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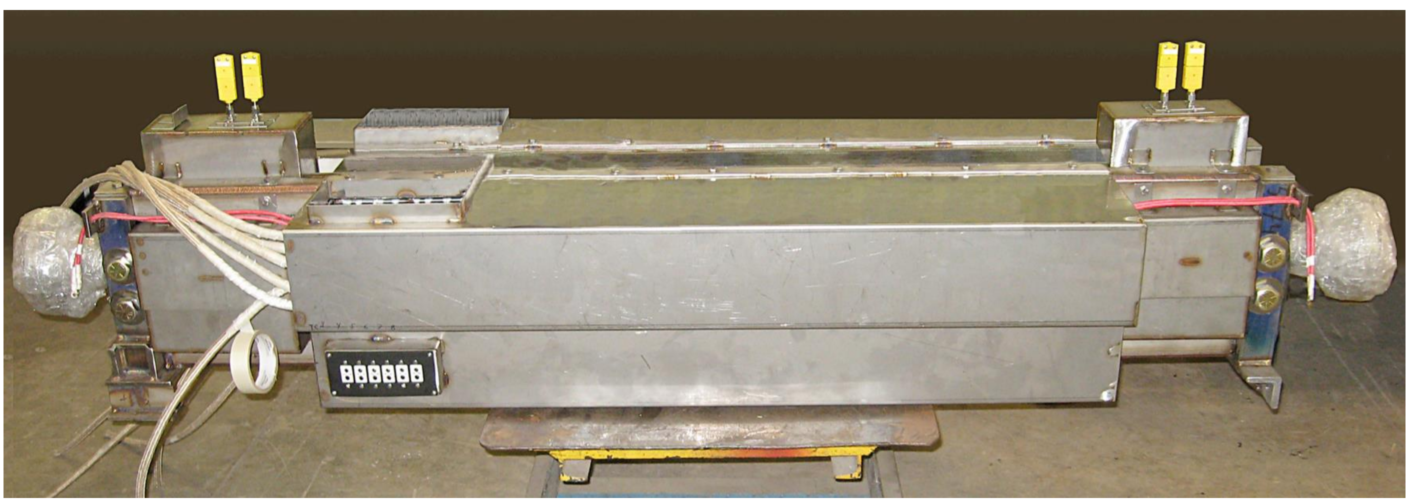
FLAT LINEAR INDUCTION PUMPS (FLIP)



PRINCIPLES OF OPERATION

Flat Linear Induction Pumps (FLIP) work by setting up a magnetic field normal to the direction of liquid flow and inducing a current in the metal which then produces a pump force in the direction of flow based on $F = J \times B$, where F is a motive force, J is a vector representing current flow and B is the magnetic flux density created by the coils in the stator.

The pump operates on the voltage introduced in the liquid metal, when it is traveling at a different velocity, generally lower, than the traveling magnetic field of the windings. This induced voltage results in a circulating current, which reacts with the magnetic field. A force is produced within the liquid metal in the direction of the traveling field and results in the developed head. The developed head decreases as the velocity of the liquid metal increases (due to lower slip resulting in a lower induced voltage) and reaches zero when the total force developed on the liquid metal just balances the frictional, constriction, and enlargement losses within the pump.

When the pump is installed in a system, this balance will occur at a lower flow rate where the developed head minus the frictional losses equals the pressure drop of the system for that same flow rate. If the pump voltage is lowered, this balance will occur at still a lower flow rate; likewise, if the voltage is increased, this balance will occur at a higher flow rate. However, the velocity can never exceed that of the magnetic field. An auto-transformer is recommended to vary the voltage to the pump, providing a full-wave voltage signal to the pump for smooth operation.

Sufficient capacitors should be used to correct the power factor to better than 0.9 and variable autotransformers should be used to control the flow from zero to full flow at whatever head is desired, limited only by the maximum specified in the inquiry.

The pump design consists of two essential parts, i.e., the flow tube with nozzle connections and the end bars, and the three-phase magnetic field stator, which produces the necessary field for reaction with induced currents in the liquid metal for the pumping action.

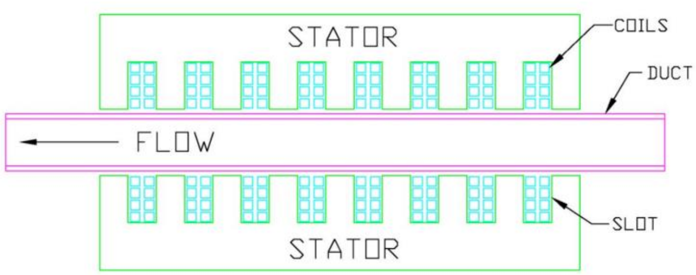


Figure 1
Simplified cross section of Flat Linear Induction Pump

The magnetic field stator is similar to that of a linear motor, which can be described as a three-phase induction motor, except that the stator is laid out flat and two field windings are used: one above and one below the flow tube of the pump. The stator, the non-moving part of a standard induction motor, is split in two parts, one above and one below the flow duct.

PRINCIPLES OF OPERATION (CONTINUED)

The three-phase field set up by the coils moves over time pushing the fluid in the pump duct in the direction the field is moving.

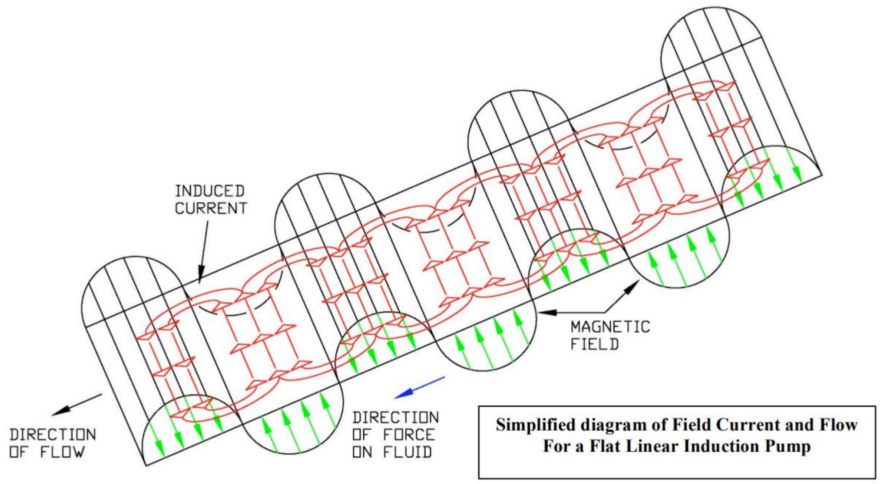


Figure 2

The flow tube for the pump consists of a series of tubes brazed together in a flat array permitting parallel flow. Copper end bars are brazed along the narrow outside edges of the flow tube over the length of the magnetic field. Thermocouples are located in the field windings and on the flow duct. The coil temperature should be approximately 300°F during normal operation. The flow tube thermocouples will reach the fluid temperature during normal operation and are of primary value for preheating.

During loop start-up operations, the pump windings can be used to preheat the flow tube for charging the system when using a liquid metal with a melting point above room temperature. Pre-heating can be initiated by turning on the power to the pump at a low value, up to 50%. The thermocouples on the flow tube will indicate the flow tube temperature and the preheat voltage can be adjusted accordingly. If preheat temperatures below 400° are maintained, the windings blower need not be used during the preheat cycle.

It is recommended that the liquid metal not be permitted to freeze within the pump. The increase in volume on melting the liquid metal later could cause permanent damage to the flow tube in the pump. If, however, the liquid does freeze in the pump duct — all re-melting must be performed in such a way as to allow the newly melted liquid to flow into an unrestricted area.

POWER SUPPLY

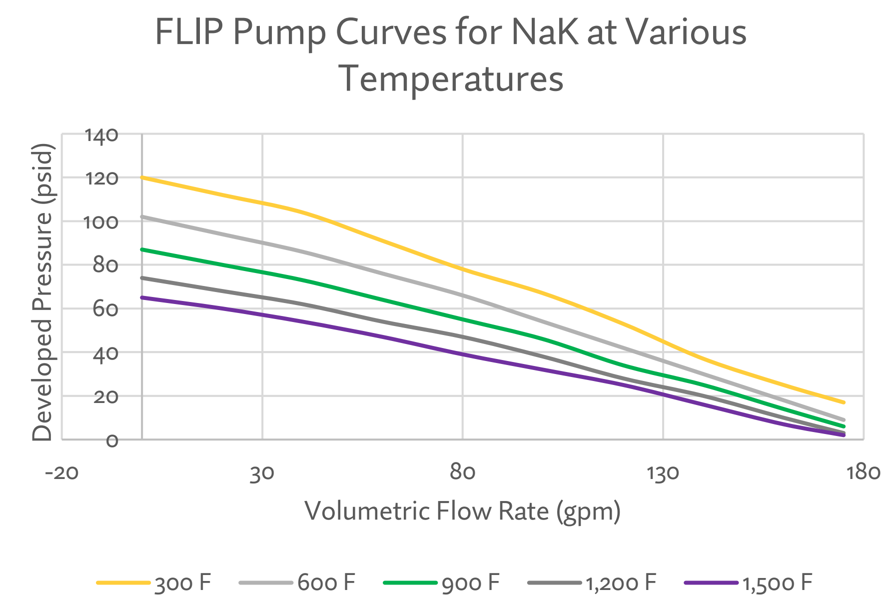
Our standard FLIP pumps require an electrical supply of 440 Volts AC, three phase, 60 Hertz.

MATERIALS OF CONSTRUCTION

Our standard FLIP pumps are fabricated primarily from 316 stainless steel. Other tube materials may be used, provided they are non-magnetic and compatible with the fluid being pumped.

APPLICATIONS

The performance curves shown here were constructed for potassium-sodium alloy (NaK) at a variety of temperatures. CEI pumps can also be used with sodium, potassium, rubidium, lithium, cesium, a variety of alkali metal-containing alloys, and other liquid metals. Further data and more detailed pump design specific to individual applications can be provided upon request.



The pumps will operate at any point on or below the maximum curves. The pumps are pressure devices; with a fixed applied voltage flow will be established according to the pressure drop in the system external to the pump. The performance of any given pump will vary somewhat with the type of fluid, temperature, and materials of construction.

PUMP PLACEMENT CONCERNS

Important factors which determine where the pump should be placed in a system are below:

1. The pump must be located in such a position that it will be flooded before and during operation to prevent the high secondary armature current from overheating the pump tube. An inlet pressure at the suction end of the pump of a least two feet of liquid metal above the vapor pressure should be maintained.
2. Piping stress due to thermal expansion and contraction of the system must not place a strain on the pump in such a manner as to rupture or cause permanent distortion of the pumping section. The pump is modeled in the run as a straight piece of tube with one vertical hanger at the pump frame support.
3. The maximum rated operating temperature of the pump must not be exceeded. Ambient temperature should be maintained below 150 °F. An open construction is used on the pump to permit natural circulation of air for cooling.

ABOUT US

Creative Engineers, Inc. (CEI) is a unique and innovative alkali metal engineering company with the capability to design, build, and operate research and pilot-scale systems to meet customer needs. Each of our alkali metal expert engineers has from 5 to 30 years of experience.

The rapid results obtainable from CEI's dedicated resources often accelerate project schedules as opposed to performing the work in-house, where the researcher's efforts are often allocated among multiple projects.

We also work with other liquid metals, such as lead, antimony, bismuth, etc. and their alloys.

Contact us today at (717) 235-5469 to find out

Flat Linear Induction Pumps (or FLIP Pumps) are specifically designed for use with liquid metals at temperatures up to 1,500°F (815°C).

They have no moving parts and no seals and are therefore ideal for use with molten metals – including alkali metals such as NaK, sodium, and lithium.

For information on smaller EM pumps, please refer to our AC EM Pumps and DC EM Pump brochures.

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