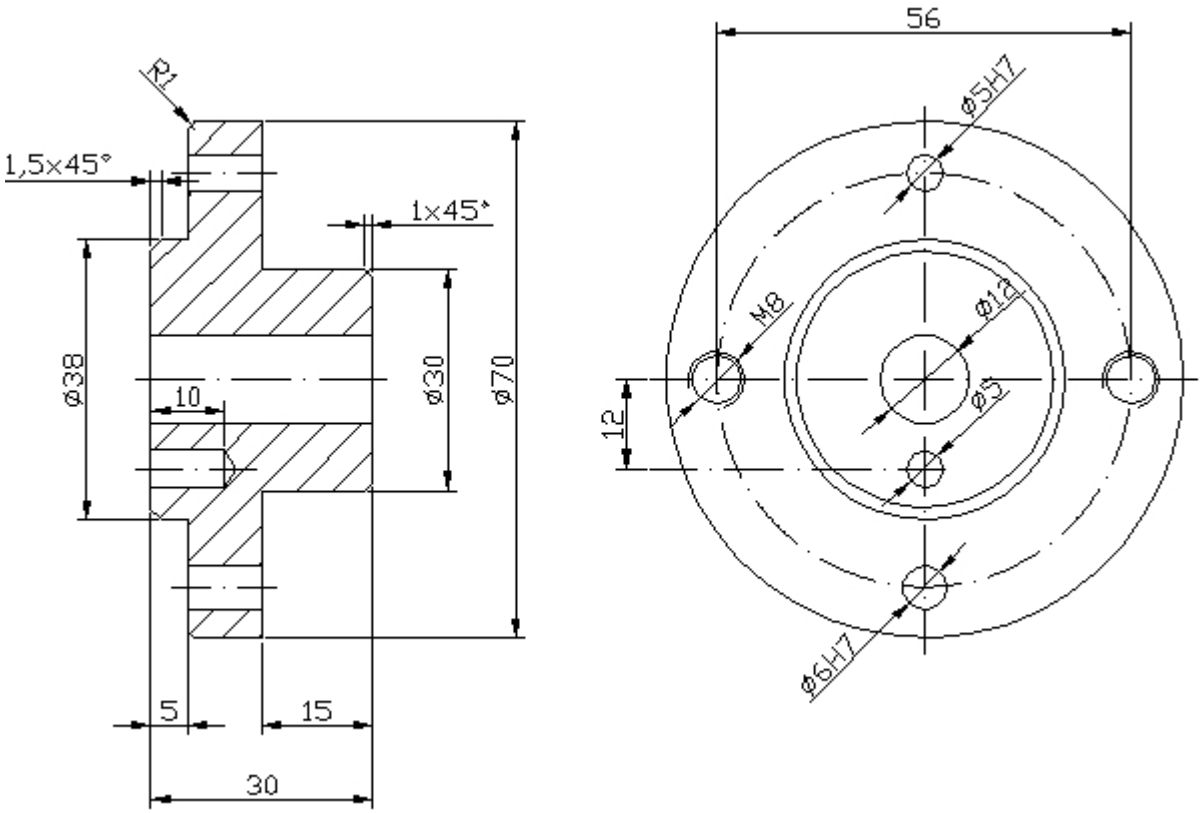
Design project II – Design of single-purpose machine

Solution example:

1. Task

For specific component (from production drawing) realize complete design configuration of single-purpose machine for machining Ø5H7, Ø6H7, Ø5, Ø12 and threads M8.

Component drawing:



2. Operations analysis

Material: steel 12 050.0

Operating schedule according to number of position:

1. Position – fixing component
2. Position – drilling: 2 holes for thread M8 to Ø6,8
   1 hole for Ø6H7 to Ø5,6
   1 hole for Ø5H7 to Ø4,7
3. Position – hole drilling to Ø12
4. Position – hole drilling to Ø5 depth h=10
5. Position – threading M8
6. Position – reaming of holes Ø6H7 and Ø5H7

3. Cutting conditions

Operation	Cutting velocity - v [m/min]	n [rpm]	Feed [mm per rev]
Drilling ∅ 4,7	21,865	1450	0,080
Drilling ∅ 5	21,991	1400	0,085
Drilling ∅ 5,6	23,687	1300	0,095
Drilling ∅ 6,8	22,987	1100	0,105
Drilling ∅ 12	21,865	580	0,170
Threading M8		280	
Reaming ∅ 5H7	2,784	500	0,440
Reaming ∅ 6H7	2,784	450	0,480

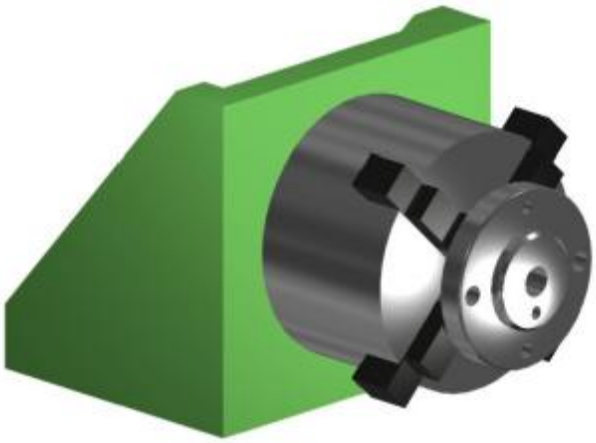
Tab.1

4. Machine configuration design

According to size of component are chosen components of MUTIPOST kit. Substructure is a base table. For positioning service space in vertical direction is used step-up spacer, which is mounted on base block. On base block sides are adjustable consoles with machining units on pads. Jack supports are located on rotary table that is on base block. For drive of power mechanisms is used hydraulic aggregate. Cooling aggregate is engaged under base table. A next accessory is electro distribution transformer.

5. A fixing and jack support design

Used jack support n. 243803.



6. Calculation of operation time and basic machine cycle

Feed to workpiece				Machining			Feed to base position			Operation time
Operation	Feed	Velocity	Time	Feed	Velocity	Time	Feed	Velocity	Time	Total
n.	[mm]	[m/min]	[s]	[mm]	[m/min]	[s]	[mm]	[m/min]	[s]	[s]
2	30	3	0,6	20	0,10	12	50	3	1	13,6
3	25	3	0,5	40	0,10	24	65	3	1,2	25,7
4	25	3	0,5	15	0,10	9	40	3	0,8	10,3
5				65+65	0,35	11,4				22,8
6	30	3	0,6	20	0,20	6	50	3	1	7,6

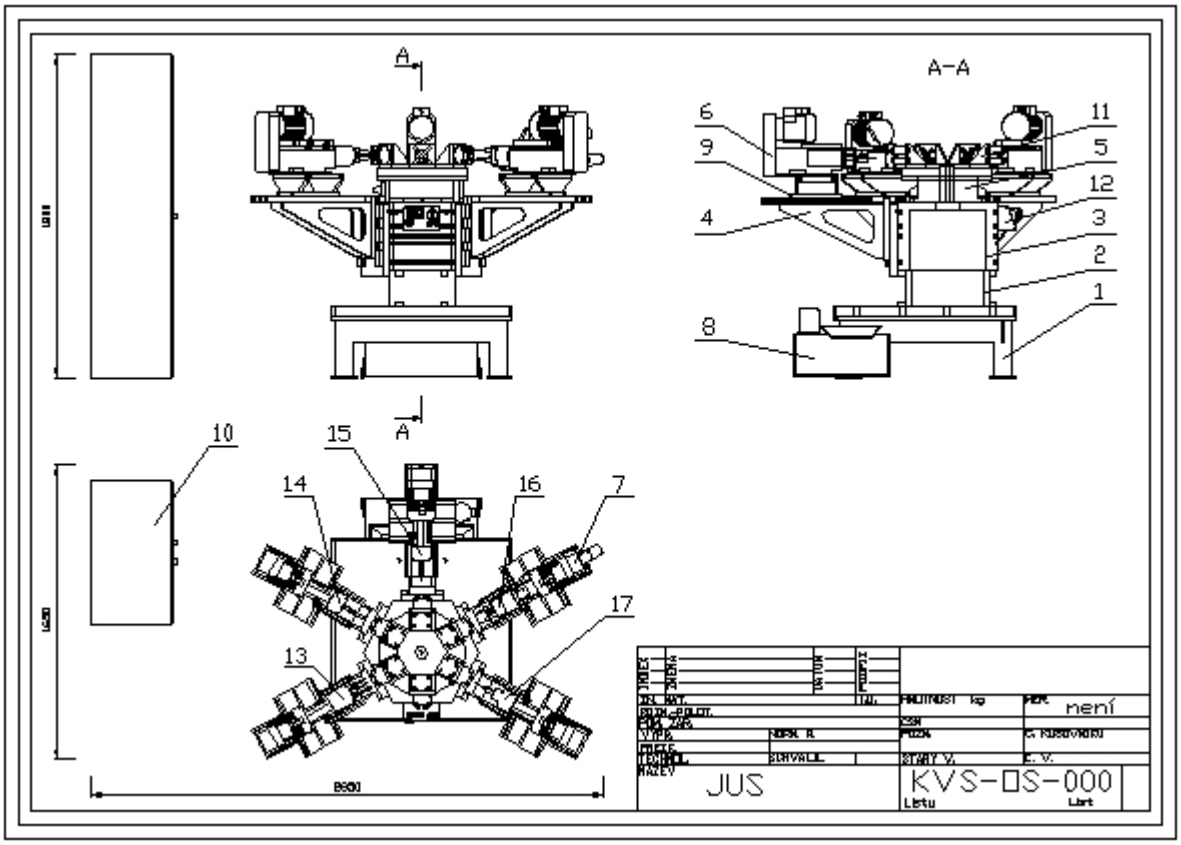
tab. 2

Basic machine cycle is according to longest operation – operation n. 3

Component change:	during working cycle
Feeds:	25,7 s
Table turning:	6,0 s
Total:	31,7 s
Locking:	4,3 s
Machine cycle:	35 s

Machine production: about 102 pieces per hour (100% machine utilization)

7. Machine design

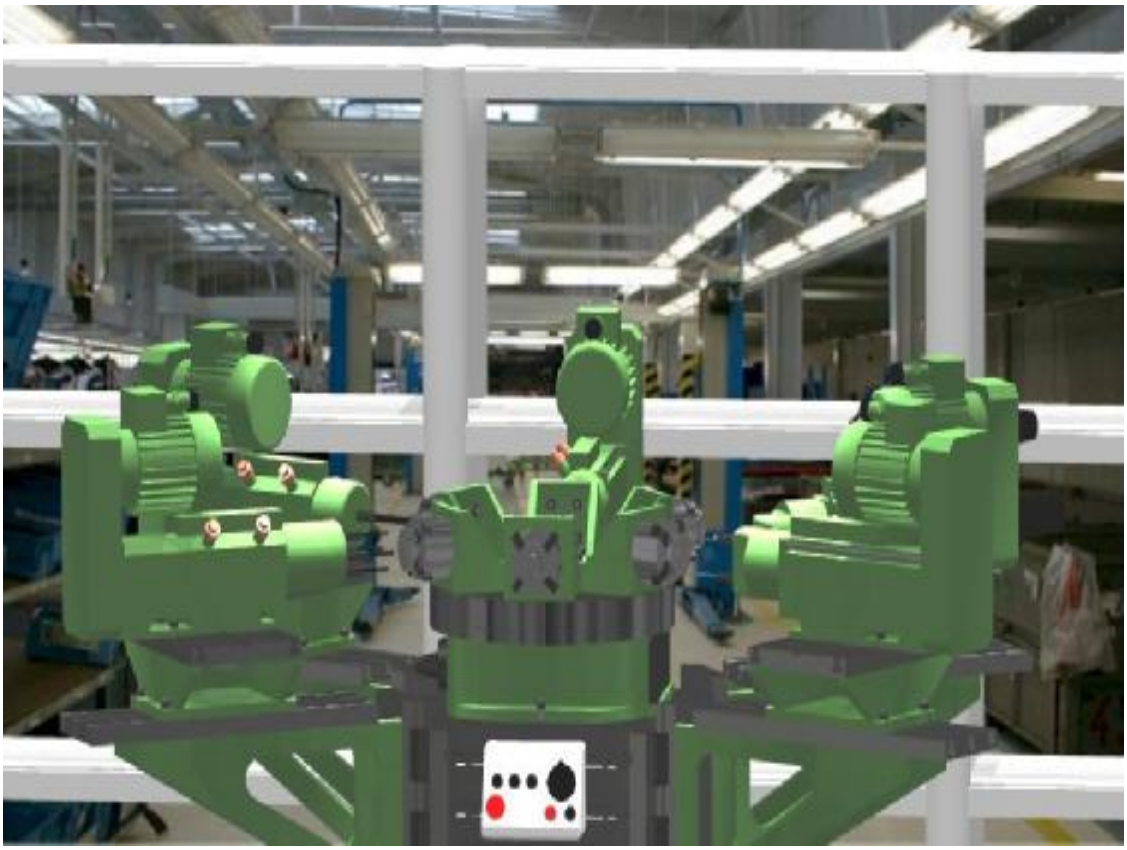


7.1. Bill of materials

Abstract from bill of materials designed machine

POS.	NAME - DIMENSIONS	DRAWING-STANDARD	MATERIAL	U.	Q.	WT. kg
1	Base table ZS-1				1	
2	Spacer MZK-2				1	
3	Hexagonal base block ZK-6				1	
4	Adjustable console KS-1				5	
5	Hydraulic rotary table EKDY-500				1	
6	Hydraulic drilling unit VJHP-10				4	
7	Thread unit ZJ 16-100				1	
8	Cooling aggregate CH-2				1	
9	Symmetric pad PS-1				5	
10	Transformer				1	
11	Jack suport_243803				6	
12	Control panel				1	
13	Multi-spindle drilling head VVH_OP2				1	
14	Multi-spindle drilling head VVH_OP3				1	
15	Multi-spindle drilling head VVH_OP4				1	
16	Multi-spindle drilling head VVH_OP5				1	
17	Multi-spindle drilling head VVH_OP6				1	

8. Service instruction



8.1. Machine action statement

The machine is identified for machining of component according to model. Component loading is done by hands. At place for loading is inserted semi product in to the chuck and held in chuck Turning by rotary table are components transferred to individual positions, where are done operations. After table locking units move directly to component by speed feed, speed feed switch to work feed and when operations are done units will move back by speed feed. When component is back in loading position, component will be unloaded and after cleaning jack support new component – semi product will be loaded.
Machine cycle is half automatic or full automatic and it is remote-controlled by switches from operators place. Every operations are possible cancel and units will move back to base positions.

8.2. Control

Machine is controlled from operators place, where are located all control elements. Central switch is locking. When central switch, hydraulic aggregate, cooling aggregate (individual switches) are on, machine will be in standby mode. Pushing button START starts machine cycle. After finish operations machine is automatically switched to standby mode. On control panel is rotary switch that is used for unit individual control. On position 0 machine is in half automatic mode, all units working. Switching of rotary switch to others positions: 1, 2, 3, 4 or 5 we can choose only required unit. On position 6 is machine full automatic mode, machine cycle time is set on 35s. Button STOP switch off full automatic mode and it is used together with control individual units. On control panel is button CENTRAL STOP too. It is for emergency state. Lights on control panel inform about machine status.

8.3. Machine set-up

Jack support setting to correct position is done by ground plug that is held in chuck and by deviation meter that is held in unit spindle. Axis in unit direction is setting by clamp moving in rotary table grooves. Horizontal axis is setting by adjustable console. Correct feed and speed feed length on drilling units is control by adjustable trips. For threaded units correct feed and stroke are achieved by guide screw that is part of unit.

8.4. Machine attendance

Machine check is every time on start and the end of shifts, when is need to clean surface of contact and working surface and spread these by oil. Chip removal from machine is every time on the end of shift and next according to requirement. Lubricating, oil and cooling emulsion refilling is done once a week.
Machine is needed to keep clean and work in common workshop temperatures.

8.5. Work accuracy check

Every time on the start of work on machine is needed to check first, third, tenth and every next fiftieth machine-made component.

8.6. Work safety

On the machine is needed to keep safety regulations according to standard ČSN for working machines.

9. Economic analysis

This economic analysis is only common. It can be use as instruction for real economic analysis.

Technical economic audit of single-purpose machine

1	Machine number		
2	Consumer - user		
3	Component - name, mark		
4	Year production	x	
5	Variant	Universal convectional machine	Single-purpose machine
6	Piece time t [min]	tk	tn
7	Coef. machine employment V	Vk	Vn
8	Type and number of machines		Type: single-purpose machine
			N. of positions:
		Total number of machines: xk	N. of spindles:
9	Machine weight total m [t]	m_k	m_n
10	Covered area S [m^2]	Sk	Sn

11	Total power input Pc [kW]	Pck	Pcn
12	Number of workers t1	Dk * Rk=t1k	Dn*Rn=t1n
13	Machine price C [Kč]	Ck	Cn
14	Wage cost per hour	Kč/h*overhead cost*t1k =Mk	Kč/h*overhead cost*t1n=Mn
	M [Kč/h]		
15	Amortization per year totally	Ck * alfa = Rk	Cn * alfa = Rn
	R [Kč]		
16	Machine rate	Rk / 3 600 = Ssk	Rn / 3 600 =Ssn
	S_s [Kč/h]		
17	Total rate per hour	Mk + Ssk = Sk	Mn + Ssn = Sn
	S [Kč/h]		
18	Machine power per hour	60 / (t1k / xk) = Pk	60 / (t1n / 1) = Pn
	P [pieces/h]		
19	Piece cost	Sk / Pk = Nk	Sn / Pn = Nn
	N [Kč/h]		

alfa=0,2 (amortization coefficient)
Number of workers per shift D
Number of shifts R

Contributions and reductions for user of single-purpose machine

20	Economic contribution for 1 year	(Nk - Nn) * x = U1	
	U_1 [Kč/r]		
21	Time of settlement (years)	Cn / U1 = Tu	
	Tu [years]		
22	Production increase	(t1k / t1n) * 100% = A	
	A [%]		
23	Saving of material relatively	mk / mn = B	
	B [t]		
24	Saving of areas	Sk - Sn = C	
	C [m^2]		
25	Saving of power input	Pck - Pcn = D	
	D [kW]		
26	Saving of workers	t1k - t1n = E	
	E		
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