TECHNICAL INFORMATION BULLETIN

PEERLESS PUMP
Hydrodynamics Division
FMC CORPORATION

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THE IMPORTANCE OF COMPLETE EVALUATION OF THE MECHANICAL DESIGN OF CENTRIFUGAL PUMPS

Until recent years, centrifugal pumps had mechanical designs based more on intuition and general appearance than a systematic integration of all of the factors involved. Shaft sizes were often chosen to make a pump look "rugged" and bearings were frequently selected simply to fit the shaft size chosen. Many designers as well as users paid little or no attention to the radial hydraulic forces present when the pump is in operation. Because of much talk and a little knowledge, some users and some manufacturers have now over-emphasized the importance of radial hydraulic forces without keeping in mind the necessity of balancing *all* of the design factors involved for an economical and reliable pump design.

The thrust forces on a pump shaft occur in a direction both at right angles to the shaft and also in the axial direction which is in line with the shaft. The radial forces consist of hydraulic unbalance and mechanical unbalance. The mechanical forces are essentially constant regardless of the point of operation of the pump. The hydraulic radial unbalanced forces are normally at a minimum at the maximum efficiency point. (They are increased when the pump is run at capacities less than 75% and greater than 125% of this point.) Thus, process pumps and other units which are frequently operated at partial capacity can have abnormally high radial thrust loads. Units which are operated far in excess of design point can also have significant side thrust particularly if some degree of cavitation is present. Since the *exact operating* point of a pump is seldom known when designing in advance and each pump design may be used for many different applications, all Peerless pump designs are based on the assumption that the shaft and bearings must be adequate for operation from 0 capacity (shut-off) to 125% of the maximum efficiency point.

Although there are many theories concerning the hydraulic design of centrifugal pumps, few people consider it reliable to simply design a centrifugal pump based on existing theory and publish performance curves calculated from these theories. It has long been standard procedure to run an actual operating test of the completed pump to determine its exact hydraulic performance. However, for many years it was felt that general formulas would accurately predict the radial thrust and the axial thrust of centrifugal pumps and all bearings and shafts were calculated on the basis of theory without making confirmation tests on the actual pump. We now know that theory is not enough and that each basic new pump design should be thoroughly tested to determine the axial and radial forces to verify that the bearings and shaft are of optimum design. Because of field failures of pumps operating at partial capacity and at high speed, many customers now insist upon a mechanical evaluation of pump designs as well as knowing the hydraulic performance. However, frequently a customer is willing to accept a highly theoretical calculation for the axial and radial thrust values in his mechanical evaluation. When he does this he is simply kidding himself, as a correct evaluation cannot really be made until test data is obtained on either the exact pump or one of very similar design.

The mechanical design of most pumps is adequate when operated near the design point or at speeds appreciably less than the maximum speed permitted for the pump in question. However, when applying a pump for operation at its maximum speed and at partial capacities or at capacities appreciably in excess of its maximum efficiency point, care should be taken to see that the mechanical design is adequate. In making a mechanical evaluation of a pump design it is not enough to

look at one or two items. The radial thrust, axial thrust, shaft overhang between the bearings and impeller, bearing spacing, shaft size, bearing size, bearing type, and ease of assembly and maintenance are factors which must all be carefully considered to give the optimum mechanical design. The use of double volutes or large shafts does not, in itself, assure adequate design. All the factors must be related in a systematic manner to give a balanced and economical design that will give long trouble free operation. This is what Peerless is doing to continue to provide the best in centrifugal pumps. Peerless has devoted much of its research and development over a ten-year period determining exactly the magnitude and nature of forces at work in pumps. Accordingly, all components in Peerless Pumps are specified to assure well-balanced design, that will guarantee long reliable economical operation.

1. Question:

Do double volute pumps have lower radial thrust values than single volute pumps?

Answer:

Yes, our tests indicate that, in general, double volute pumps have less radial thrust than single volute pumps, particularly to the left of the design point.

2. Question:

If double volute pumps have less radial thrust than single volute pumps, why are they not used on all pump designs?

Answer:

Double volute cases are generally more expensive than single volute cases, and are difficult to make in small sizes. In many sizes they offer no overall advantages over single volute pumps.

3. Question:

Will double volute pumps always give better mechanical service than single volute units?

Answer:

No, a single volute pump with adequate shaft size and adequate bearings will give the same service as a double volute pump. The design combination of volute, shaft, and bearings which is most economical for optimum design must be used. Normally, double volute pumps can be justified only on large size units developing relatively high heads.

4. Question:

Can a shaft be too large in diameter?

Answer:

Yes, a shaft that is larger than necessary will require an expensive sleeve and bearings, will have greater rubbing speeds at the packing than is otherwise necessary, and will require larger mechanical seals leading to greater replacement costs and higher rubbing speeds. The shaft should be adequate in size but an excessively large shaft can lead the customer to unnecessary replacement expenses and poor operating experience.

5. Question:

Are axial thrust loads important?

Answer:

Yes. Our experience shows that bearings ample to carry the radial thrust load are rarely a problem. The axial thrust load on single suction pumps can be appreciable and the bearing size should be carefully selected, based on actual tests of axial thrust.

6. Question:

Is the weight of a pump a good indication of its adequate mechanical design?

Answer:

No. A pump may be heavy but if there is a long overhang between the impeller and the bearings, if the bearings are not properly selected and spaced, and the design is not carefully integrated, an apparently rugged pump can require more maintenance than one which weighs less.

7. Question:

What is Peerless' attitude concerning comparative merits of single and double volute designs?

Answer:

There is need for both. Hydraulic requirements of the specific application, capacity, head, and speed are governing factors in selecting the proper unit. The Peerless Sales Engineer is qualified to make recommendations on both single and double volute centrifugal pumps.

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