a 80 m/s, then this band beside the purpose to bore with the use of jet effect. In this case it is necessary to pass to the bit with central collection of washing and to find a pressure decrease in a bit after equation

$$P_д = \frac{\rho_{пр} V^2}{2\mu_д^2} = \frac{\rho_{пр} Q^2}{2\mu_д^2 f_д^2},$$

where V is an average rate of movement of fluid in the channels of bit.

In case if the sum of pressure drops exceeds pressure which develops a pump at the set diameter of boxes (taking into account the coefficient of b_p=0,75-0,8), then it is necessary to define a possible drilling depth at this expense of Q. For the further boring it is necessary to decrease the expense of circulating fluid and conduct an analogical calculation at a new expense.

8 Determination of borer, талевого cable and талевої collection

A borer gets out after a nominal carrying capacity in a compliance with most weight of drill or обсадної string in mid air.

For determining the most weight of column there is a comparative table (table. 13).

Table 13

Comparative table of weight boring and borings casings

Coefficients	Drill string	Intermediate column	Operating columnar
Length of column, m			
Weight a 1 m, H			
Weight of column, H			

A short technical attribute over of borer which is chosen is brought.

Determination of hoist cable and hoist system is executed according to the calculation of count of rollers of hoist block

$$T = \frac{K_1 Q_г}{2P_к},$$

where T is a count of rollers of hoist block; Qг is a static duty on a wall hook from weight of the most hard drill string; Pк is a bursting duty for a hoist cable which is chosen; K_1 is an assurance of hoist cable coefficient on a blowout (K_1=4).

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Addition 1

Example of registration of ГТП

ГЕОЛОГО-ТЕХНІЧНИЙ PROJECT
borehole drilling
by the budgeted depth ___ m

Boring goal –

Air drill –

Closing off borehole wellhead –

surface casing –

intermediate column –

the operating column –

Geological part							Technical part							
Scale of depths	Geological drill core	Category breeds		Reservoir pressure, MPa	Pressure of hydraulic fracturing, MPa	Expected complications	Well design	Drill string	Drill bits	Boring behavior			Flushing liquid, kg/m^3 density	Hoist system
		after hardness	after an abrasivity							Abutment, N	Frequency of rotation, min^{-1}	Expense of circulating fluid, l/s		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Methodical guidelines to implementation of course project from discipline of "Well Drilling (Oil & Gas)" for the students of speciality 185 Oil and gas engineering and technologies

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