

Pump operating effects on transient fluid flow	العنوان:
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المُلخَص العَرَبِي

ملخص البحث

تحدث ظاهره الطرق المائى فى خطوط الانابيب نتيجة للتغير المفاجىء فى سرعه السائل يتبعها تغير مفاجىء فى الضغط ، وهى ظاهره ذات آثار مدمره على اجهزه القياس المستخدمه وخطوط الانابيب.

بعض الابحاث اخذت فى الاعتبار الارتباط بين جسم الانبويه والمائع اثناء ظاهره الطرق المائى مع الاهتمام بالحركه المحوريه لجسم الانبويه وكذلك الاحتكاك على السطح الخارجى للانبويه ، ونتج عن ذلك منظومه الأربع معادلات والتي تم فيها اضافه كل من معادله الحركه لجسم الانبويه وعلاقه الانفعال لماده جسم الانبويه بالاضافه الى منظومه المعادلتين و التى تحتوى معادله الاستمراريه ومعادله كميته الحركه للمائع.

من الابحاث السابقه تم الحصول على الحلول العدديه للظاهره والتي اظهرت اهميه تأثير الحركه المحوريه لجسم الانبويه وقوى الاخماد على السطح الخارجى لها.

وبالرغم من ذلك فان الدراسات السابقه لم تقدم دراسه تحليليه توضح فيها تأثير وجود مضخه فى بدايه الانبويه على مختلف المتغيرات الناتجه عن هذه الظاهره.

فى هذا البحث تم دراسه الارتباط الديناميكي بين جسم الانبويه والمائع وتأثير وجود المضخه على ظاهره الطرق المائى.

ملخص البحث

وقد تمت الدراسة من خلال عمل تحليل للمعادلات الحاكمة للظاهرة والحصول على المتغيرات المرتبطة بهذه الظاهرة اخذ في الاعتبار وجود المضخة في بدايه الانبويه وذلك باستخدام طريقه المعادلات المميزه (MOC) وايضا تم عمل بعض التجارب لتبرهن على صحة الطرق التحليليه المستخدمه.

ايضا تم استنتاج القيم العظمى لضغط السائل داخل الانبويه والاجهادات المؤثره على الانبويه والزمن اللازم لاختتام فوجه الضغط والاجهاد وشكل كل منهما وذلك في ظروف حديه تحاكي منظومه الانابيب العمليه. و كذلك تم الوصول لبرنامج لحل هذه المعادلات باستخدام الحاسب الالى واختبرت مدى استجابته البرنامج لتاثير المتغيرات المختلفه.

من نتائج البحث تم استنتاج اماكن القيم العظمى للضغط والاجهاد على طول الانبويه وذلك في ازمته غلق مختلفه للمحبس. وقد بينت النتائج مدى التطابق بين النتائج التجريبيه والنتائج من حل منظومه الاربع معادلات عن تلك النتائج من منظومه المعادلتين.

وبحل منظومه الاربع معادلات يتبين انه في حاله غلق المحبس في زمن اقل من او يساوى $10t_{wp}$ تزداد القيم العظمى للضغط المتولد عن ظاهره الطرق المائى بزياده بعد المسافه عن الطلمبه. اما في حاله غلق المحبس في زمن اكبر من $10t_{wp}$ تكون اقل قيمه للضغط واعلى قيمه للاجهاد كلما اقتربنا من المقاطع المتوسطه من الانبويه، وهذه المعلومات ستكون مفيده في تصميم خطوط الانابيب اخذين في الاعتبار اقصى اجهاد من الممكن ان تتحمله الانبويه.

ABSTRACT

Water hammer is the dynamic slam, bang, or shudder that occurs in pipes when a sudden change in fluid velocity creates a significant change in fluid pressure. Water hammer can destroy hydraulic devices and causes pipes and penstocks to rupture.

Water hammer phenomena due to sudden closure of a valve, with centrifugal pump at upstream, are studied both theoretically and experimentally. Also the study is extended theoretically for the case of using tank instead of pump.

Usually, fluid compressibility and pipe elasticity are taken into consideration, which produce a two equations model composed of continuity and fluid momentum equations. In relatively recent publications, interactions between pipe and fluid during water hammer were studied taking into consideration axial pipe motion as well as friction on outside pipe wall. This produces a four equations model, where pipe wall momentum equations as well as stress-strain relations of pipe wall material are considered.

Some numerical results were obtained in previous studies indicating the importance of fluid structure interaction, although a systematic study of the effect of different parameters is still lacking. In the present study, dynamic fluid pipe coupling is analyzed taking into considerations, the outside friction on pipe wall.

The problem is analytically solved using the method of characteristics. This approach helps to clarify, the centrifugal pump effect on the hammering waves, based on the characteristic equations, to estimate the maximum and

ABSTRACT

minimum values of pressure, stress wave, damping time, and hammering wave shape.

Streeter program is developed to solve four equations model to estimate the maximum and minimum values of pressure and stress. Also programs illustrate the position of maximum hammering wave's effect along the pipe line due to change in valve closing time.

Theoretical and experimental results indicate that; for the same condition the maximum pressure resulted from the four equations model is less than resulted from the two equations model.

Also in case of using four equations model with valve closing time less than or equal ten times the wave period, as the distance from the pump increases, the maximum pressure increases, and with valve closing time more than ten times the wave period, the minimum pressure value reaches at the middle sections of the pipe, and the maximum stress values occur at the middle sections of the pipe. This information is useful in pipe design.

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**Mansoura University
Faculty of Engineering
Mechanical Power Engineering Department**

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Submitted in Partial Fulfillment of Requirements for the Master of
Science in Mechanical Power Engineering

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Research title: PUMP OPERATING EFFECTS ON TRANSIENT
FLUID FLOW

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ABSTRACT

Water hammer is the dynamic slam, bang, or shudder that occurs in pipes when a sudden change in fluid velocity creates a significant change in fluid pressure. Water hammer can destroy hydraulic devices and causes pipes and penstocks to rupture.

Water hammer phenomena due to sudden closure of a valve, with centrifugal pump at upstream, are studied both theoretically and experimentally. Also the study is extended theoretically for the case of using tank instead of pump.

Usually, fluid compressibility and pipe elasticity are taken into consideration, which produce a two equations model composed of continuity and fluid momentum equations. In relatively recent publications, interactions between pipe and fluid during water hammer were studied taking into consideration axial pipe motion as well as friction on outside pipe wall. This produces a four equations model, where pipe wall momentum equations as well as stress-strain relations of pipe wall material are considered.

Some numerical results were obtained in previous studies indicating the importance of fluid structure interaction, although a systematic study of the effect of different parameters is still lacking. In the present study, dynamic fluid pipe coupling is analyzed taking into considerations, the outside friction on pipe wall.

The problem is analytically solved using the method of characteristics. This approach helps to clarify, the centrifugal pump effect on the hammering waves, based on the characteristic equations, to estimate the maximum and

ABSTRACT

minimum values of pressure, stress wave, damping time, and hammering wave shape.

Streeter program is developed to solve four equations model to estimate the maximum and minimum values of pressure and stress. Also programs illustrate the position of maximum hammering wave's effect along the pipe line due to change in valve closing time.

Theoretical and experimental results indicate that; for the same condition the maximum pressure resulted from the four equations model is less than resulted from the two equations model.

Also in case of using four equations model with valve closing time less than or equal ten times the wave period, as the distance from the pump increases, the maximum pressure increases, and with valve closing time more than ten times the wave period, the minimum pressure value reaches at the middle sections of the pipe, and the maximum stress values occur at the middle sections of the pipe. This information is useful in pipe design.

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NOMENCLATURE

- A** Cross-sectional area of pipe (m^2)
- A_G** Area of opening of a valve (m^2)
- a** Wave speed of sound (m/s)
- a₁, a₂** Pump characteristics curve constants
- b** Ratio of pipe density to fluid density
- B** Pipeline characteristics impedance $B = a / gA$
- B_M** Coefficient
- B_p** Coefficient
- C⁺** Positive characteristic line
- C⁻** Negative characteristic line
- C_x** Viscous damping coefficient $C_x = 2m\omega\xi = 2\xi A_p \sqrt{E\rho_p}$
- C_d** Orifice discharge coefficient
- d** Ratio of pipe radius to wall thickness
- D** Inside pipe diameter (m)
- E** Young's modulus of elasticity (N/m^2)
- e** Thickness of pipe wall (m)
- f** Friction factor

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قسم هندسة القوى الميكانيكية

تأثير تشغيل المضخة على سريان الانتقال للمائع

رسالة

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2011



**Mansoura University
Faculty of Engineering
Mechanical Power Engineering Department**

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Submitted in Partial Fulfillment of Requirements for the Master of
Science in Mechanical Power Engineering

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