Proceedings of the 17th International Conference on Manufacturing Systems – ICMaS
ISSN 1842-3183
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ADJACENT INSTALLATIONS FOR MACHINE-TOOLS. MODERN COOLING SYSTEMS FOR TOOL AND PIECE

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Abstract: *In this paper will be presented modern types of installations for tools' cooling which work in hard conditions, specific to high speed cutting (HSC). There are installations which work with cooling fluids water based, specific emulations for the machining. For this type of installations are used modern components characterised by performances which make them competitive on the manufacturers market of cooling equipments.*

Key words: *heavy machine-tools, high speed cutting, adjacent installations.*

1. INTRODUCTION

In the actual context of the increase of the speed cutting, the cooling problem of the tool and piece becomes very important. For the heavy machine-tools, which work in hard cutting conditions, there is a must to use performance cooling systems, controlled by numerical control equipment (see [3]).

2. TOOL COOLING INSTALLATIONS FOR MODERN MACHINE-TOOLS

Figure 1 presents the scheme of a complex cooling installation used for vertical modern lathes (see [2]).

The pumps 2, 3 and 40 are mounted on the basin 1. The pump 2 sends the cooling fluid towards a thermostat installation which will assure a constant temperature. Coupling and decoupling of this circuit is realised with the shut-off valve 5. The pump 3 works at maximum pressure, adjusted at 4 bar with the pressure valve 6. The pressure will be checked on the manometer 7. The directional control valve 8 allows the cooling of the turning tools, and the directional control valve 9 allows the cooling of diamond milling device of the abrasive disc. From the shut-off valves 10 and 11 the pressure point are realised for different accessories, for example the manually washing pistol for pieces.

The electro-pump 4 can work at two pressures predefined. The valve 12 is set at a maximum pressure of 25 bar, and the valve 13 only at 6 bar.

If the directional control valve with pneumatic control 14 is not actuated, on the circuit "a" a pressure of 6 bar is obtained, pressure enough for the exterior tool cooling (see [4]). By actuating the directional control valve 14 the maximum pressure becomes of 25 bar, value which is necessary for the tools with internal cooling circuit.

Figure 1 contains also: 15 – minimum – maximum level indicator, 16 and 17 are switches which confirm the state of the paper filter, 18 – paper filtration system. The function of the installation results from the cyclorama from Table 1.

The pumps used in this type of installations are special pumps, which have the characteristics flow pressure as the one in Fig. 2. Thus, on the characteristic for the pump 18 at 25 l/min a maximum pressure of 16 bar can be obtained.

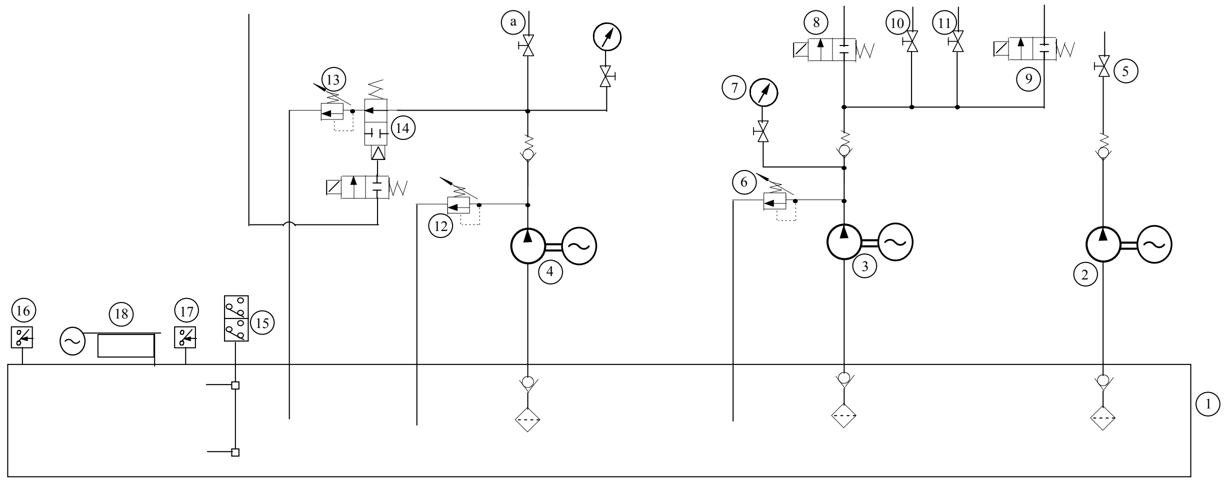

Fig. 1. The scheme of a complex cooling installation used for vertical modern lathes.

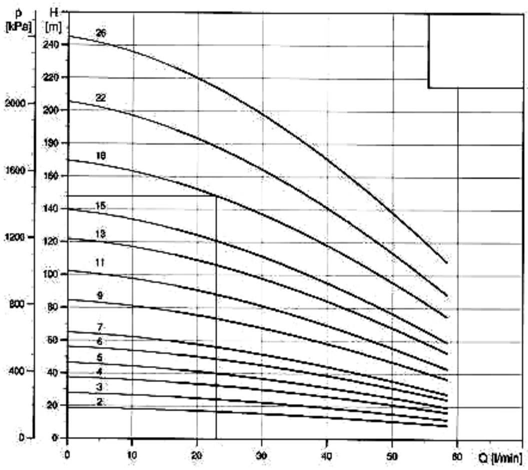

Fig. 2. The characteristics flow pressure.

Table 1

The function of the installation

Nr	Phase	Electro Magnets		Pressure switch		Electric Motors		Observations
		1E	2E	7	6	24	25	
1	STOP	-	-	-	-	-	-	
2	START Cooling at 7 bar.	After 5s +	-	+	-	+	-	The engine starts with 5 s before the coupling of the directional control valve 11.
3	START Cooling at 25-30 bar.	-	After 5s +	-	+	-	+	The engine starts with 5 s before the coupling of the directional control valve 10.

The cooling installation from Fig.3 has been realised for a vertical lathe.

The installation offers the possibility of exterior tool cooling at a maximum pressure of 10 bar, with a flow of 40 l/min, but also of interior tool cooling with a 30 l/min flow and 30 bar pressure.

It can be noticed that for the cooling pressure confirmation, it is compulsory for the CNC machines to use the pressure switches 6 and 7.

Figure 3 contains also: 1 – basin, 2 – high pressure electro-pump, 3 – low pressure electro-pump, 4,5 – check valves, 6, 7 – pressure switches, 8, 9 – manometers, 10, 11 – directional control valves, 12, 13, 14, 15, 20 – shut-off valves, 16, 17, 18, 19 – check valves, 21 – filling plug, 22 – level indicator, 23 – electric level indicator.

For the CNC machine-tools the cooling installation is controlled by the machine's software, function of the machining procedure used (see [1]).

It exist modern cooling systems dedicated for the tools which work with high speed cutting which can supply up to four specific cooling circuits.

3. MATHEMATIC MODELS FOR THE COOLING SYSTEMS

For high cutting speeds and if the machine's precision is influenced by environment's temperature, it appears the problem to maintain a constant temperature for the cooling fluid.

If the dissipated heat by cutting process it is known, it can be considered that a part of the heat is dissipated to the environment and the rest of it continues to increase the temperature of the emulsion:

$$W \cdot \mathrm{d}t = V \cdot \rho \cdot C \cdot \mathrm{d}\theta + E \cdot S \cdot \theta \cdot \mathrm{d}t \,. \qquad (1)$$

In equation 1: W [W] – the power dissipated by the cutting process in time, V [m^3] – volume of emulsion, C [J / (kg · ^{0}K)] – specific heat of the emulsion, $d\theta$ [^{0}K] – temperature increase in comparison with environment's temperature in the time dt, E [J / (m^2 · s · ^{0}K)] – heat evacuation coefficient by radiation.

After solving the differential equation (1), the equation (2) will be obtained:

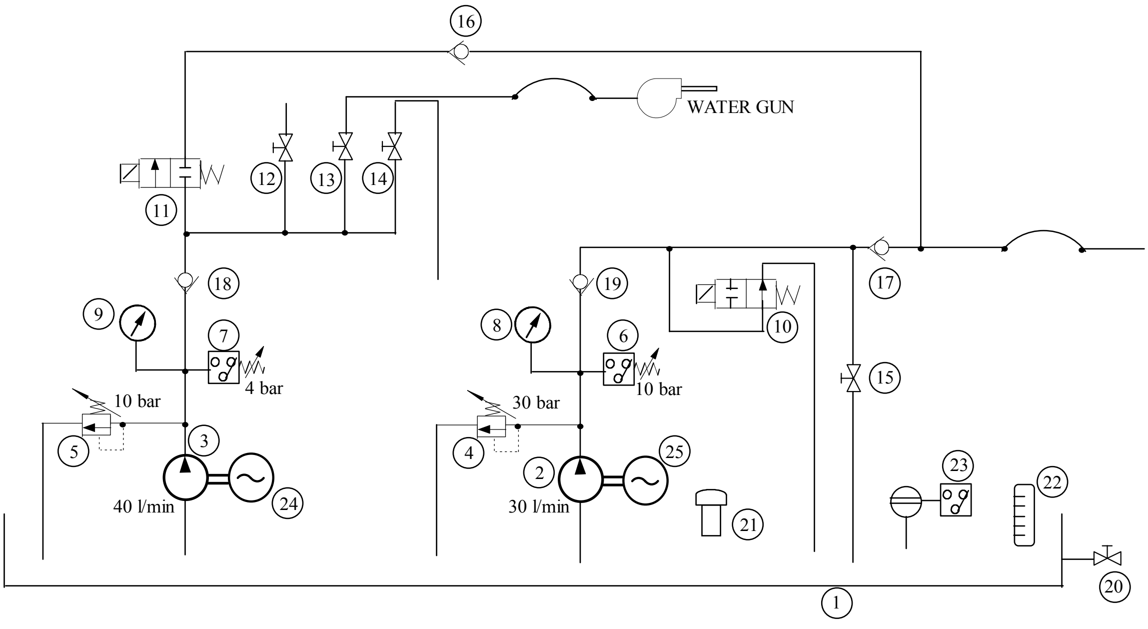

Fig. 3. The cooling installation for a vertical lathe.

$$\theta = \frac{W}{E \cdot S}\left(1 - e^{-\frac{E \cdot S}{V \cdot \rho \cdot C} \cdot t}\right) + \theta_0 \,. \qquad (2)$$

For the initial moment the emulsion temperature is considered equal with the environment temperature: $\theta = \theta_0$. If it is needed to determine the temperature after the stabilisation of the thermal regime, for continuous function, in the equation (2) the solution for t tending toward infinite is:

$$\theta_F = \frac{W \cdot E}{S} + \theta_0 \,. \qquad (3)$$

In the equation (3): θ_F – final temperature. The heating characteristic is presented in Fig. 4.

If the final temperature exceeds the imposed temperature, it is recommended in the first phase the increase of the emulsion's volume and/or the increase of the radiation surface (S) by using some radiators.

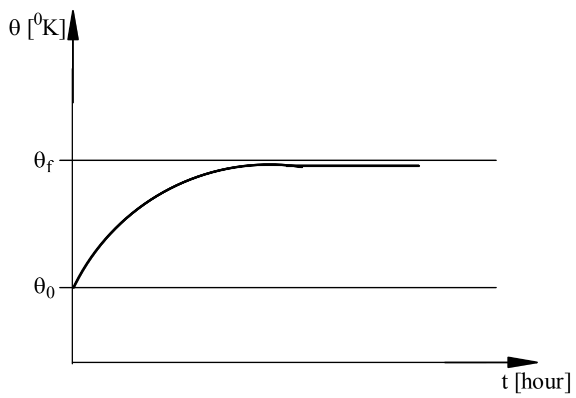

Fig. 4. The heating characteristic.

If the temperature, in real function time, increases over the recommended values for a machine-tool, the emulsion has to be cooled off. For cooling the emulsion are used thermostat refrigerated systems.

They are produced by specialised companies; their calculus and choosing are made based on the specific documentation.

In the case that there are more CNC machine-tools which work in HSC conditions in the same hall, there are centralised installations for filtration and cooling of the emulsion for all the machine-tools. The basins of each machine-tool are supplied from this central installation by pumps systems. In Figure 5 it is presented the schema of the cooling installation of such a machine-tool.

The cooling installation assures the necessary emulsion for all operations.

The emulsion tank has the volume of 3000 l. this is a separated construction placed behind the machine.

Three electro-pumps are used as follows:

- an electro-pump of 600 l/min at maximum pressure of 6 bar, 1,
- an electro-pump of 50 l/min at maximum pressure of 20 bar, 2,
- an electro-pump of 50 l/min at maximum pressure of 6 bar, 3.

The electro-pump 1 aspires by the shut-off valve 4 and supplies the electro-pneumatic directional control valve 7 (see [5]). If it is not actuated, the cooling fluid passed by the check valve 8 and arrives in the supply pipes system in the working area.

The pressure can be read on the manometer 9 and it is electrically confirmed with the pressure switch 10. By actuating the directional control valve 7 the fluid arrives directly in the tank.

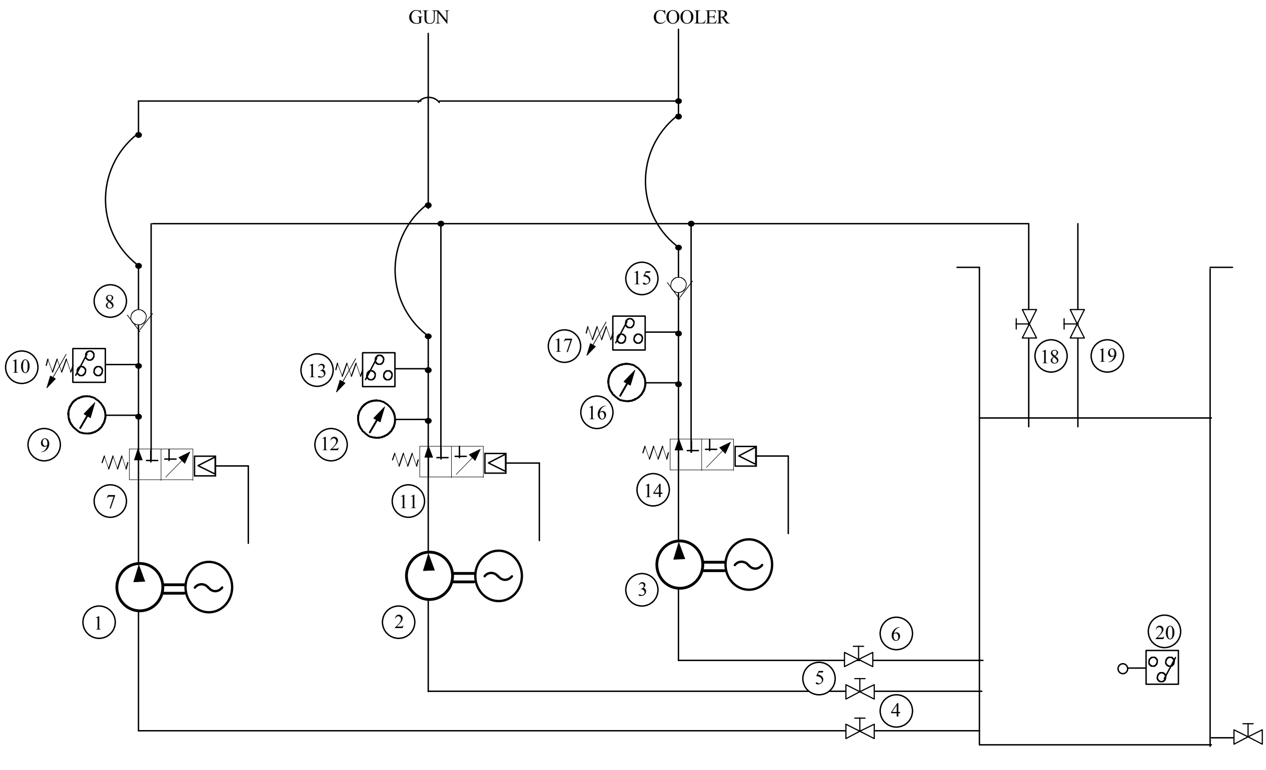

Fig. 5. The schema of the cooling installation.

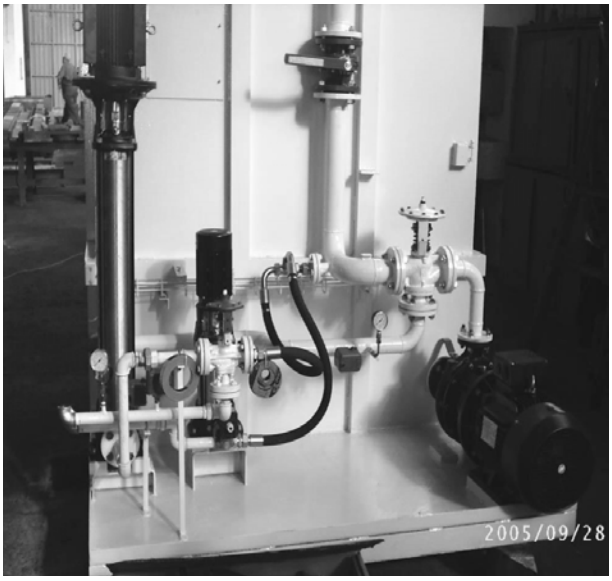

Fig. 6. The realisation of the installation, according to the schema of the cooling installation.

The electro-pump 2 aspires by the shut-off valve 5 and supplies the electro-pneumatic directional control valve 11. If it is not actuated, the cooling fluid arrives in the supply pipes system of the washing pistol in the working area.

The pressure can be read on the manometer 12 and can be electrically confirmed with the pressure switch 13. By actuating the directional control valve 11 the fluid arrives directly in the tank.

The electro-pump 3 aspires by the shut-off valve 6 and supplies the directional control valve 14. If it is not actuated, the cooling fluid passes by the check valve 15 and arrives in the supply pipes system in the working area.

The pressure can be read on the manometer 16 and is electrically confirmed by the pressure switch 17. By actuating the directional control valve 14 the fluid arrives directly in the tank.

The return circuit of the three pumps is controlled by the shut-off valve 18.

The shut-off valve 19 controls the supply of the basin with cooling fluid from the central installation. In the tank there is minimum level indicator 20.

Figure 6 presents the realisation of the installation, according to the schema from Fig. 5.

The presented installation takes part from the equipment of a rectification machine tool utilised in the production of the automobiles.

4. CONCLUSIONS

At present the tools and pieces cooling can not be considered as a collateral problem of the machine-tools.

The increase of the cutting speeds and the maintaining of controllable temperatures, especially at the CNC machine-tools, represent demands which are already included in the offer demands for the producers.

In these conditions the realisation of these systems supposes the existence of specialists from the design field who could realise installations with large flows and high pressures for difficult working environments, for example the emulsions.

There are companies who produce pumps and directional and distribution equipments which to lend itself to cooling installations, the designer being the one who has to join them in an optimal system.

The cooling installations are designed and are produced according to the specific demands to each type of machine and operation.

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