TOMSK POLYTECHNIC UNIVERSITY
FACULTY OF MECHANICAL ENGINEERING

UNDERGRADUATE THESIS

HIGH PRESSURE EJECTION SYSTEM OF DREDGING

BY

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INTRODUCTION

REQUIREMENTS OF UNDERGRADUATE THESIS

1. TO DETERMINE THE METHODOLOGY OF CALCULATING THE HYDRAULIC PARAMETERS OF A DREDGER.

2. TO DESIGN A PRODUCTION PROCESS FOR THE MANUFACTURE OF A DRIVING SHAFT (COMPONENT PART OF THE DREDGER).

INITIAL DATA

DREDGING DEPTH.	1m … 5m
MAXIMUM DISTANCE BETWEEN PONTOON AND DISCHARGE POINT.	120m
PRODUCTIVITY.	15m^3/hr
DESIGN DRAWING OF DRIVING SHAFT	GIVEN
MINIMUM THICKNESS OF SAND LAYER	0.5m
DESIRED RANGE OF SAND GRAINS	0.06…2.1mm

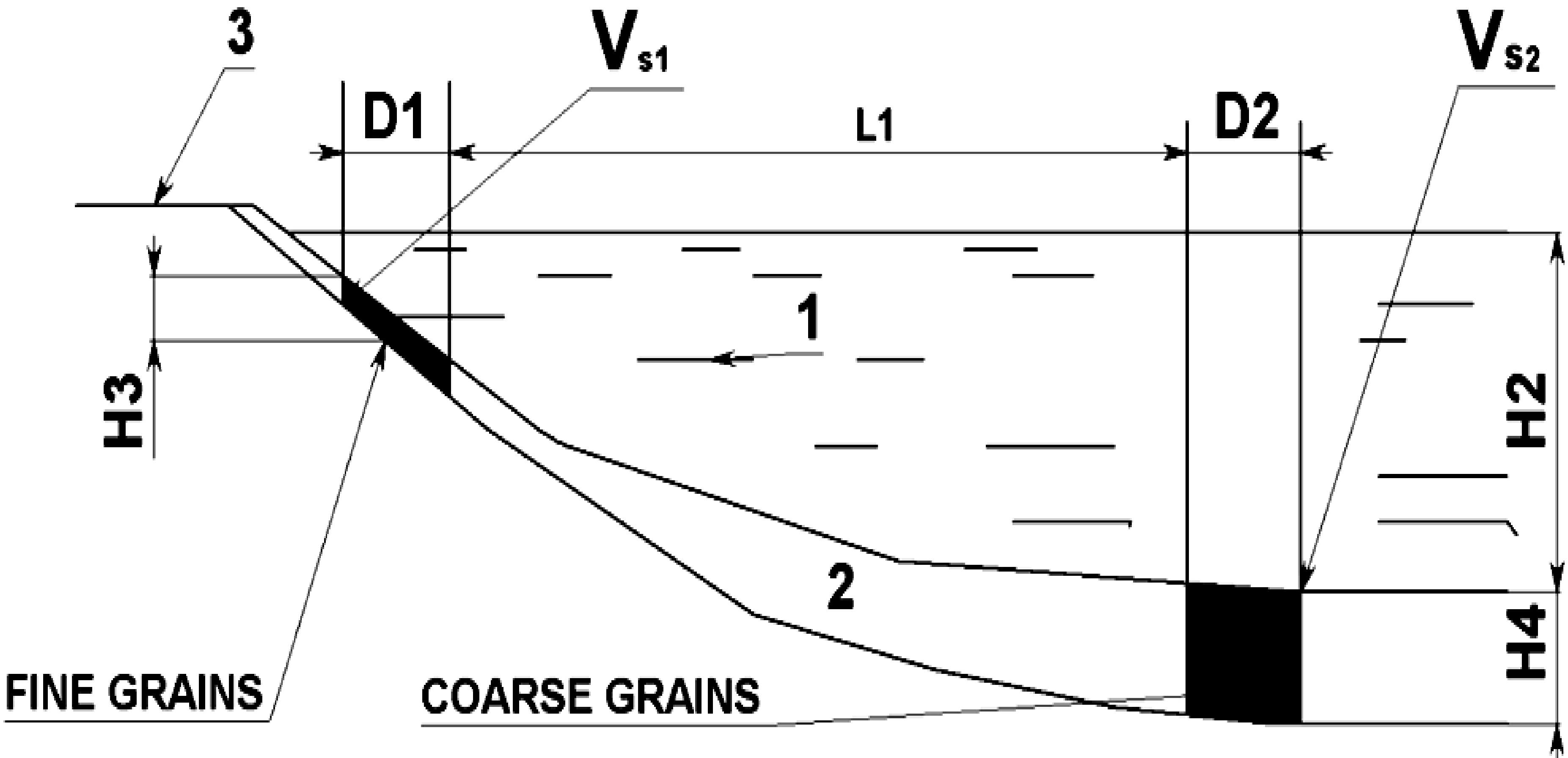


FIG.1 **-DISTRIBUTION OF SAND AND GRAINS OF SAND UNDER WATER QUANTITY**

D1=D2 , Vs2>>Vs1 where: **1**-water ,**2**-sand layer ,**3-**land above water level ,**Vs1-** volume of sand close to riverbank ,**Vs2-** volume of sand at a distance **L1** from the river bank.

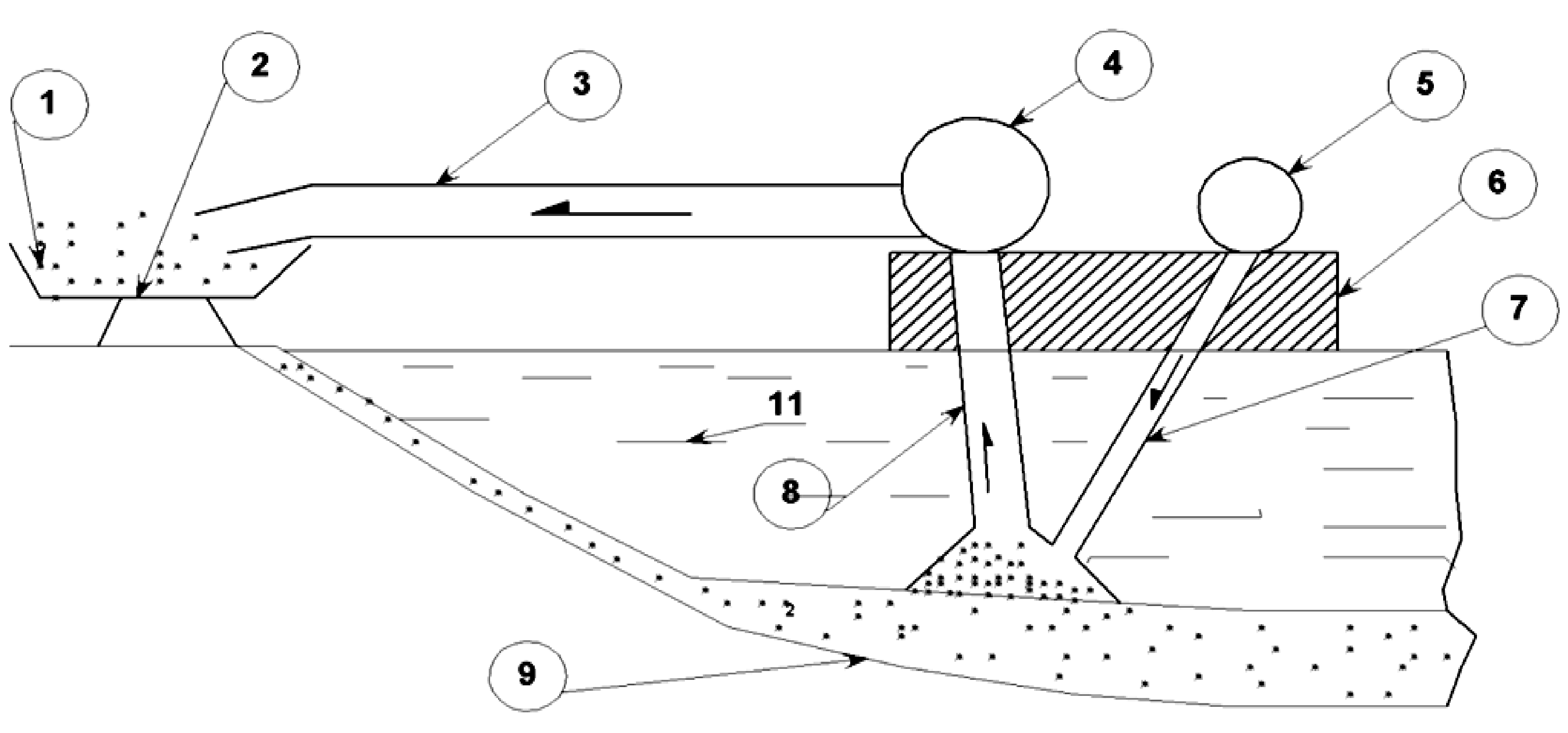
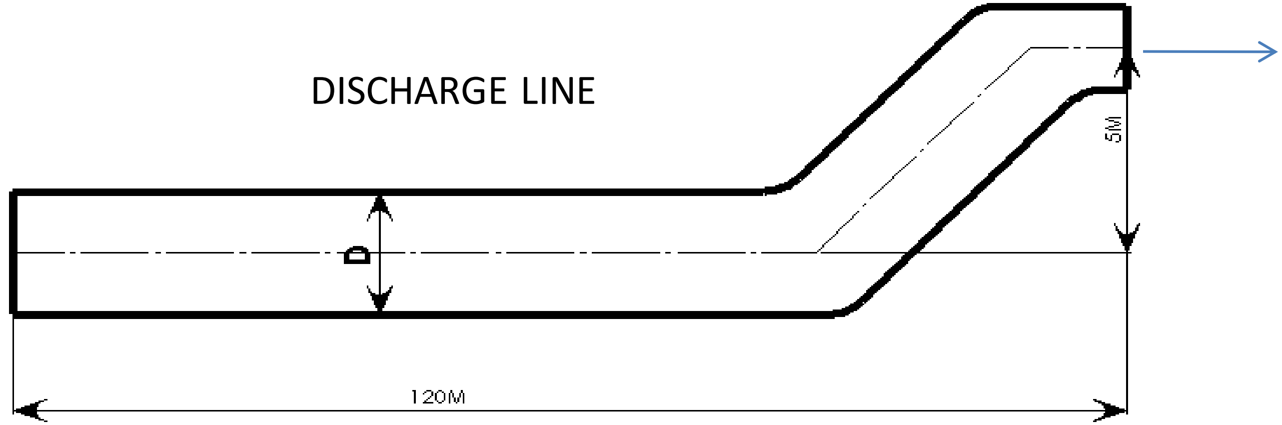
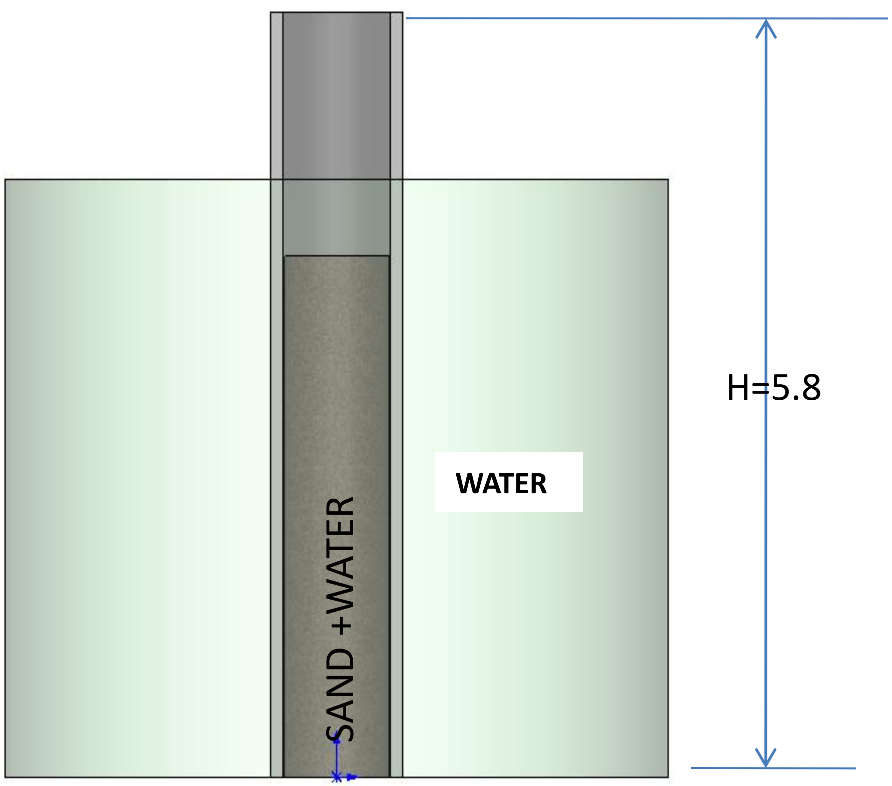


FIG.2 **- LAYOUT OF COMPACT SAND DREDGER**

Where 1-discharged sand, 2- Hopper ,3-discharge pipe ,4-onboard suction pump ,5—onboard water-injector pump ,6-pontoon /barge, 7-water injection pipe ,8-suction pipe ,9-sand layer ,

$$[\Delta p] >>> (\Delta p_{(s+w)} + \Delta p)$$



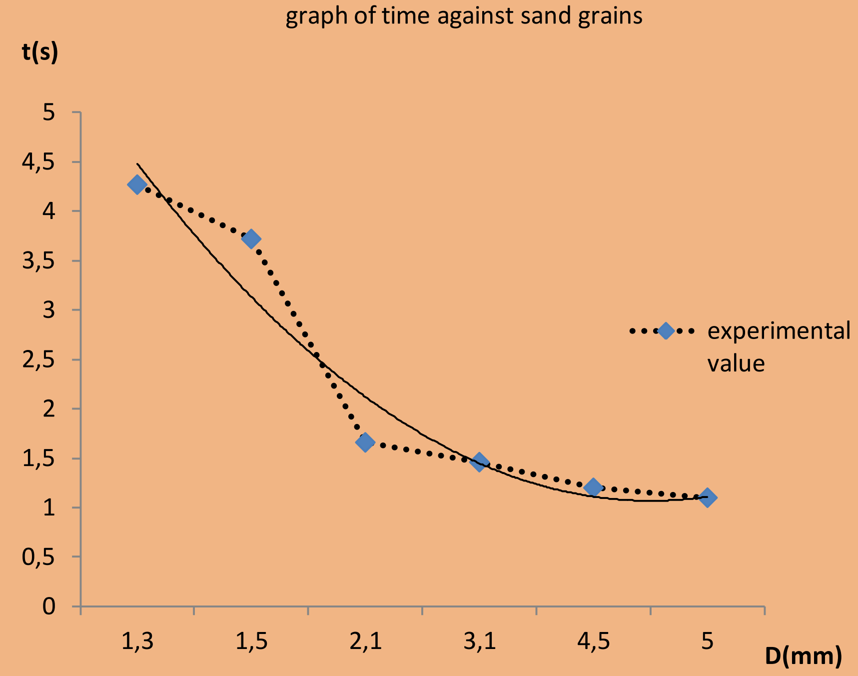


SUCTION LINE

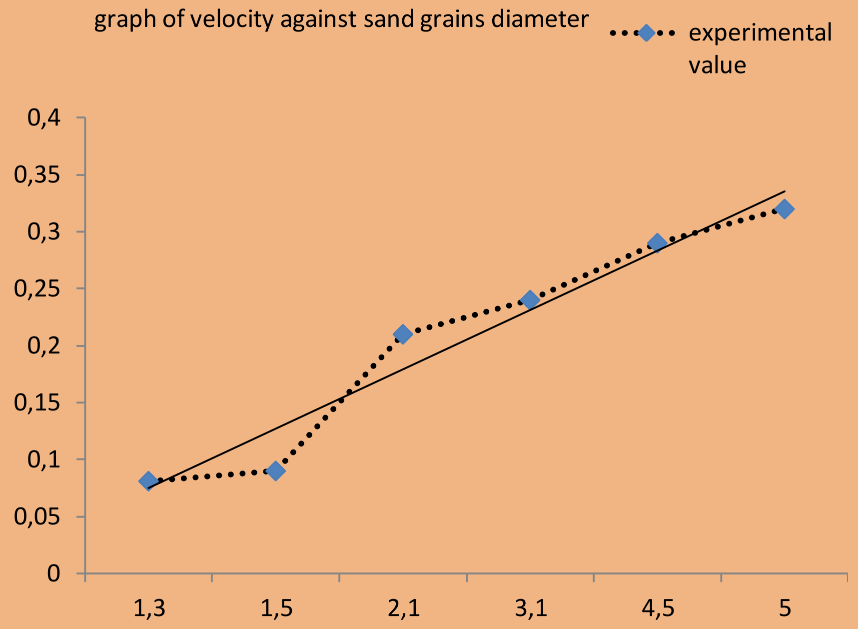
In the suction line there are recommended velocities and pressure losses (0.2…1.5m/s:0.03…0.06MPa).In the equation above the total pressure loss should be far less than the recommended losses. There are two losses considered in the suction, loss due to height and due to friction. Since the loss due to height does not depend on variable parameters, we can reduce the losses by varying the diameter and velocity to reduce the loss due to friction. In the discharge line there are recommended velocities (3…7 m/s).we consider the loss due to the length of 120m,due to the height 5m and also account for minor losses. We keep varying the velocity until we achieve the minimum power of the pump required.

SAND VELOCITY EXPERIMENT

GRAPH OF TIME AGAINST SAND GRAINS



GRAPH OF VELOCITY AGAINST SAND GRAINS DIAMETER



$$k_v = \frac{v_2 - v_1}{D_2 - D_1} = \frac{3.3 - 0.08}{5 - 1.3} = 0.068[\frac{m/s}{mm}]$$

$$v_{sandgrain} = k_v \times D_{sandgrain}$$

RESULTS

SUCTION LINE

$$v_{sandgrain} = k_v \times D_{sandgrain} = 0.068 \times 2.1 = 0.143[\frac{m/s}{mm} \times mm] = 0.143 m/s$$

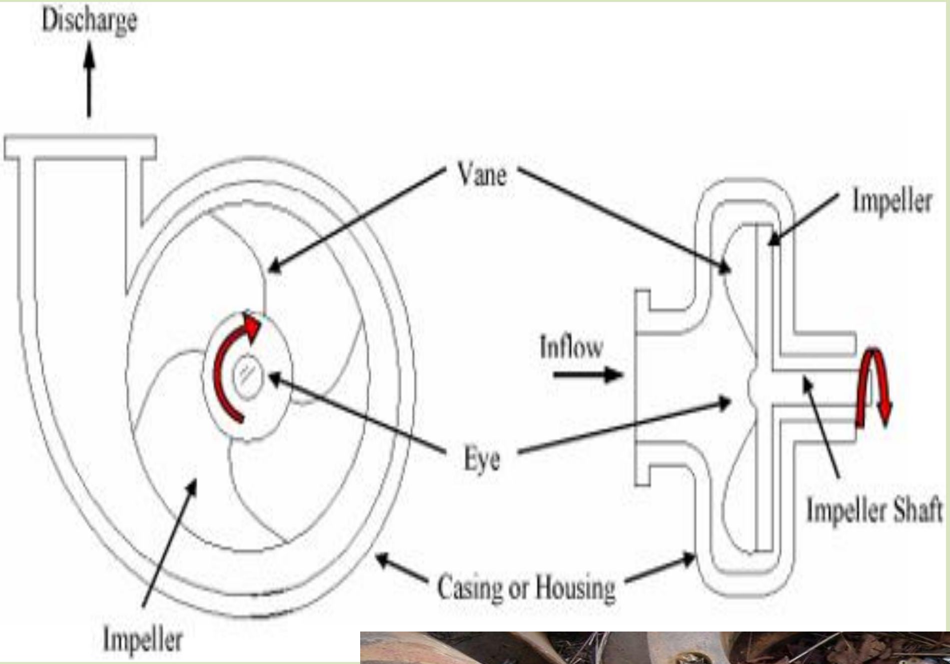
V=0.3m/s; D= 0.133m; Δp_{Σ} =0.03MPa

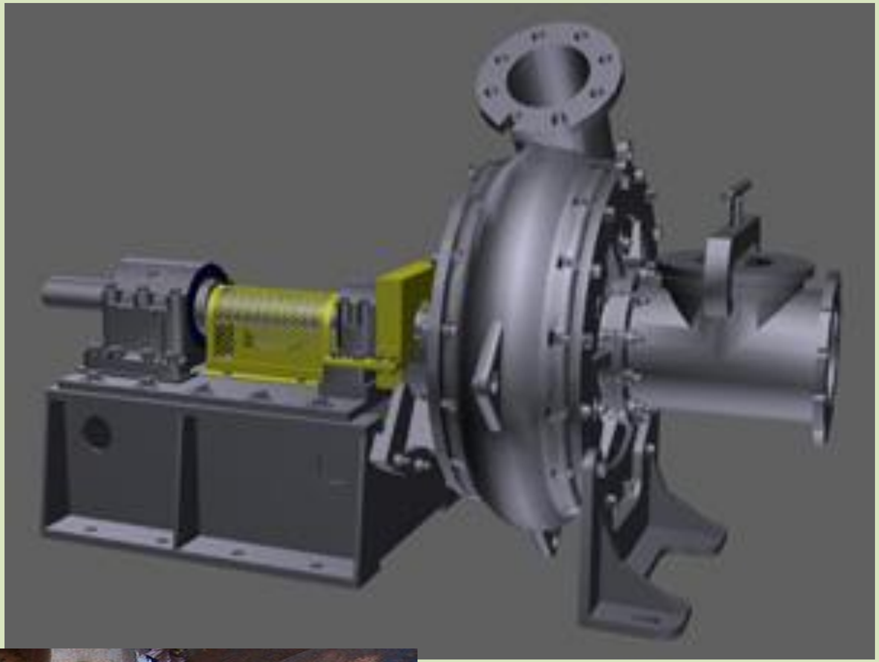
DISCHARGE LINE

V=2.5 m/s; D=0.05m; Δp_{Σ} =0.4MPa

$$N_{P(D=50mm)} = 2.8 Kwatts$$

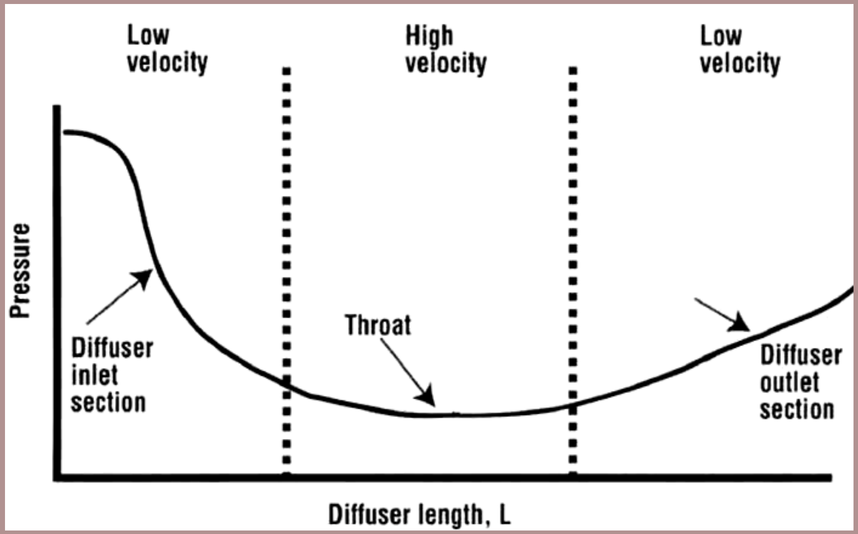
CENTRIFUGAL PUMP





EJECTOR PUMP

The design is quite simple; an ejector is a pumping device. It has no moving parts. Rather, it uses a fluid or gas as a motive force. Very often, the motive fluid is steam and the device is called a "steam jet ejector." Basic ejector components are the steam chest, nozzle, suction, throat, diffuser and the discharge



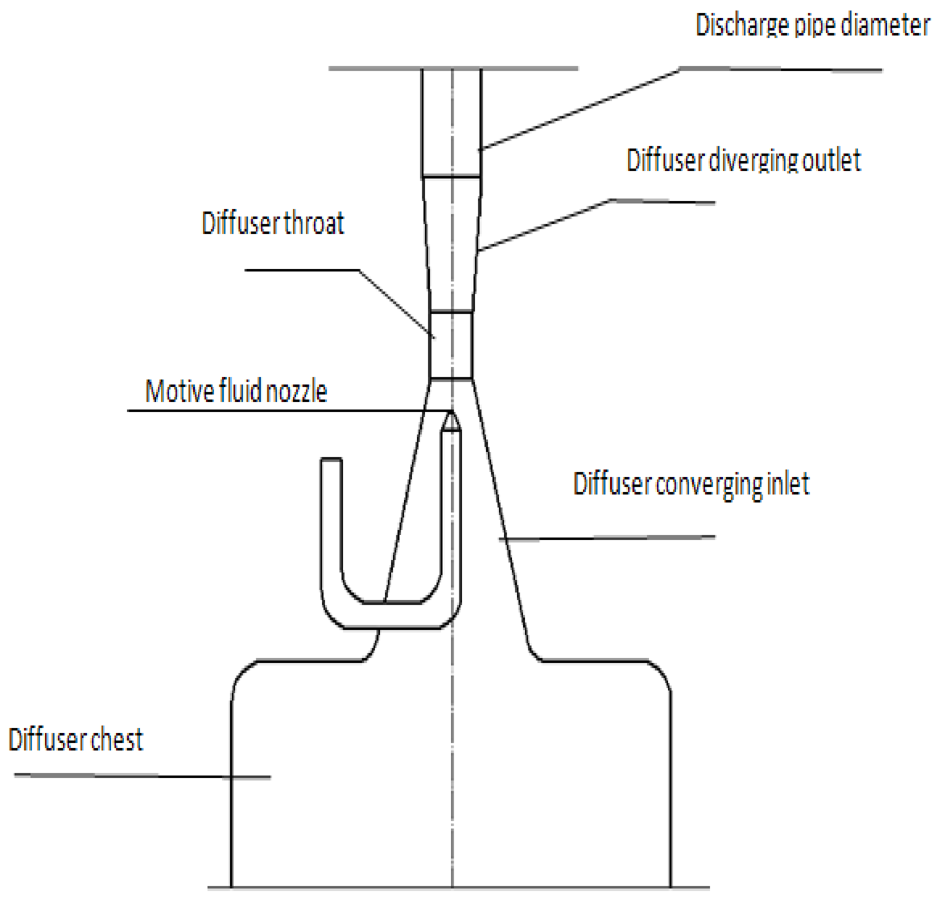
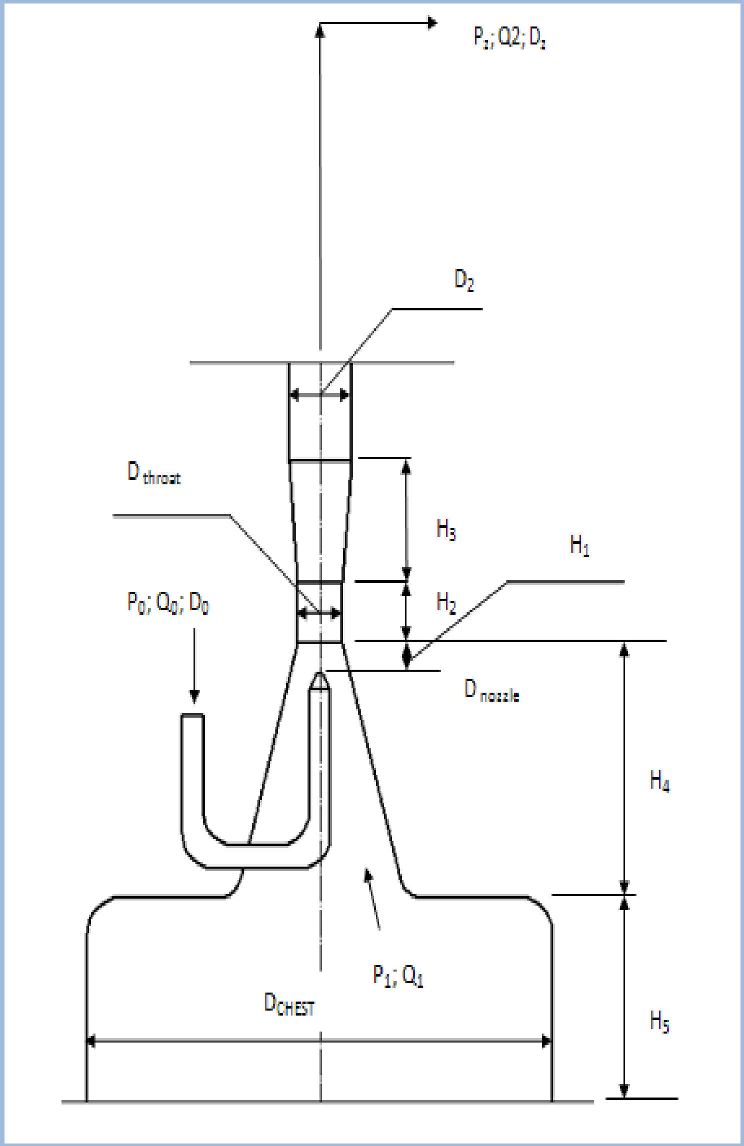


FIG.4.5 PARTS OF EJECTOR PUMP FOR DREDGING

EJECTOR PUMP SPECIFICATIONS



- D_2**=50mm-** discharge pipe diameter from previous calculations;
- $H_3=(2...5)D_{THROAT}$ -from hydraulic engineer's manual;
- $H_2=(2...5)D_{NOZZLE}$-from hydraulic engineer's manual;
- $H_1=(0.8...3)D_{NOZZLE}$ -from hydraulic engineer's manual;
- These conditions are required to be met in throat depending on the kind of pressure needed in the diverging discharge line.
- The converging-diverging angles are within the range of (5......15) degrees

$$\frac{Area_{throat}}{Area_{mottive-fluid-nozzle}} \geq 4; high-pressure$$

$$\frac{Area_{throat}}{Area_{mottive-fluid-nozzle}} < 4; low-pressure$$

For an ejector pump, the discharge flow rate (Q_2) is the sum of the motive fluid's flow rate the inlet fluid's flow rate: where the motive fluid constitutes 20% of the total flow rate and the inlet fluid accounts for the remaining 80%.

$$Q_2 = Q_0 + Q_1 \qquad \Rightarrow Q_0 = 0.2Q_2 = 0.2 \times 0.0042 = 0.00084 m^3/s$$

$$P_0 = (P_0 - P_2) + \Delta P_\Sigma \qquad (P_0 - P_2) = \Delta P_0$$

$$\Rightarrow \Delta P_0 = \rho_0 g h$$

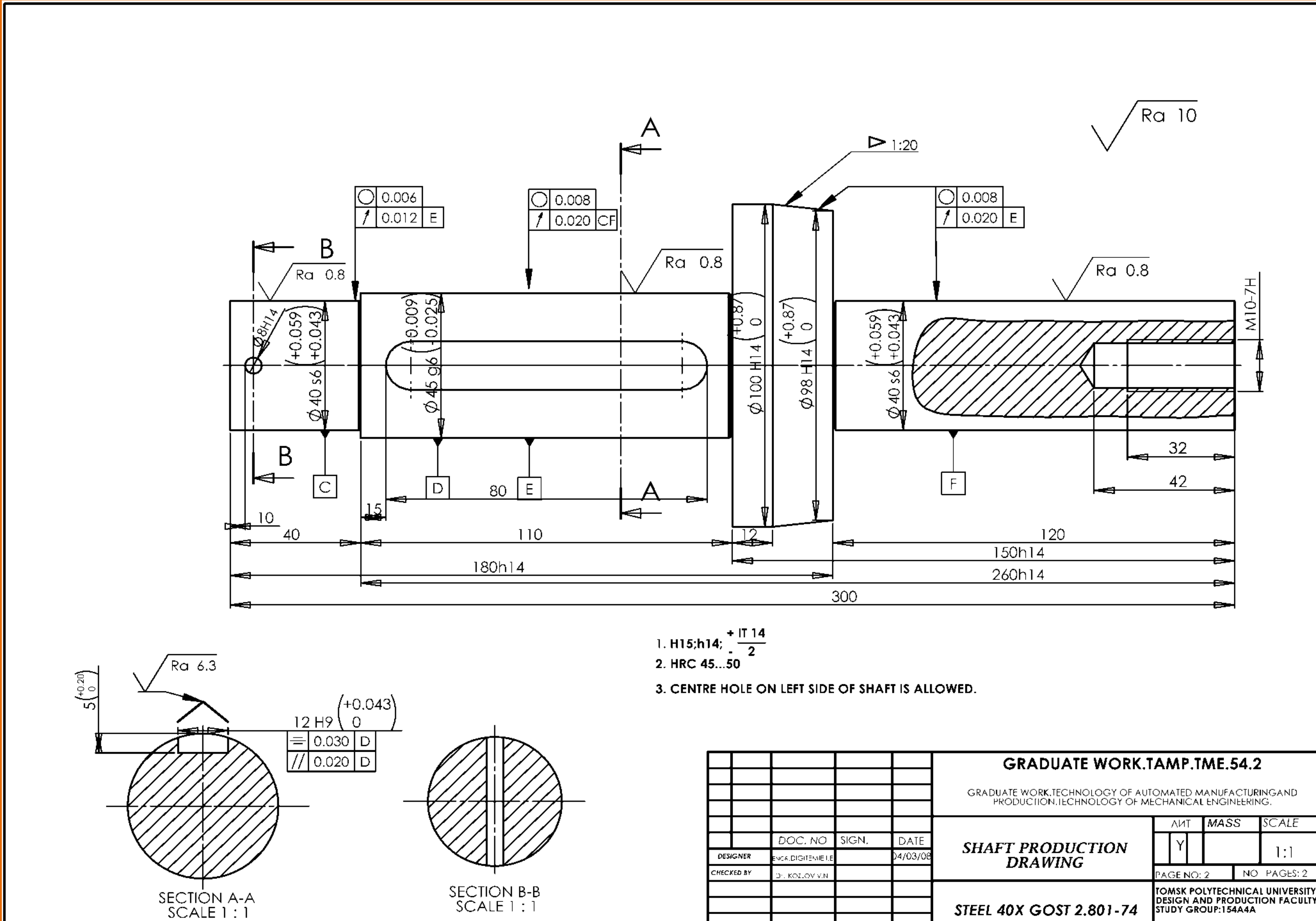
COMPARISON OF CENTRIFUGAL AND EJECTOR PUMP

CHARACTERISTICS	CENTRIFUGAL PUMP	EJECTORPUMP
Discharge diameter	50mm	50mm
Discharge velocity	2.5m/s	2.5m/s
Suction velocity	0.3m/s	----------------
Total pressure loss	0.4MPa	0.4MPa
Pump power	1.67Kwatts	1.64Kwatts
Construction	Very hard	Quite simple
Cavitation	Certain	Practically no
Vane/bearing damage	yes	no
Shaft breakage	yes	no
Rotating parts	yes	no

CONCLUSION

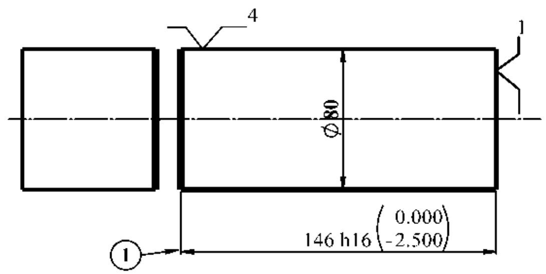
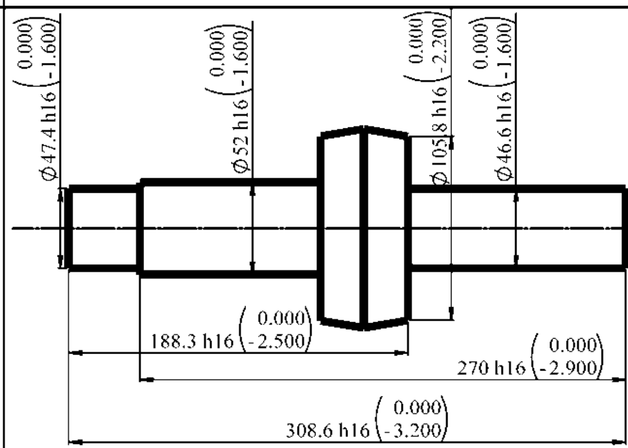
Based on the content of the table above we conclude that the ejector pump is preferable to centrifugal pump in the design of a mini dredger.

PRODUCTION PROCESS



PRODUCTION PROCESS

TOMSK POLYTECHNIC UNIVERSITY	DEPARTMENT OF MECHANICAL ENGINEERING
PRODUCTION PROCESS	
MATERIAL: STEEL 40X	BLANK — TYPE: CYLINDRICAL BAR; 1

Operation	Passes	DESCRIPTION OF OPERATION	OPERATIONAL SKETCH	MACHINE TOOL	ATTACHMENT	CUTTING TOOL	MEASURING TOOL	9	№ OF PASSES	11	12	DEPTH OF CUT, mm	mm rev	m/min	16	17	To,min	TBc	Tn3	Tшт	Tшт.к	23
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1	**Operation № 1** **1.** Clamp iron bar on milling machine vice 2. Cut off the required length (1). 3. Take off the cut off length.				HSS P6M5		1		O-800 B-7	80	.....	Sz-0.02 S-1.84	22	12	80	3.72					
2		**Operation № 2** 1. Take the required length to the foundry for the next transitional operation. 2. Stamp forge the work piece in accordance with the drawing. 3. Take off the blank form the stamp and leave to cool						....	....	....	....	....	...	....	....	...	...					

GRADUATE WORK.TAMP.TME.54.2

SHAFT PRODUCTION PROCCESS

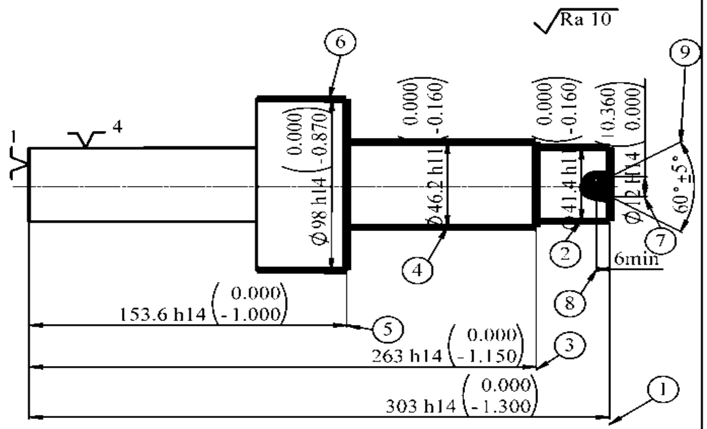
TOMSK POLYTECHNIC UNIVERSITY, INSTITUTE OF MECHANICAL ENGINEERING, STUDY GROUP

PRODUCTION PROCESS

1	2	3	4

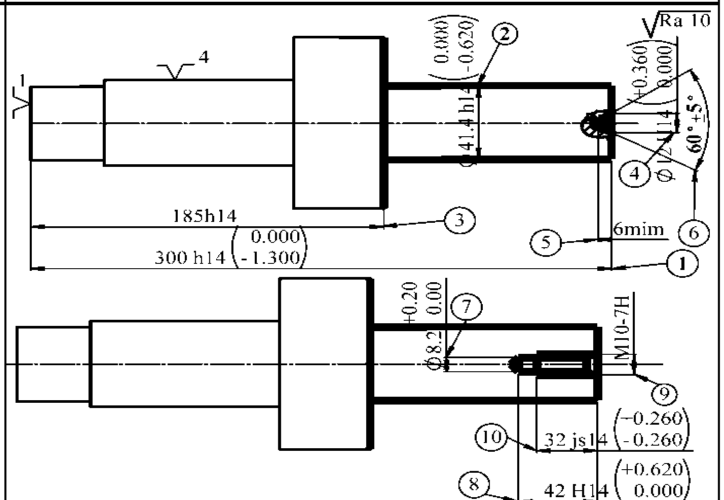
Operation № 3

1. Clamp the blank on the lathe 3 jaw chuck.
2. Face the right end of the work piece and make the length (1).
3. Centre drill the hole (7), sustain the sizes (8), (9).
4. Rough turn the surface(2) sustaining the size (3).
5. Rough turn the surface (4) sustaining the size (5).
6. Rough turn the surface (6).
7. Remove work piece from the lathe chuck.



Operation № 4

1. Clamp the machined half of the work piece.
2. Face the right end , sustaining the size (1).
3. Turn the surface (2) sustaining the size (3).
4. Centre drill the hole (4) sustaining the sizes (5),(6).
5. Drill a hole (7) with depth (8).
6. Tap the same hole (9) sustaining the size (10).
7. Remove the work piece from the 3- jaw chuck.

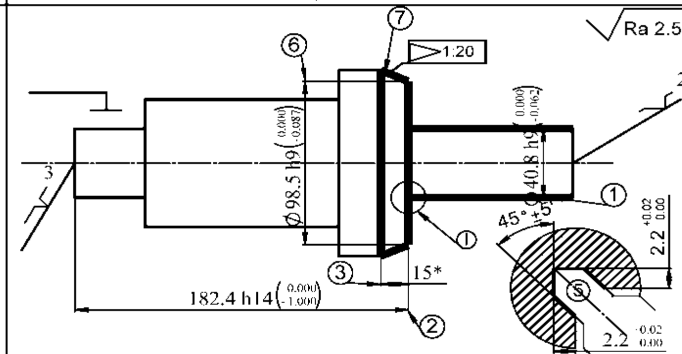
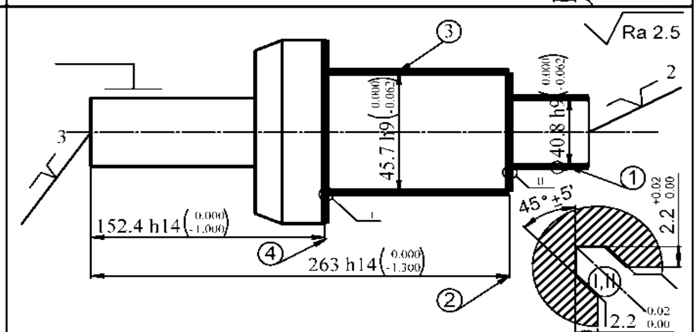
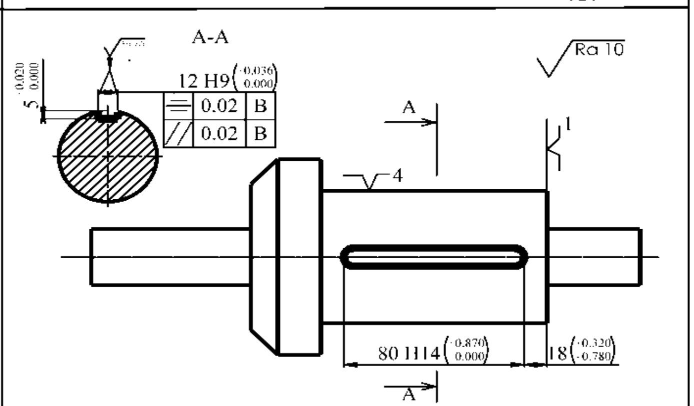


5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
		T5K6		1	3	D=47.4		3	0.115		630	93.8	0.33					
		P6M5		1	1	D=12	11	6	0.09		1600	45.2	0.08					
		T5K6		1	1	D=47.4	40	3.1	0.23		630	93.8	0.28					
		T5K6		1	2	D=52	110	1.9	0.23		1600	102.9	0.76					
		T5K6		1	1	D=105.8	30	3.35	0.23		315	104.7	1.45					
		T5K6		1	2	D=46.6	24	3	0.115		630	93.8	0.33					
		T5K6		1	2	D=46.7	115	2.68	0.23		630	93.8	0.79					
		P6M5		1	2	D=12	11	6	0.09		1600	45.2	0.08					
		P6M5		1	1	D=10	45	5	0.09		1600	45.2	0.47					
		P6M5		1	1	D=8.5	32	0.8	1.5		80	2.5	0.27					

GRADUATE WORK.TAMP.TME.54.2

SHAFT PRODUCTION PROCCESS

PRODUCTION PROCESS

1	2	3	4	5	6
		Operation № 5 1. Clamp work piece between centers on a lathe for finish turning. 2. Turn the surface (1) sustaining the size 2). 3.Taper turn surface (7) sustaining the sizes(3). 4 Make the relief cut (I) for safe grinding purpose. 5- Remove work piece from centers.			
		Operation № 6 1. Clamp work piece between centers. 2. Turn the surface (1) sustaining the size (2). 3. Turn the surface(3) sustaining the size (4) 4 Make the relief cuts(I),(II) for safe grinding purpose. 5 Remove work piece from lathe centers.			
		Operation № 7 1. Clamp work on milling v-block. 2. Mill the key slot (1) to the depth of (2) sustaining the sizes (3), (4). 4. Unclamp work piece from v-block.			

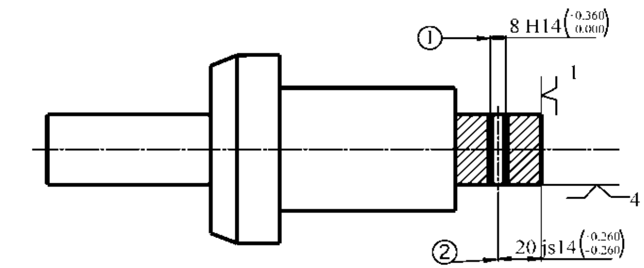
Operation	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
№ 5	T5K6		1	1	D 41.4	115	0.1	0.33		1600	203	0.72					
№ 5	P6M5		1	1	D=1000	ι	B=17	0.07		80	24.8	0.18					
№ 5	P6M5		1	1	D–40.8	2.83	2.02	0.07		80	10.5	0.51					
№ 6	T5K6		1	1	D=41.4	37	0.33	0.1		1600	208.1	0.23					
№ 6	T5K6		1	1	D 46.2	111	0.28	0.1		1600	232.2	0.69					
№ 6	P6M5		1	2	D 40.8	2.83	2.02	0.07		80	10.5	0.51					
№ 7					D=12	5	B=12	Szl–0.06	5.67	315	11.88	2.12					
№ 7					D–12	80	B–12	Sza=0.009		315	11.88						

SHAFT PRODUCTION PROCCESS

PRODUCTION PROCESS

Operation № 8

1. Clamp work piece on v-block.
2. Drill the hole of (1) sustaining the distance (2).
3. Remove work piece from v-block.

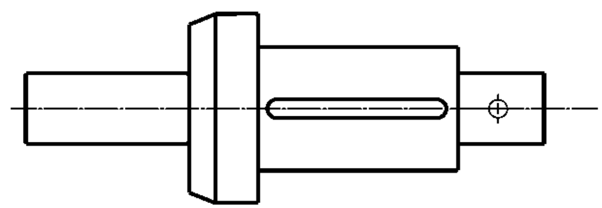


7	8	9	10	11	12	13	14	16	15	17	18
P6M5		1	1	D 8	41	4	0.09		1600	45.2	0.29

Operation № 8.2

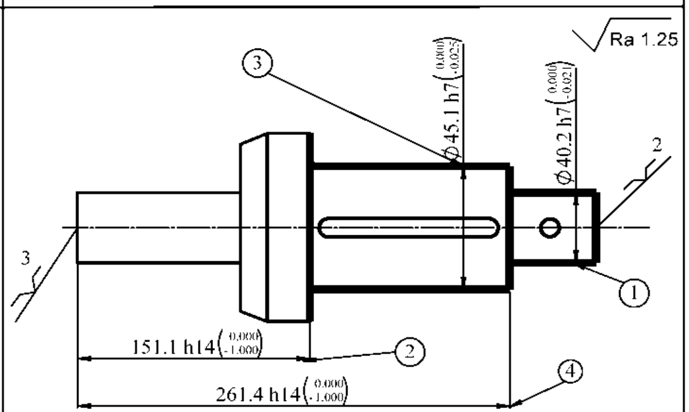
[HEAT TREATMENT OPERATION]

1. Take work piece for heat treatment (quench and temper to HRC 45…50).



Operation № 9

1. Clamp work piece between centers.
2. Grind the surface (1) and sustain the size (2)
3. Grind the surface (3) and sustain the size (4).
4. Remove work piece from centres.



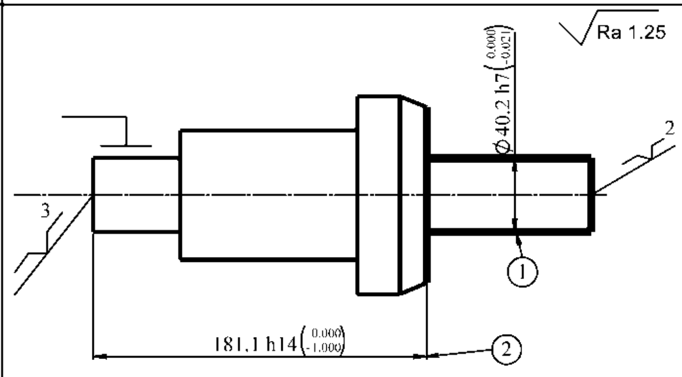
7	8	9	10	11	12	13	14	16	15	17	18
740X127X50 25 40 CM2 K5		1	8	D−750	40	0.05	35	2240	nwp 160 ngw−1000	v wp−30 v gw−35	0.05
740X127X50 25 40 CM2 K5		1	8	D−750	110	0.05	35	2240	nwp−160 ngw−1000	v wp−22.97 v gw−35	0.05

SHAFT PRODUCTION PROCESS

PRODUCTION PROCESS

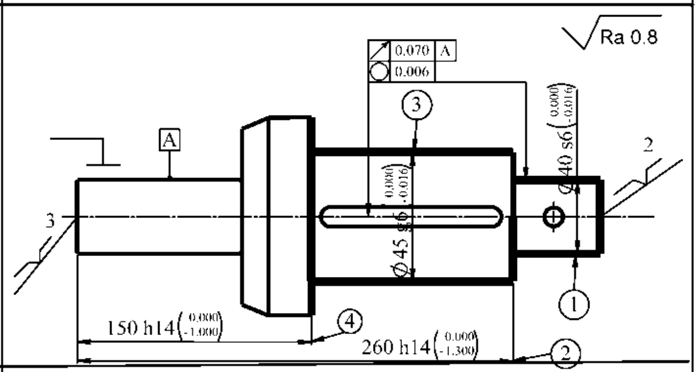
Operation №10

1. Clamp work piece between centers.
2. Grind the surface (1) and sustain the length (2).
3. Remove work piece from centres.



Operation №11

1. Clamp work piece between centers.
2. Finish grind the surface (1) and sustain the size (2).
3. Finish grind the surface (3) and sustain the size (4).
4. Remove work piece from centres.

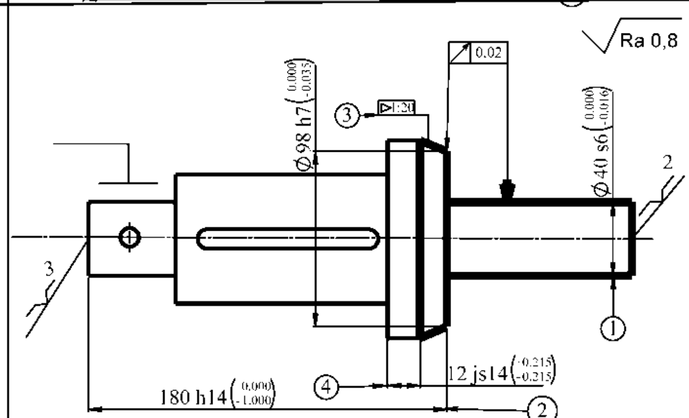


Operation №12

1. Clamp work piece between centers.
2. Finish grind the surface (1) and sustain the size (2).
3. Remove work piece from centres.

Operation №13

1. Clamp work piece between centers.
2. Finish grind conical surface (3) and maintain the size (4).
3. Remove work piece from centers.



Operation	7	9	10	11	12	13	14	15	16	17	18
№10	740X127X50 25 40 CM2 K5	1	8	D=750	120	0.05	35	2240	nwp=160 ngw=1000	v wp=30 v gw=35	0.05
№11	740X127X50 25 40 CM2 K5	1	4	D=750	40	0.05	35	2240	nwp=160 ngw=1000	v wp=30 v gw=35	0.02
№11	740X127X50 25 40 CM2 K5	1	3	D=750	110	0.05	35	2240	nwp=160 ngw=1000	v wp=30 v gw=35	0.05
№12/13	740X127X50 25 40 CM2 K5	1	4	D=750	120	0.05	35	2240	nwp=160 ngw=1000	v wp=30 v gw=35	0.05

SHAFT PRODUCTION PROCESS