How Heat Generated in a Hydraulic System can be Turned into "Green Savings"

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An issue with all mechanical processes is that the process generates a certain amount of heat; this especially true in the case of hydraulic systems. Heat is generated when the fluid is pressurized, heat generated from the friction of the pressurized fluid flowing through the lines, routing through valves and other devices that create pressure drops, and finally the transfer of fluid energy back to mechanical energy to do work. Fluid power designers attempt to reduce as much as possible the generation of such heat. This includes the use of components that generate a minimum of pressure drop, correct sizing of hydraulic lines, and work duty cycles. However, no matter how energy efficient the design, the system still generates heat. The designer must build into the hydraulic system a means for removing excess heat or risk damaging the equipment. A rule of thumb in fluid power is that for open loop hydraulic systems around 30% of the input horsepower is lost to heat.

Basic to thermal dynamics is the process of heat transfer from the device to someplace else where the heat can be safely dispersed. In simple "open loop" hydraulic systems, the hydraulic reservoir is the primary means for heat transfer. Fluid power designers carefully select reservoirs, not only for storage of system fluid but also for the reservoir's heat transfer properties. Most systems are cooled by relying on the heat transfer from tank surfaces to the surrounding air. The rate of heat transfer is dependent on the amount of reservoir surface area, fluid dwell time, the material the reservoir is constructed from, the temperature of the fluid and type, the ambient air temperature, and ambient air exchange rates. Positive heat exchange can be detrimentally effected if the hydraulic power unit is placed somewhere non conducive to ambient cooling; such as an unventilated equipment rooms or placement where it is exposed to direct sunlight. Heat exchange is based on the temperature differential (ΔT). The greater the ΔT the better the heat exchange, moving from the higher heat source to the cooler. This is the principle that all heat exchangers are based on, whether air/fluid or fluid/fluid. The common radiator used on mobile equipment is a classic example of an air/fluid heat exchange system. In industry where equipment is stationary, fluid/fluid heat exchange is quite common. Two types of heat transfer units are often used; plate coils and tube & shell. For the purposes of this discussion I will pass over the plate coil systems and discuss tube & shell.

The principle of a tube & shell heat exchanger is that the hydraulic fluid is passed through the heat exchanger tubes that are surrounded by a jacket of cooling fluid, normally water. The water is connected to the pressure side of the water system and the heat exchanger discharge water is connected either to the effluent drain or to a water cooling system such as a cooling tower. The hot hydraulic fluid exchanges the heat to the water, which is then carried off. Typically the heat exchanger is installed downstream from the return filters and upstream from the reservoir. This system is highly efficient in removing the heat from the hydraulic fluid and maintaining a cool system. By keeping the fluid temperature cool the hydraulic system is more efficient and it will increase the overall lifetime of the system. The typical way of controlling the flow of hydraulic fluid through the heat exchanger is with a mechanical valve that is very much like the thermostat valve found on most cars and trucks. When the fluid heats to a certain preset temperature the valves opens allowing the fluid to flow through the heat exchanger. Otherwise the fluid, if not warm enough, bypasses the heat exchanger straight to the reservoir. Now that we understand the heat exchange principle we can now begin the discussion of how this can be utilized to generate "green savings".

In many applications water is heated to a desired working temperature. Raising the water from the ambient line temperature to the working temperature requires the input of energy, usually from some form of heating device such as a gas or electric water heater. Let's assume the ambient water line temperature is 65° F and we need to raise the temperature to 120° F working temperature. The water heater will have to input enough energy to overcome a ΔT of 55°. Rather than taking the discharge water from the heat exchanger and dumping it down the drain, the heat exchanger can work as a pre heater. For discussion purposes let's say, conservatively, the heat exchanger raises the water temperature 25° F; instead of having the water heater raise the temperature 55° F, it will only have to raise it 30°. This is a savings of 45%. Over time this can lead to a substantial energy cost reduction; more than paying for the cost of the heat exchanger and installation.

Water is not the only heat exchange medium that can be used. In hydroponic heat systems, utilizing heat transfer fluids; again the heat exchanger can use the hydroponic heat transfer fluid to cool the hydraulic system and preheat the hydroponic fluid. Thus, cutting overall energy costs in heating. Other hydroponic heating systems are hot water heat systems and again the heat exchanger can be used as a feed water preheater.

Taking the “greening” one step farther; rather than use standard mineral based hydraulic oil in the system, the use of a water based fluid will enhance the system operation. Water based hydraulic fluids contain between 35% to 60% water. Water’s better heat transfer properties over mineral or vegetable based oils will significantly increase the heat transfer capability. For example: If in an oil based system the heat exchanger is able to pull out 75% of the heat and the water based system is able to pull out 85%; it’s a “no brainer”. Also, if a water based hydraulic fluid is used; the cooler it is kept the less water will evaporate out. The best operating temperature for water based fluids is < 50° C (122° F).

If the hydraulic power unit’s input power is 25 hp and it’s estimated that the system will generate 30% in heat; that’s a little over 8 hp or 343.764 BTU/min or 20626 BTU/hr. If, through a heat exchanger and a system with water based hydraulic fluid, 85% of the heat energy can be captured; that’s 17532 BTU/hr. That’s energy that’s already been paid for; why pay for it again?

When considering the use of a heat exchanger; there can be some negatives also. Before purchasing a heat exchanger make certain that the exchanger is fabricated from the right materials. Whatever the hydraulic fluid tubes are made of should be of material that the water will not corrode. Similarly the tubes should be made of material that the hydraulic fluid will not react to, especially if the hydraulic fluid is water based. Nothing can ruin a day more than finding water in your hydraulic fluid from a leaky heat exchanger. Also, the heat exchanger must be sized correctly to effectively pull the maximum amount of heat. Undersized exchangers will not allow enough fluid dwell time to pull out the heat. Heat exchangers that are oversized will pull out the heat, but why pay for what you don’t need. Some system designers recommend placing the heat exchanger upstream from the return filters because if the material in the heat exchanger should begin to degrade and start “sluffing off”; the filter will be in place to capture the contaminants before they can get into the reservoir.
Finding and using the services of a fluid power professional to help chose the correct heat exchanger and install it is probably the wisest way to go.

Finally, the idea of using a heat exchanger has the potential to make systems more efficient. Who would have ever thought that “going green” could actually put green into your wallet.

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