New Recuperative Heat Exchangers for Hydraulic Machine-Tool Drives

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To ensure the required temperature range of the working liquid in hydraulically driven machine tools, heat exchangers are employed. Heating of the working liquid in machine-tool drives is not common, except for faster initial heating at low ambient temperature.

In most cases, excess heat is liberated in hydraulically drives, and what is needed is to discharge this heat so as to prevent impermissible temperatures of the working liquid and thermal deformation of the machine-tool components, with accompanying loss of machining precision.

In current hydraulic machine-tool drives, the working liquid is cooled by means of recuperative surface heat exchangers of liquid–liquid or liquid–air type. For precision machine tools, in some circumstances, heat-exchanging evaporators from vapor-compression cooling systems are installed [1].

Heat exchangers of liquid–air type are often known as air heat exchangers, while those of liquid–liquid type are known as liquid or water heat exchangers. For all air heat exchangers, heat transfer is intensified by means of corrugated metal plates (ribs) on the air side.

In recent years, the leading manufacturers of heat exchangers have developed, patented, and produced improved new designs.

The tube–plate air heat exchanger in Fig. 1 is characterized by improved reliability and working life [2]. It contains a plate assembly 2, the spacing of the plates is \( h \). Each plate includes a projection \( A \) in the shape of a hollow truncated cone. The projections of adjacent plates are nested and joined together so as to produce a tubular channel \( B \) for the passage of cooled working liquid.

The channel formed by the conical projections is very strong, since its wall thickness is always at least twice the thickness of each projection. Each plate is smoothly connected to the conical projection through curvilinear section \( C \), whose wall thickness is equal to that of the plate and the conical projection. The heat exchanger is equipped with connectors 1 and 3 for passage of the working liquid.

The main distinguishing feature of this heat exchanger is that each projection \( A \) slots into the adjacent one, with a particular gap (later sealed), without the need for great mechanical force capable of plastic deformation of the plates. The air flux at the plates that cools the working liquid is produced by a fan (not shown in Fig. 1).

OAO Gazkholodtekhnika (Moscow) has developed, and put into mass production, the AVO range of air-cooling systems, which may be used to cool the working liquid in hydraulic machine-tool drives and elsewhere [3]. The basic structural modules of the AVO systems are tube–plate heat exchangers of liquid–air type and axial air fans. Depending on the cooling rate required, different numbers of heat exchangers may be used in the AVO systems, which permit the cooling of working liquids at pressure up to 3.2 MPa.

The Gac Corporation (Japan) has patented a compact tube–plate air heat exchanger, a section of which is shown in Fig. 2 [4]. The section consists of flat parallel heat-exchanger tubes 2 in the direction of axis \( A \)
(spaced at intervals of \(P_1\)) and plates 1. The ends of tubes 2, which are soldered into the slots of cylindrical collectors 3 and 5, are separated by a gap \(P_2\), which is less than \(P_1\).

The cooled working liquid is sent through connector 6 to collector 5 (arrow C) and leaves through connector 4 of collector 3 (arrow D). The air that cools the working liquid is supplied by a fan in the direction perpendicular to axis A of the pipes 2 (arrow B). This design ensures an effective configuration of the heat exchanger surfaces, and correspondingly the unit as a whole is compact.

Thermowave produces reliable tube–plate air heat exchangers of two types: (1) with mechanical seals; (2) with welded modules [5]. These heat exchangers may be used to cool working liquids characterized by pressures up to 3.2 MPa and flow rates up to 1300 l/min.

York International (United States) has developed a compact tube–plate air heat exchanger with increased heat transfer [6]. The section of heat-exchanger plate 1 in Fig. 3 is sinusoidal, with two waves for each series of heat-exchanger tubes. The heat-exchanger tubes (not shown in Fig. 3), which carry the cooled working liquid, pass through holes A in plates 1. The tube configuration depends on the required heat-exchanger performance.

Hisaka Works (Japan) has developed a reliable tube–plate air heat exchanger [7]. It contains heat-conducting metal plates 2 (Fig. 4), with holes A and B to accommodate the tubes for the cooled working liquid. Air-cooled plate 2 forms the central section D, together with triangular sections C at the upper and lower sides of section D. The surface of the plates in sections C includes spherical projections 3 and ovoid projections 3. The heat exchanger is very effective and ensures minimum pressure losses of the cooled working liquid.

In recuperative heat exchangers, the efficiency is increased by deformational cutting so as to produce finned surfaces of the heat-exchanger tubes [8]. This method, based on cutting and bending of surface layers of the metal in the part, also ensures high productivity and a wide range of the resulting macrorelief.

This is a waste-free method and employs regular metal-cutting equipment. In contrast to conventional cutting, the goal in deformational cutting is to obtain specified shape, precision, and quality not of the part’s surface but of the cut layer (essentially the chip). The geometric shape of the corresponding tool rules out destruction of the margin along the projection line of the auxiliary edge.

The primary cutting edge separates the surface layer, while the tool’s front surface ensures subsequent