SELECTION AND SIZING CRITERIA FOR CENTRIFUGAL PROCESS PUMPS

By

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ABSTRACT

This paper discusses the primary factors to consider in the sizing of ANSI standard centrifugal pumps for production and plant applications.

Practical information on selecting equipment for present and future requirements will be discussed. Material selection, mechanical seal selection, and pump modifications will be covered as part of the selection process. Explanation and calculations of NPSH and its relation to cavitation and pump sizing will be briefly mentioned. A basic overview of electric driver selection will also be touched upon.

INTRODUCTION

Centrifugal pumps play an important part in production and intraplant liquid movement. Because they play an integral part, the selection of the right pump to do the job is critical in maintaining a hold on operating costs and efficiency. Because of their prevalence in production and processing facilities, the main type of centrifugal pump to be discussed will be the ANSI (or AVS) centrifugal pump.

Below, will be covered those major points that should be addressed when selecting the best pump for the application. By carefully considering each aspect discussed below, the end result will be the most efficient and cost effective piece of equipment for the task.

BASIC PUMP SIZING CRITERIA

Throughout this discussion, the following basic specifications will be used: A pump is needed that will move 42 GPM (1440 BPD) at a dynamic head of 50 ft. The fluid is water.

The basic object is to select a pump that will move the liquid at the specified flow and required pressure with the least amount of expended energy. To do this, as in Fig. 1, a pump on whose curve the pumping conditions fall nearest to the pump's Best Efficiency Point (BEP) is selected. The BEP is defined as the point on the pump's curve at which the pressure and flow are in the right relationship to cause the least turbulence within the pump.

Unfortunately, rarely will the flow conditions fall exactly on the BEP. Therefore, a pump should be selected that most nearly approaches the BEP. As shutoff is approached, on the left side of the curve, the probability of recirculation, increased shaft deflection, noise and vibration increases. Conversely, to the right of the BEP, turbulence and friction losses increase. Each of these can reduce output and operating efficiency.

A common occurence is that there may be two, or more, pumps that will give the desired output with relatively close efficiency ratings. In this case, overall requirements and projected requirements must be taken into account.

In Fig. 2, (a) appears to be the best option. The pump is smaller than in (b)(the impeller is 6 inches instead of 10 inches trimmed to 6). It should, therefore, cost less. But, this pump leaves no room for expansion.

For example, this pump is part of a water disposal system. The maximum flow needed is 42 GPM. But, the company is planning to drill several more wells, anticipating a doubling of the water. The larger pump now becomes the most economical option. By merely replacing the impeller with a larger diameter one, the expected capacities can be met. The cost of a new pump, and maintenance time and dollars have been saved.

Again, overall requirements must be considered.

NPSH AND PUMP SELECTION

Net Positive Suction Head (NPSH) is an expression of the relationship of suction head to the liquid's vapor pressure. It is critical for pump operation and life that the liquid not reach its vapor point inside the pump. There must be sufficient NPSH, or buffer, to allow for entry pressure drops.

In Fig. 3, as the liquid enters the pump, it loses pressure due to friction, turbulence and other factors. At point A, the pressure loss is sufficient to cause the liquid to vaporize. At B, the impeller begins to repressurize the fluid. At C, the fluid reliquifies. At that point, the gas bubbles implode to reform the liquid. As they implode, much energy is expended causing reduced output and probable pump damage. The pump is cavitating.

To overcome this, there must be sufficient pressure on the liquid to insure that B is above the vapor pressure of that liquid. As in Fig. 4, the distance from A-C (NPSH available) must be larger than the distance from A-B (NPSH required by the pump) to keep the pump from cavitating.

Because of the different designs, the NPSH requirements for all pumps of the same size are not, necessarily, the same. The NPSH requirement for a pump is printed on the individual performance curve. When moving a liquid that is near its vapor pressure, the NPSH requirement of a pump may eliminate it from consideration.

As a final note on NPSH: In order to get accurate assessments of NPSH availability, all calculations should be made in relation to PSIA, since vapor pressure is expressed in PSIA versus PSIG.

SECONDARY CONSIDERATION

MATERIALS

One of the advantages of centrifugal pumps of the type under discussion is that they are relatively more readily available in a variety of alloys than are many other types of pumps. Therefore, it becomes more practical to use the alloy best suited for a particular liquid, without the usual extended delivery schedules and great expense. There are several factors to weigh in making the final decision as to which material to use.

Pump Life

One of the most important aspects of pump life longevity is proper alloy selection. The corrosive and erosive effects of the pumped liquid will help determine how long the pump will last. Even though this concept is elementary, there are aspects of it that, when applied, may prove economical.

1. Because of corrosivity, X years of life can be expected from a pump. If a higher alloy is used, the expected life jumps to 2X. But, the upgrading of alloys will cost 2.3 times the price of the original pump. The upgrade, therefore, may not be practical.

2. As with sizing requirements, pump operations in the future should be looked at. A Ductile Cast Iron (DCI) pump may work fine for our present application. But, within a year the production department plans a CO_2 flood. With that, the CO_2 and H_2S content of the water will rise. By using a stainless steel pump for the present application, long term costs are reduced by not having to replace that pump.

Environment

Besides the obvious internal considerations, the environment should be addressed. For example, equipment for offshore operations is often specified to be made of MONEL because of the corrosize effects of the sea air. Special materials are required for high H_2S content environments.

As part of the environment is the external mechanics of the material. Some of the newer plastics and fiberglasses might be a valid option over stainless steel because of corrosion resistance and price. But, rough handling and improper flange loading combined with the natural elements may greatly shorten the life of these pumps.

Experience

One factor that cannot be overlooked is experience. Particularly in production fields, each site has its own characteristics. The makeup of different pay zones may effect the type of metallurgy required.

For instance, in one geographic area, three separate producers are using three different types of metallurgy for their pumps (DCI, 316 Stainless Steel and an alloy 20). Their individual producing areas dictated the selections.

As with proper sizing, proper alloy selection will help insure the most economical and efficient operations for both immediate and projected requirements.

MECHANICAL SEALS

Probably, the most overlooked aspect of leak proofing a pump and in the selection of a mechanical seal is stuffing box pressure. This pressure is a direct result of axial thrusting. Depending on the design and size of the pump, this pressure may be as much as 100% of the discharge pressure. Since this pressure is acting directly on the seal, a mechanical seal must be selected that can withstand the pressures.

As in the case of the example pump, the 50 ft. of head may, because it is a relative term, equate to 200 PSI. Therefore, the pressure should be known.

To help increase the life of the mechanical seal and also limit leakage, a seal "flush" can be used. These range from a simple tubing run from the discharge of the pump into the stuffing box to specialized units with self-contained reservoirs.

Regardless of the type, a seal flush will help wash away abrasives and keep the seal cool and lubricated. It may, also, help reduce the effect of the higher pressures by stabilizing the pressure differential created between the sealing elements.

As a last point, the materials of construction for the mechanical seal must be compatible with the liquid pumped. The seal elements should be at least as corrosion resistant as the pump itself.

ELECTRIC MOTORS

To complete the pump package, there must be some sort of "driver". Since electric motors are the most prevalent types, they will be discussed briefly.

Non-overloading

A centrifugal pump, since it is not a positive displacement unit, is capable of varying flow conditions depending on incoming flow and pressure. Therefore, to insure that the motor is able to operate throughout the full range of the performance curve, it must be sized to meet the "end of the curve", or non-overloading requirements.

For example, with our 42 GPM flow and 50 ft. TDH, the required horsepower is 0.6 (see Fig. 5). A 1 hp motor will satisfy the requirement. But, if inlet flow increases to 60 GPM, 1.3 hp is required. Since the motor is only capable of 1.0 hp, it will malfunction in an attempt to generate 1.3 hp. The motor should have originally been sized to a nominal horsepower of 1.5 hp, to meet the 1.3 hp requirement.

High Efficiency

Most electric motor manufacturers offer a "High Efficiency" motor. This type of motor is more expensive than either the TEFC or Explosion Proof motors. But, this initial cost might be offset by the cost of power usage. The relationship is based on amount of daily usage.

RPM Modification

Since flow, head and horsepower are functions of the RPM of the motor, pump performance can be modified to meet different specifications by using a V-Belt or variable speed driver. Care must always be taken, however, in running a pump at a higher rotative speed than published on the performance curves.

CONCLUSION

Above were discussed several points that should be considered when specifying a centrifugal pump package. With the available options in pumps and ancillary equipment, the optimum unit for the job can be selected.

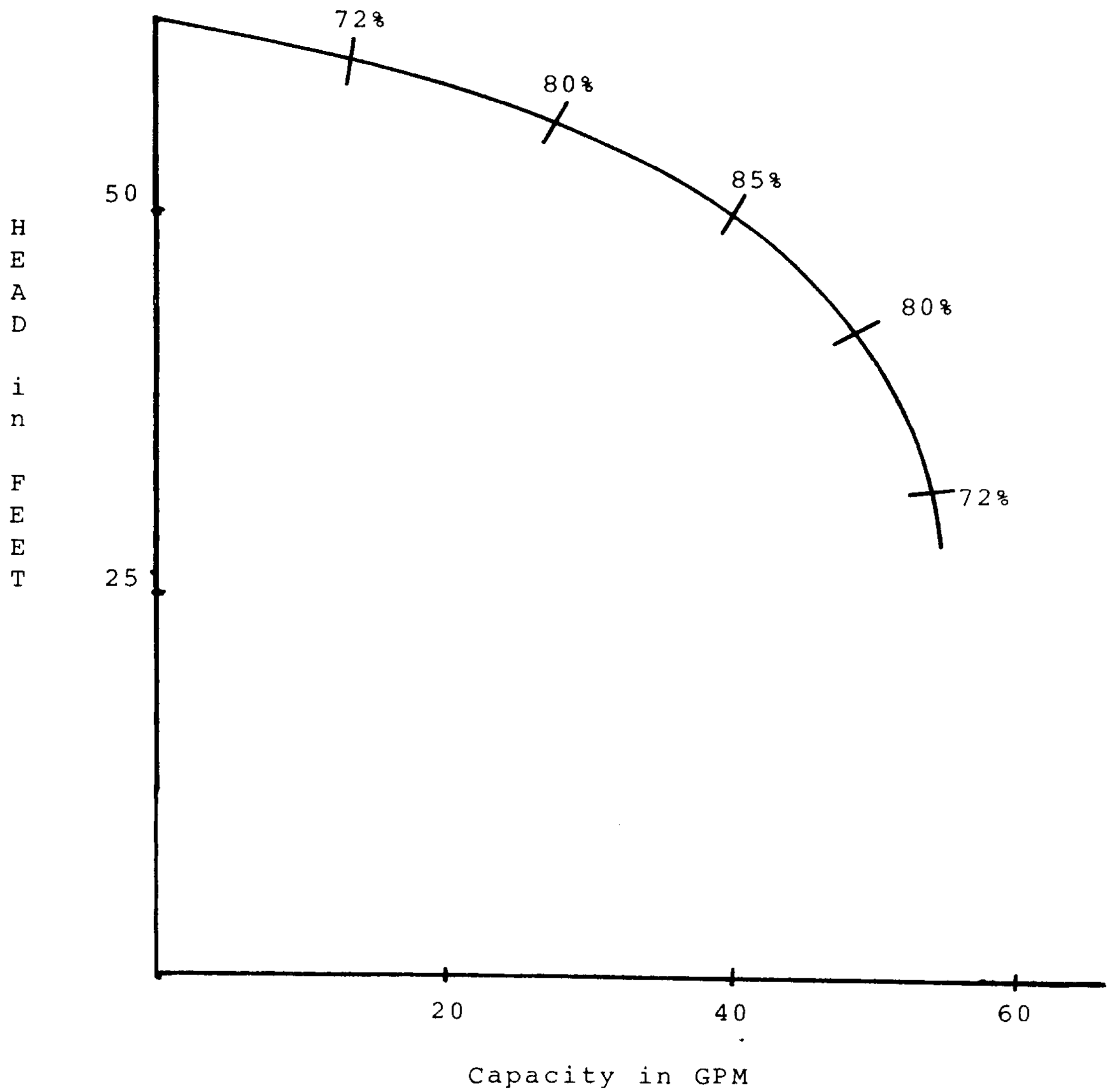
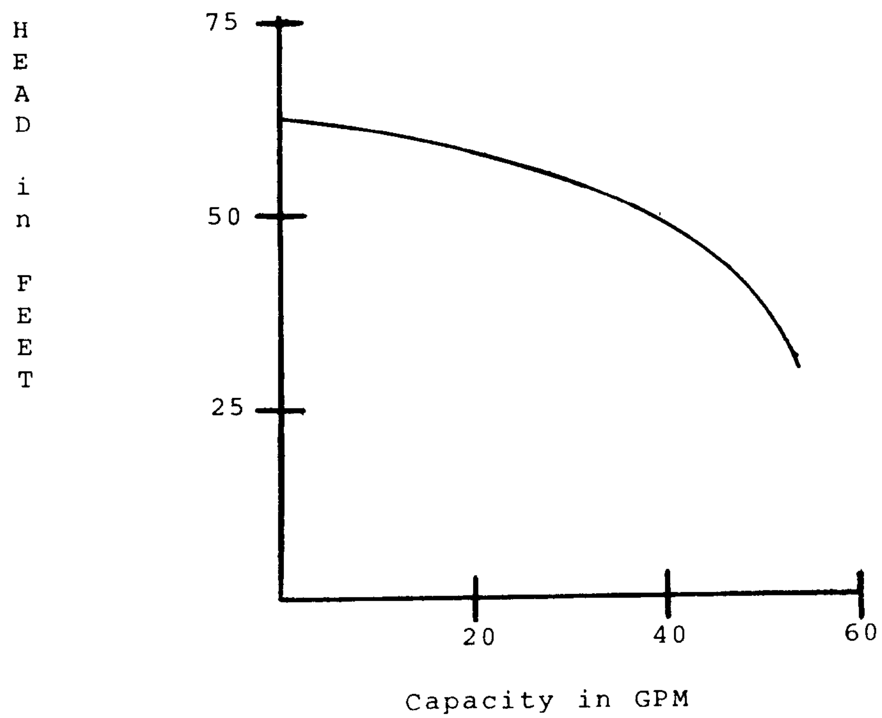


FIGURE 1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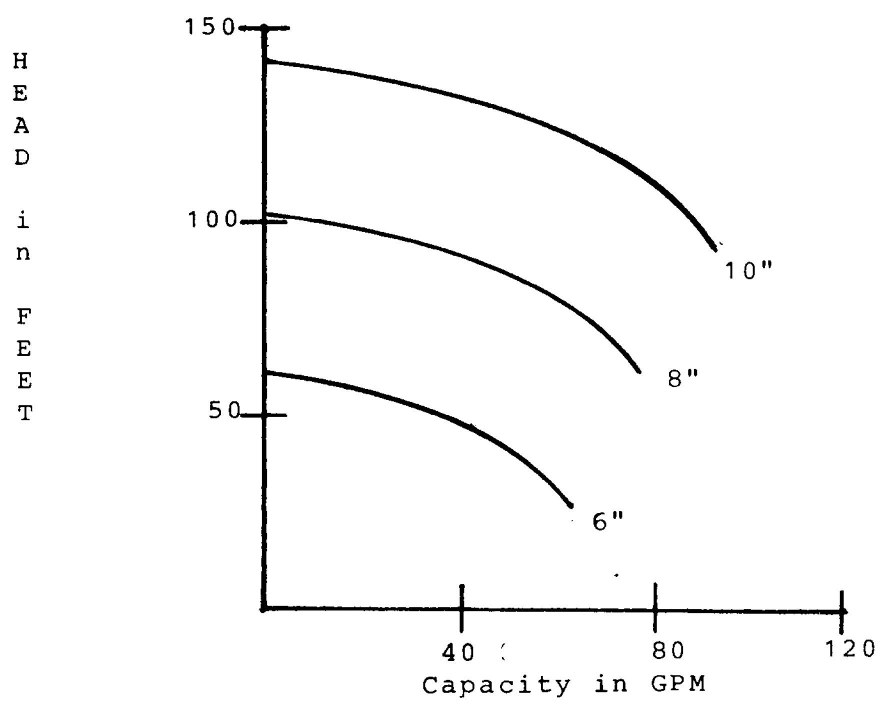
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Capacity in GPM

(b)

FIGURE 2

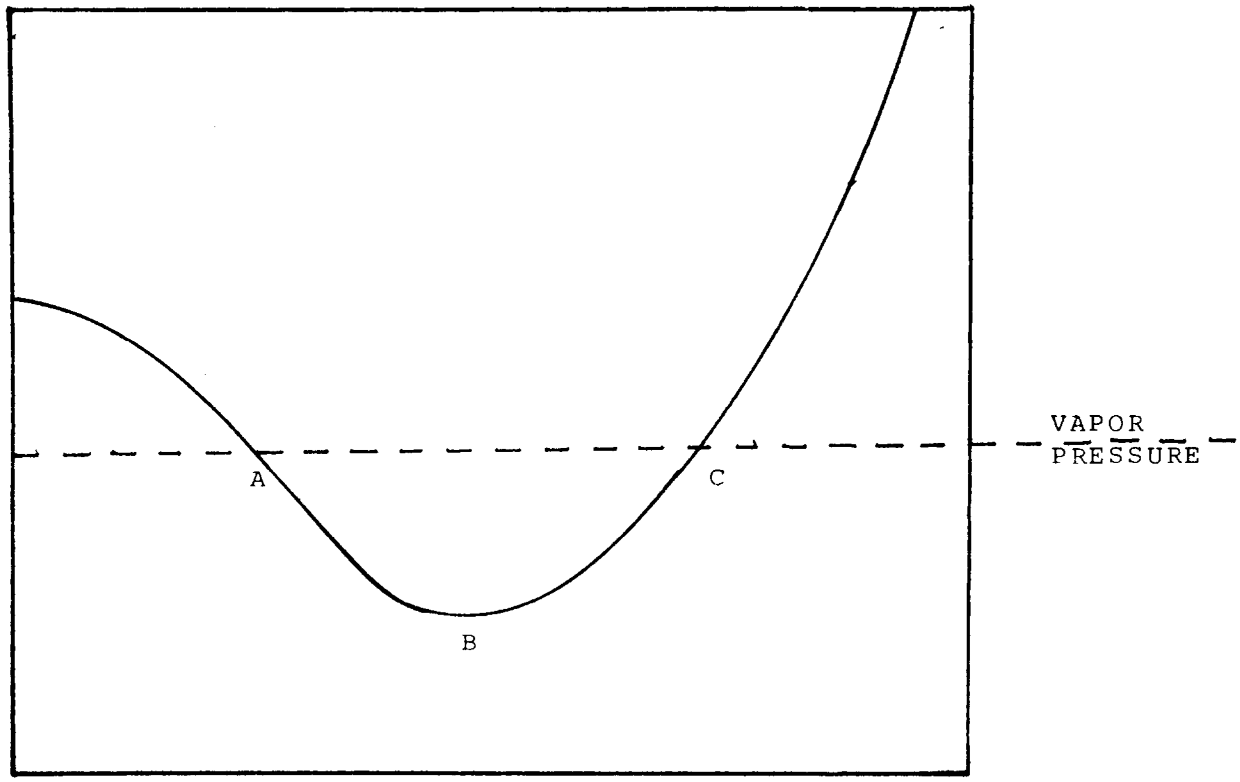
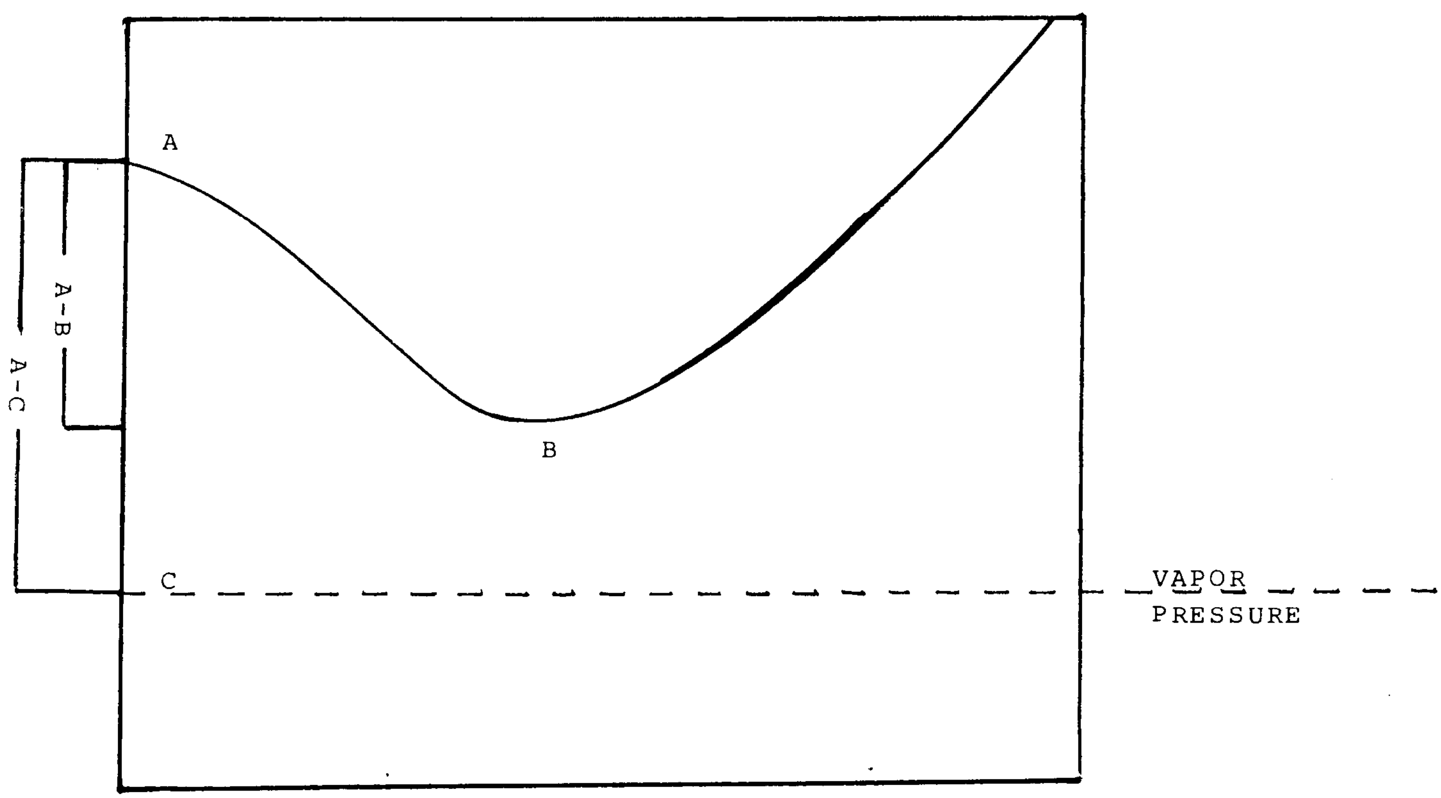


FIGURE 3



A-C must be greater than A-B to prevent Cavitation.

FIGURE 4

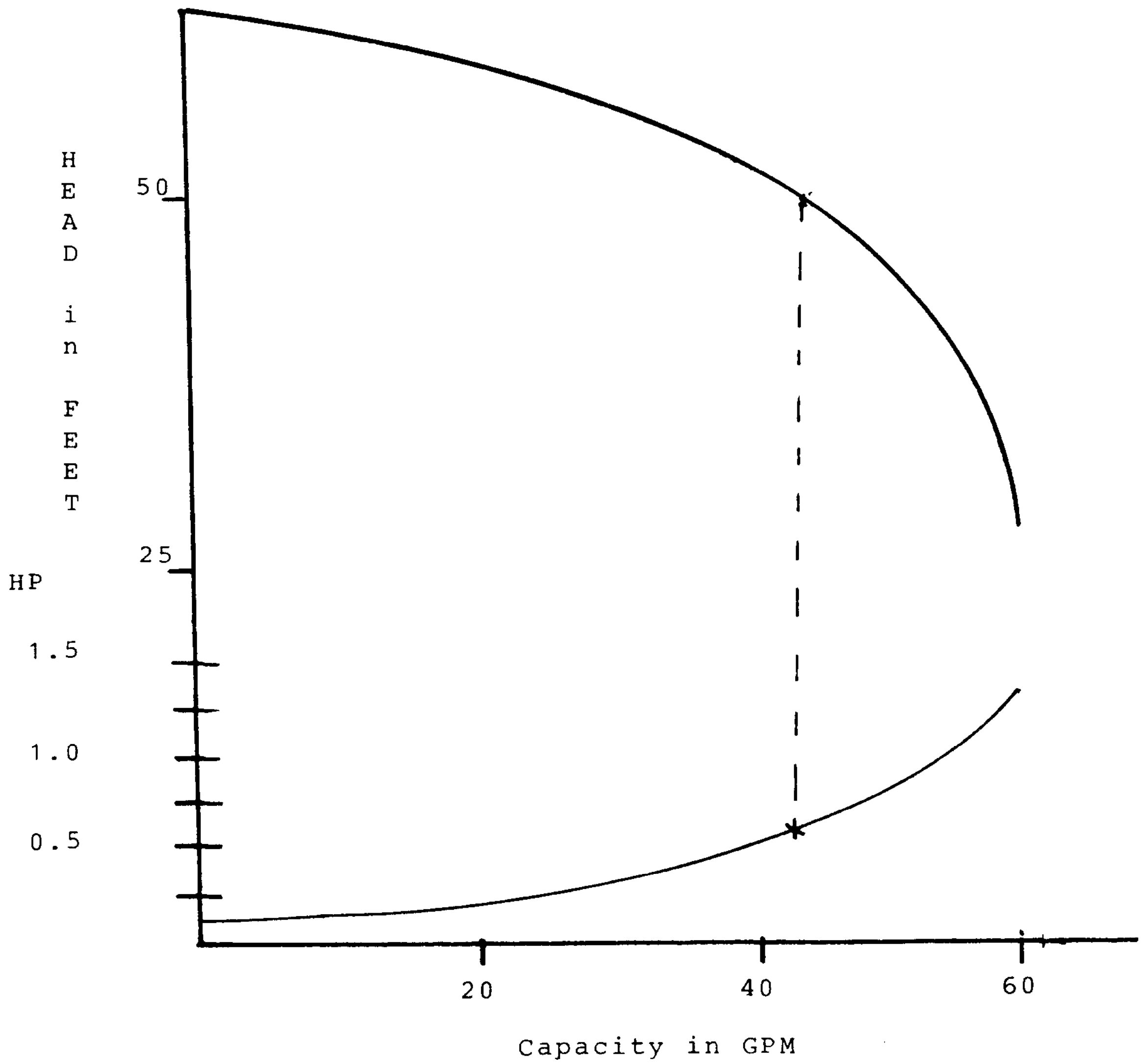


FIGURE 5 — HORSEPOWER AND PERFORMANCE