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Status report of research project on improving design of hopper dredge pump, July 1960

John B. Herbich

James L. Long

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FRITZ ENGINEERING LABORATORY
HYDRAULICS DIVISION
Memorandum No. M-13
F.L. Report No. 277-M-13

STATUS REPORT OF RESEARCH PROJECT
ON
IMPROVING DESIGN OF A HOPPER DREDGE PUMP

Prepared by
John B. Herbich
and
James L. Long

Prepared for
U.S. ARMY ENGINEER DISTRICT; PHILADELPHIA
Corps of Engineers
Philadelphia 29, Pennsylvania
Contract No. DA-36-109-CIVENG-59-112
July 1960
Bethlehem, Pennsylvania
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STATUS REPORT OF RESEARCH PROJECT

ON

IMPROVING DESIGN OF A HOPPER DREDGE PUMP

I. INTRODUCTION

The following report summarizes the studies performed during the months of May and June 1960, at the Hydraulics Division of Fritz Engineering Laboratory, under terms of Contract No. DA-36-109-CIVENG-59-112. Earlier work was described in Status Reports dated: December 1958 (1)*, February 1959 (2), April 1959 (3), June 1959 (4), December 1959 (6), February 1960 (7), March 1960 (9), April 1960 (10), May 1960 (11), and June 1960 (12) and a Project Report dated September 1959 (5).

Memorandum No. M-11 was specially prepared summarizing the work done on analysis of high-speed movies and was submitted to the Sponsor in June in place of a regular status report for that month.

II. EXPERIMENTAL STUDIES

A. General Comments

The silt-clay-water mixture is being allowed to settle down and clear water is periodically siphoned out in order to increase the concentration of the mixture. A check test is planned as soon as the mixture concentration reaches about 1380 grams per liter.

*Numbers in parentheses refer to References, page 6.
B. High-Speed Moving Pictures

A separate Memorandum (No. M-11) entitled "Analysis of High-Speed Movies of a Model Pump" was submitted to the Sponsor last month.

C. Pressure Tests

(a) Preliminary Analysis

Preliminary analysis of the volute pressure readings for two mixture concentrations of 1232 grams per liter (Memorandum M-9) and 1334 grams per liter (Memorandum M-6) indicates that the pressure variation around the volute, with the pump operating at the best efficiency point (bep) (between 800 and 1000 gpm), was on the average of 3-1/2 psi for all speeds. (Table I) At lower and higher discharges, the pressure variation was more erratic but in general tended to be greater for higher speeds.

Examination of Figures I-IV of Memorandum M-9 and Figures II-V of Memorandum M-6 shows two distinct pressure variations in almost every curve:

(1) The pressures at the location of No. 1 and 2 taps, near the cut water, are always low with respect to the pressure in the rest of the volute (taps Nos. 3 to 7).

(2) The pressure at the No. 8 tap is below the average volute pressure for all flows above 200 gpm.
In addition there is an unexplained pressure drop at tap No. 4 in most of the data.

(b) General Comments

The pressure variation of 3-1/2 psi represents about 9% of the discharge head and since the major part of this variation occurs at the discharge end of the volute it is probable that it will have an adverse effect on the pump performance. The major pressure variations (taps Nos. 1, 2, and 8) occur in the vicinity of the cut-water of the pump casings and in the remaining part of the volute the pressure variation is small.

The non-uniform pressure distribution may have a number of undesirable effects on the pump operation:

(1) The flow from the impeller may not be uniform around the volute, higher flow occurring in the vicinity of the low pressure. In addition there may be also a secondary effect of pulsating flow in the impeller passages.

(2) The lower pressure at taps No. 1 and 2 induce more recirculation than would normally exist through the cut-water.

(3) The uneven pressure distribution will cause a slight radial load on the shaft. There seem to be sufficient
experimental evidence that there is a relationship between the measured pressure distribution and the radial force (13) and the radial force may be computed from the measured pressure distribution in the volute.

The pressure variation at tap No. 8 is also of concern because in this case the pressure drops at the discharge end of the casing. This may be the result of recirculation through the cut-water. Up to 200 gpm, the discharge is high enough to build up the pressure near the discharge end of the volute and maintain it at tap No. 8. Above 200 gpm the recirculation affects the discharge head, and this condition is aggravated by the low pressure in the first quarter past the cut-water. The high-speed movies also show some evidence of recirculation.

(c) Tentative Conclusions

The uneven pressure distribution in the pump volute appears to be a result of the large cut-off and the resulting cut-off area which is larger than necessary to handle its part of the impeller's discharge. This situation causes uneven flow from the impeller passages and encourages recirculation. If practical considerations allow, the cut-off area should be reduced.

Despite the conditions at the cut-water the remaining part of the volute appears to be satisfactory.
C. 270° Pipe Bend Tests

A preliminary report on 270° Pipe Bend tests has been prepared and will be submitted to the Sponsor early in July 1960 as Memorandum No. M-10.

III. RECOMMENDATIONS FOR IMPELLER DESIGN CHANGES

The following additional impeller vane designs were completed:

(1) Trial Design V
Shape of vane: logarithmic
Entrance angle: 45 degrees
Exit angle: 28-3/4 degrees

(2) Trial Design VI
Shape of vane: involute
Entrance angle: 45 degrees
Exit angle: 28-3/4 degrees

Sketches of Trial Designs V and VI are presented in the Appendix.

IV. EXPERIMENTAL TEST PROGRAM

The impeller vane of Trial Design V was ordered on May 26, 1960. The manufacturer indicates that the delivery of the impeller will be delayed by about three weeks from the originally scheduled date of June 30, 1960.

The impeller vane of Trial Design VI was ordered on June 9, 1960.
REFERENCES

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(2) Herbich, J. B.  
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(3) Herbich, J. B.  
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(4) Herbich, J. B.  
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CHARACTERISTICS OF A MODEL DREDGE PUMP  
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(6) Herbich, J. B.  
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(7) Herbich, J. B.  
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Lehigh University, February 1960

(8) Weiss, W. L.  
SUGGESTED DESIGN CHANGES FOR A CENTRIFUGAL PUMP IMPELLER HANDLING DREDGED MUD  
Fritz Engineering Laboratory Special Report  
Lehigh University, November 1959
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(9) Herbich, J. B. STATUS REPORT OF RESEARCH PROJECT ON IMPROVING DESIGN OF A HOPPER DREDGE PUMP. Fritz Engineering Laboratory Memorandum No. M-8 Lehigh University March 1960

(10) Herbich, J. B. STATUS REPORT OF RESEARCH PROJECT ON IMPROVING DESIGN OF A HOPPER DREDGE PUMP. Fritz Engineering Laboratory Memorandum No. M-9 Lehigh University April 1960

(11) Herbich, J. B. STATUS REPORT OF RESEARCH PROJECT ON IMPROVING DESIGN OF A HOPPER DREDGE PUMP. Fritz Engineering Laboratory Memorandum No. M-12 Lehigh University May 1960


### Mixture Concentration 1232 grams/liter

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### Mixture Concentration 1334 grams/liter

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**TABLE 1 - PRESSURE VARIATION AROUND VOLUTE IN PSI**