

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ
السَّلَامُ عَلَیْكُمْ وَرَحْمَةُ اللّٰهِ وَبَرَکَاتُهُ





حلول مبتكرة لزيادة إنتاج آبار البترول القديمة والحديثة

by
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إسم البحث باللغة العربية:

تحسين كفاءة المضخة النفاثة (*Jet Pump*) المستخدمة في حقول البترول وذلك بدراسة تأثير مختلف العوامل التصميمية والعوامل التشغيلية على أداء المضخة عملياً وعددياً.

إسم البحث باللغة الإنجليزية:

Improving the efficiency of the jet pump used in the oil fields by studying the effect of various design and operational parameters on the pump performance, experimentally and numerically



Outlines

- 1)- Introduction**
- 2)- Problem Statement in My Field**
- 3)- Literature Review**
- 4)- Objectives of The research**
- 5)- Mathematical Models and Numerical methodology**
- 6)- Mesh Independent Solution and CFD Code Validation**
- 7)- Optimization Results**
- 8)- Experimental Work**
- 9)- Conclusion and Recommendation**

■ INTRODUCTION

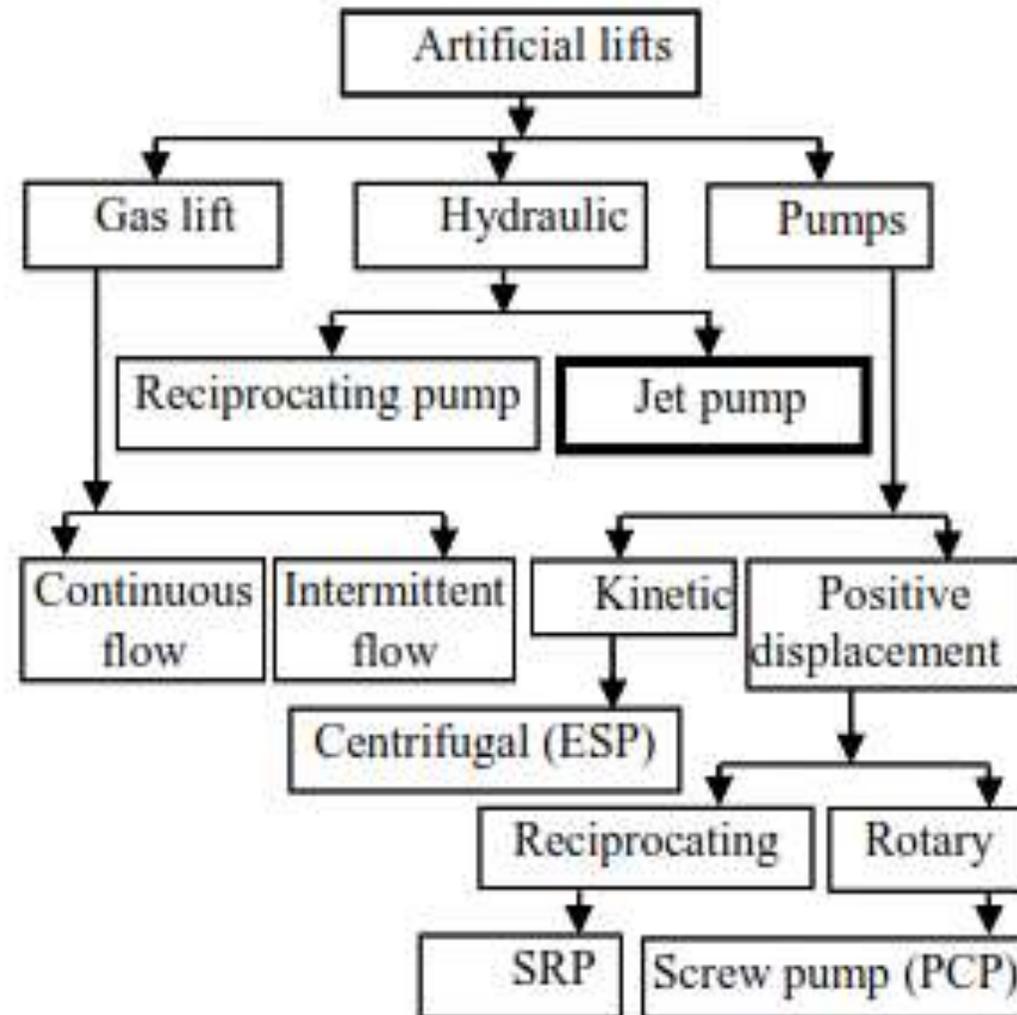
□ ينخفض معدل الإنتاج من حقول النفط مع مرور الوقت بسبب العوامل المختلفة. لذلك من الضروري استخدام بعض الطرق لتعويض انخفاض معدل الإنتاج. يشير الرفع الإصطناعي إلى استخدام الوسائل الإصطناعية لزيادة تدفق السوائل مثل النفط الخام أو الماء من بئر الإنتاج، وتعتبر الوسائل الإصطناعية من أنسب الطرق لزيادة معدل الإنتاج.

□ تعد المضخة النفاثة (**Jet Pump**) أحد وسائل الرفع الإصطناعية.

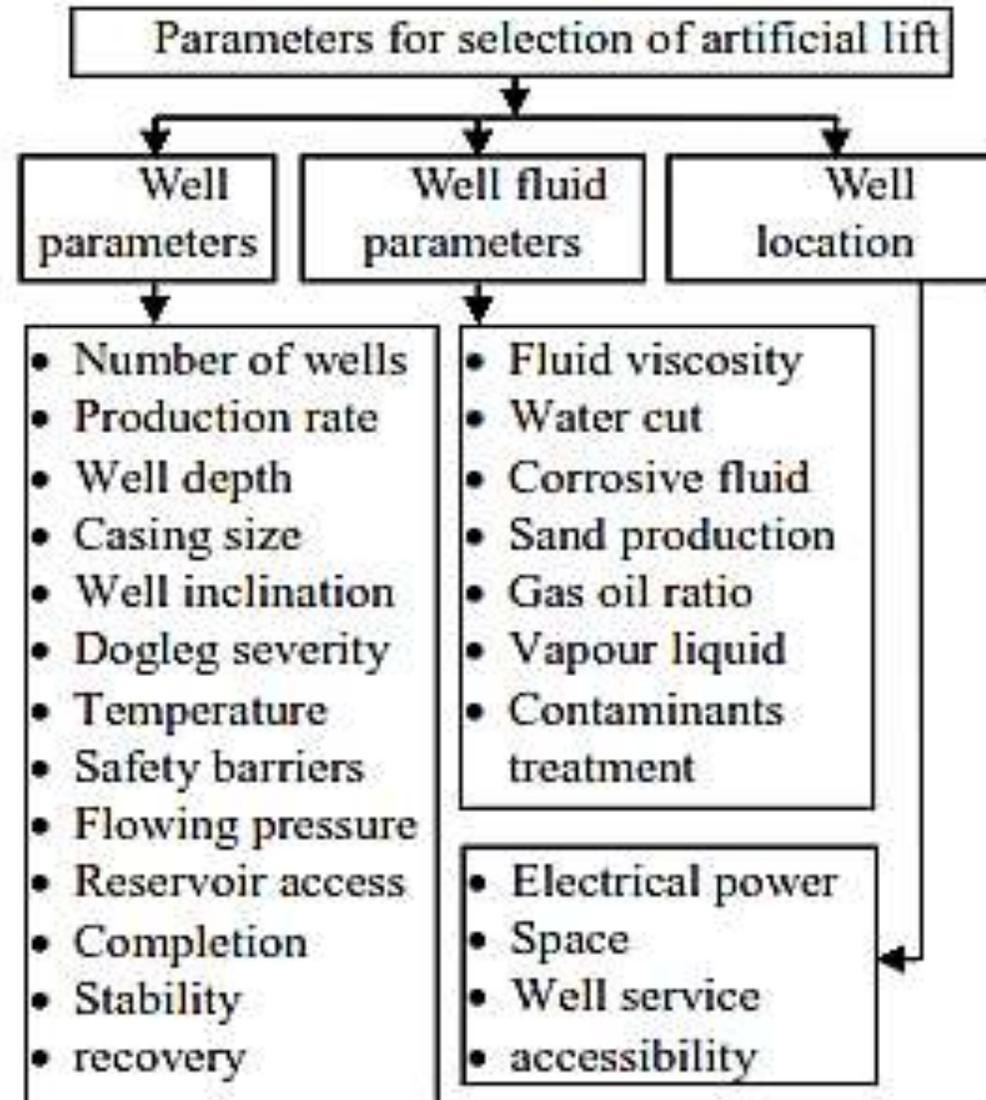
■ INTRODUCTION

- **Jet pump** has come important rule in the oil production of the petroleum field. Also, it has come into widespread use in many branches of engineering.
- **Jet pump** is a non-conventional pump used widely in many applications to convey a wide range of liquids and bulk solids.
- **Hundreds** of jet pump systems have been installed in industry all over the world since the early **70 years**.
- In recent years, the jet pump (also known as **eductor**, **suction nozzle** and **injector**) has been increasing in popularity as a fluid and and bulk solids transportation system.

- The types of artificial lifts (AL) which supplement energy to lift the fluid from the wells can be expressed as the following:

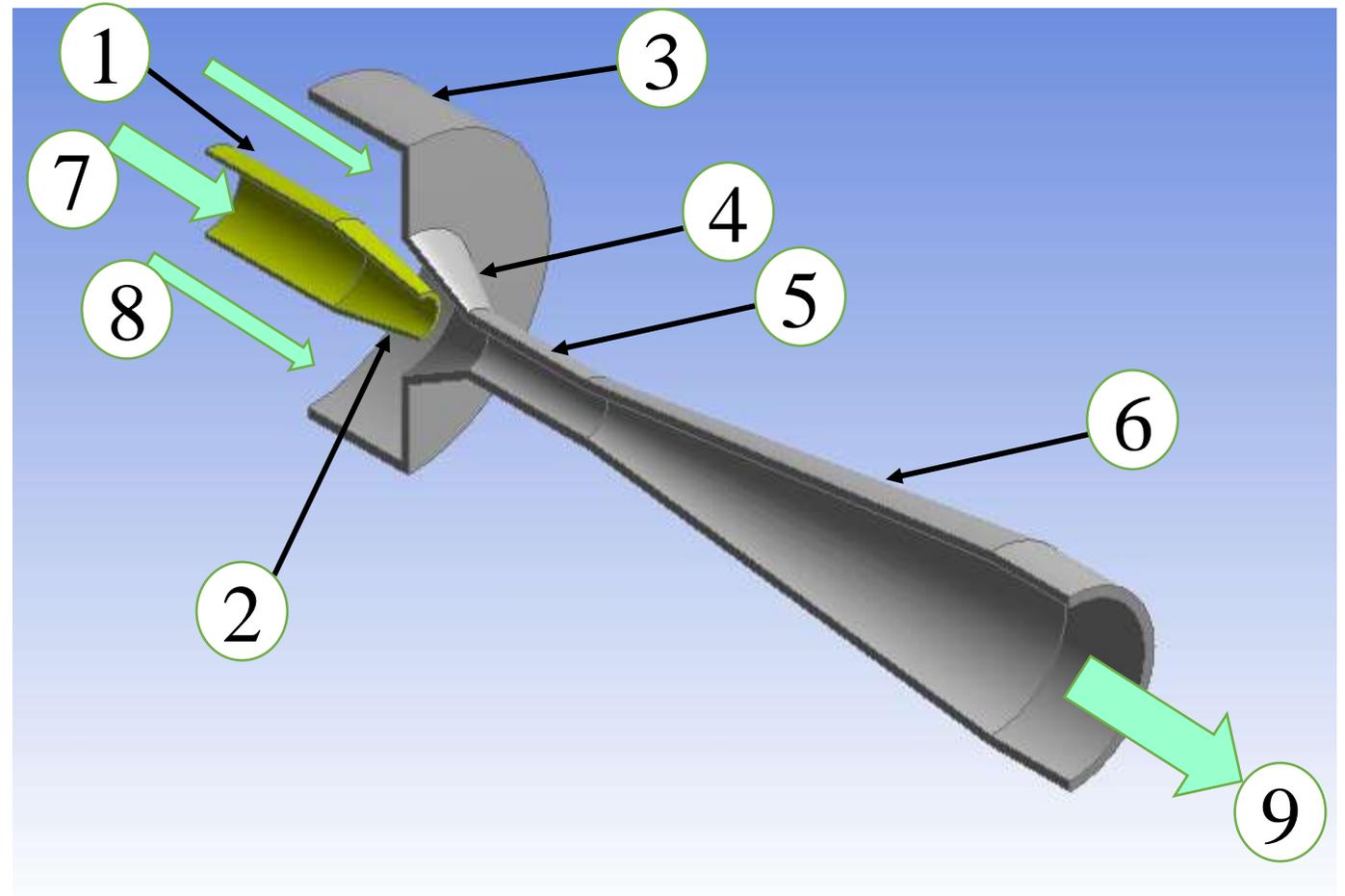


- The several criteria that used for selecting any artificial lifts (AL) can be expressed as the following:



➤ Jet Pump Main Components

- 1)- Motive Line
- 2)- Motive Nozzle
- 3)- Suction Chamber
- 4)- Suction Nozzle
- 5)- Mixing Chamber
- 6)- Diffuser
- 7)- Motive Flow
- 8)- Entrained Flow
- 9)- Total (Mixed) Flow



➤ **The Advantages of Jet Pump**

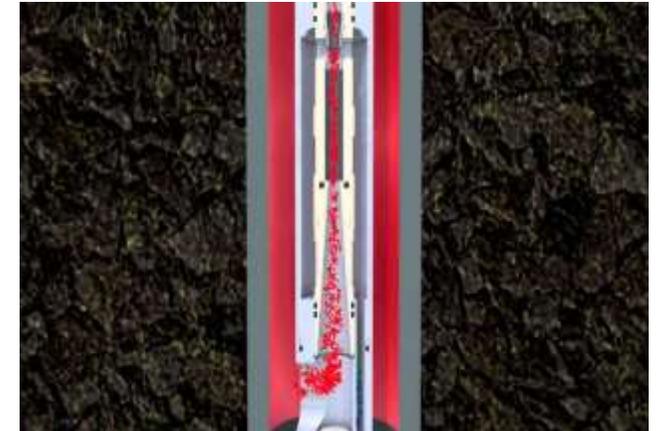
- 1)- Simplicity and Reliability (No moving parts).**
- 2)- No Water Leakage.**
- 3)- Low Capital Cost and Little or no Requirement of Maintenance.**
- 4)- Minimum Attrition of Material to be conveyed (Do not suffer from shearing, smearing or degradation problems).**
- 5)- High Temperature Applications (Due to lack of moving parts).**

➤ **The Dis-advantages of Jet Pump**

1)- Low Efficiency.

➤ **The Applications of Jet Pump**

1)- Petroleum Production.



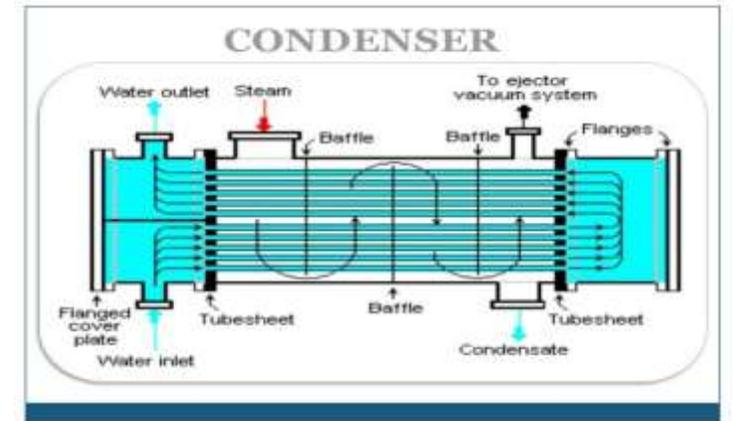
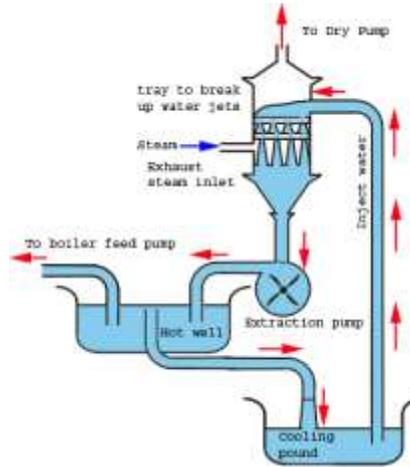
2)- Chemical Industry (Stainless-Steel).



3)- Slurry Systems Marine.



4)- Thermal Power Plants.



5)- Petrochemicals.



6)- Marine Applications (Jet Propulsion Pump).



7)- Construction Industry.



8)- Aquariums.



■ Problem Statement in My Field

- The cost of petroleum production in my company is Very High, due to the following reasons:-
 - The **Low oil Production** due to the low efficiency of Jet pump.
 - The **High Capital Cost** due to purchasing jet pump from foreign vendor.
 - The **High Running Cost** due to purchasing jet pump spare parts from foreign vendor.
 - The **High Running Cost** due to engineering consults from foreign experts.

➤ Literature review

- Covers the period (1852-2020).

➤ MAIN CONCLUSIONS FROM REVIEW

□ أوضحت الدراسات السابقة أن كفاءة المضخة النفاثة (Jet Pump) **صغيرة** وتحتاج إلى تحسين.

□ أوضحت الدراسات السابقة أنه يوجد **نقص** كبير في الأبحاث المتعلقة بعمل تحسين لكفاءة المضخة النفاثة المحورية المستخدمة في حقول النفط، ولهذا سيقوم البحث الحالي بتغطية هذا الموضوع.

الهدف من البحث الحالى:

- (1):** يهدف البحث الحالى إلى دراسة وتحسين أداء المضخة النفاثة المستخدمة فى حقول البترول، وتوفير إستهلاك مائع التشغيل.
- (2):** أيضاً يهدف البحث الحالى إلى تحديد تأثير العوامل التصميمية والعوامل التشغيلية على أداء المضخة النفاثة (Jet Pump) عملياً وعددياً.
- (3):** الوصول إلى أفضل تصميم وتنفيذه عملياً فى أحد حقول البترول.

الهدف من البحث الحالى:

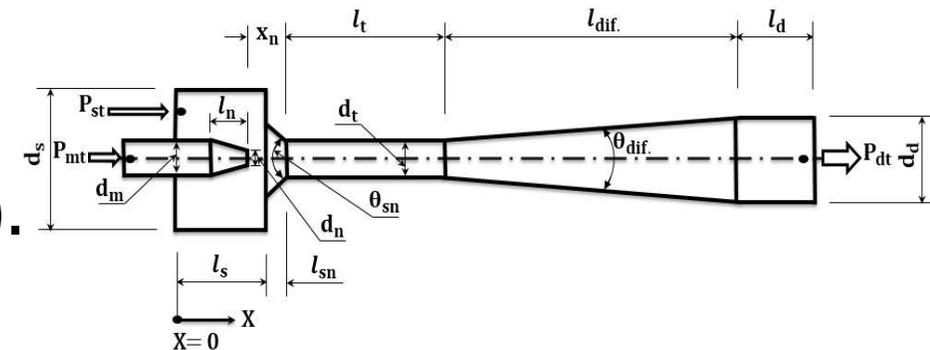
4): عمل تصميم لنموذج رياضى يمكن من خلاله دراسة تأثير العوامل التصميمية والعوامل التشغيلية على أداء المضخة النفاثة (**Jet Pump**)

ملحوظة: تم إستخدام **الماء** كمائع أولى ومائع ثانوى فى التجارب العملية بدلاً من إستخدام **الزيت** كمائع ثانوى وذلك نظراً لعدم توافر الإمكانيات المعملية وصعوبة إجراء التجارب العملية بأحد حقول البترول.

Procedures of the current research

- ❑ **Validating** the computational model with the available previous experimental and computational data from the literature.
- ❑ **Performing** computational study to investigate the effects of different parameters on the performance of axial-water jet pump as following:

- Effect of diffuser angle, ($\theta_{\text{dif.}}$).
- Effect of the mixing chamber length, (l_t).
- Effect of the area ratio, ($A_r = A_n/A_t$).
- Effect of the driving nozzle position, (Z).



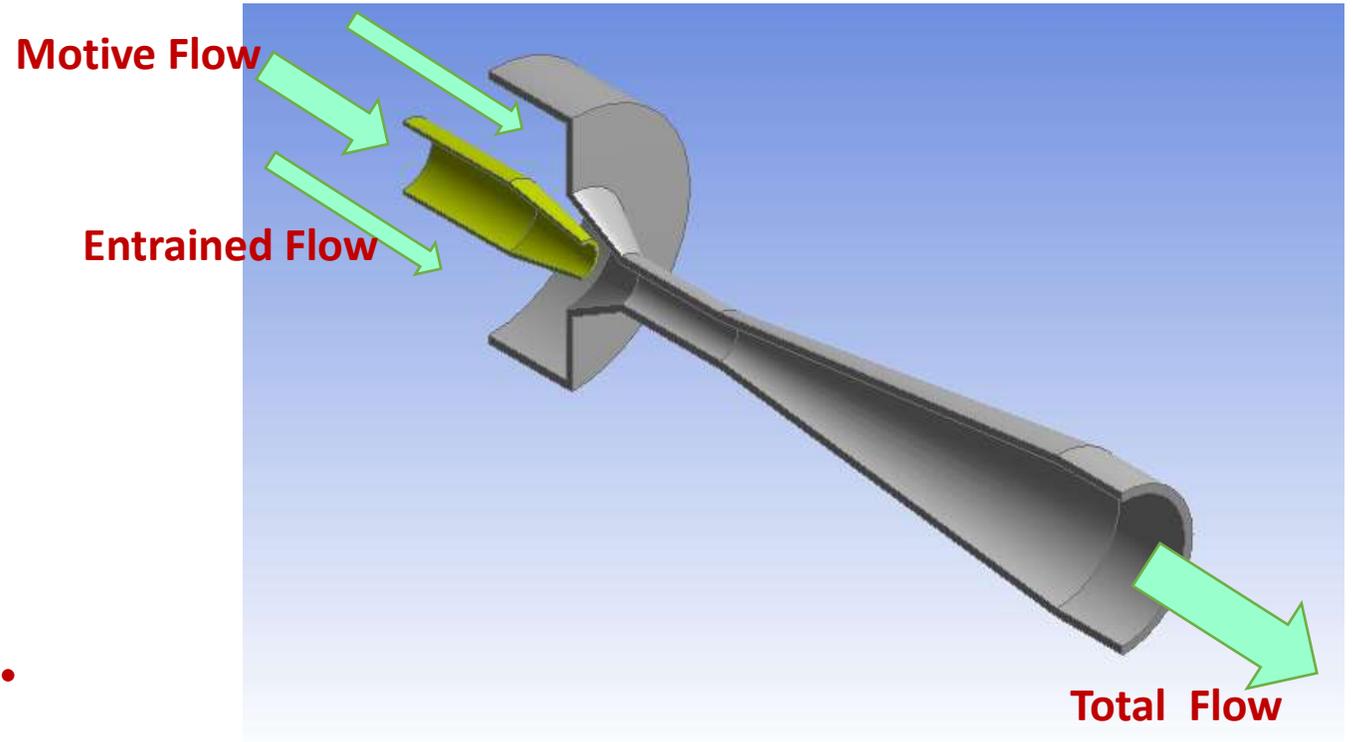
- ❑ **Performing** computations to estimate different parameters that cannot be simply measured in the laboratory such as **streamline contours** at different locations along the axial-water jet pump.
- ❑ **Designing** and fabricating the **optimum** design **axial-water jet pump** tested model.
- ❑ **Constructing experimental test rig** including the optimum design axial-water jet pump tested model and testing the effect of the operational parameters and different nozzle relative positions (**Z = 0, 1 and 2**) on the performance of axial-water jet pump.
- ❑ **Verification** of the **experimental model** results by validation with the **computational model** results.

MATHEMATICAL MODEL

➤ Model selection ?

☐ Specify domain physics

- ✓ **Water flow in motive.**
- ✓ **Water flow in suction.**
- ✓ **Water flow in pump outlet.**



➤ Internal flow modelling-continue

□ *Model assumptions*

- The flow within the jet pump is **steady**.
- The flow within the jet pump is **incompressible**; both the motive fluid and suction (entrained) fluid is **water**.
- There is **no heat transfer** between water and surroundings; so energy equation is not needed.
- The surface roughness is taken as zero (**$K = 0$**).
- The effect of **buoyancy** is ignored.
- The flow model is considered as a **two dimensional water single-phase flow, steady** and **turbulent** flow.

Numerical Methodology

2D Steady Heat Conduction



$$\frac{\partial}{\partial x} \left(\Gamma \frac{\partial \phi}{\partial x} \right) + \frac{\partial}{\partial y} \left(\Gamma \frac{\partial \phi}{\partial y} \right) + S = 0$$

$$\int_{\Delta V} \frac{\partial}{\partial x} \left(\Gamma \frac{\partial \phi}{\partial x} \right) dx \cdot dy + \int_{\Delta V} \frac{\partial}{\partial y} \left(\Gamma \frac{\partial \phi}{\partial y} \right) dx \cdot dy + \int_{\Delta V} S \phi dV = 0$$

$$a_P \phi_P = a_W \phi_W + a_E \phi_E + a_S \phi_S + a_N \phi_N + S_u$$

a_W	a_E	a_S	a_N	a_P
$\frac{\Gamma_x \Delta x}{\Delta x \Delta y}$	$\frac{\Gamma_x \Delta x}{\Delta x \Delta y}$	$\frac{\Gamma_y \Delta y}{\Delta x \Delta y}$	$\frac{\Gamma_y \Delta y}{\Delta x \Delta y}$	$a_W + a_E + a_S + a_N + a_P - S_u$



➤ Numerical Technique

- The **finite volume** method is used.
- The **SIMPLE Algorithm** for pressure velocity coupling is used.
- For internal flow, the **second order upwind** is used for discretization of all equations.
- The **2D double-precision** is used for a better resolution of the turbulent flow field.
- The **Transition SST-Turbulence model** is used.

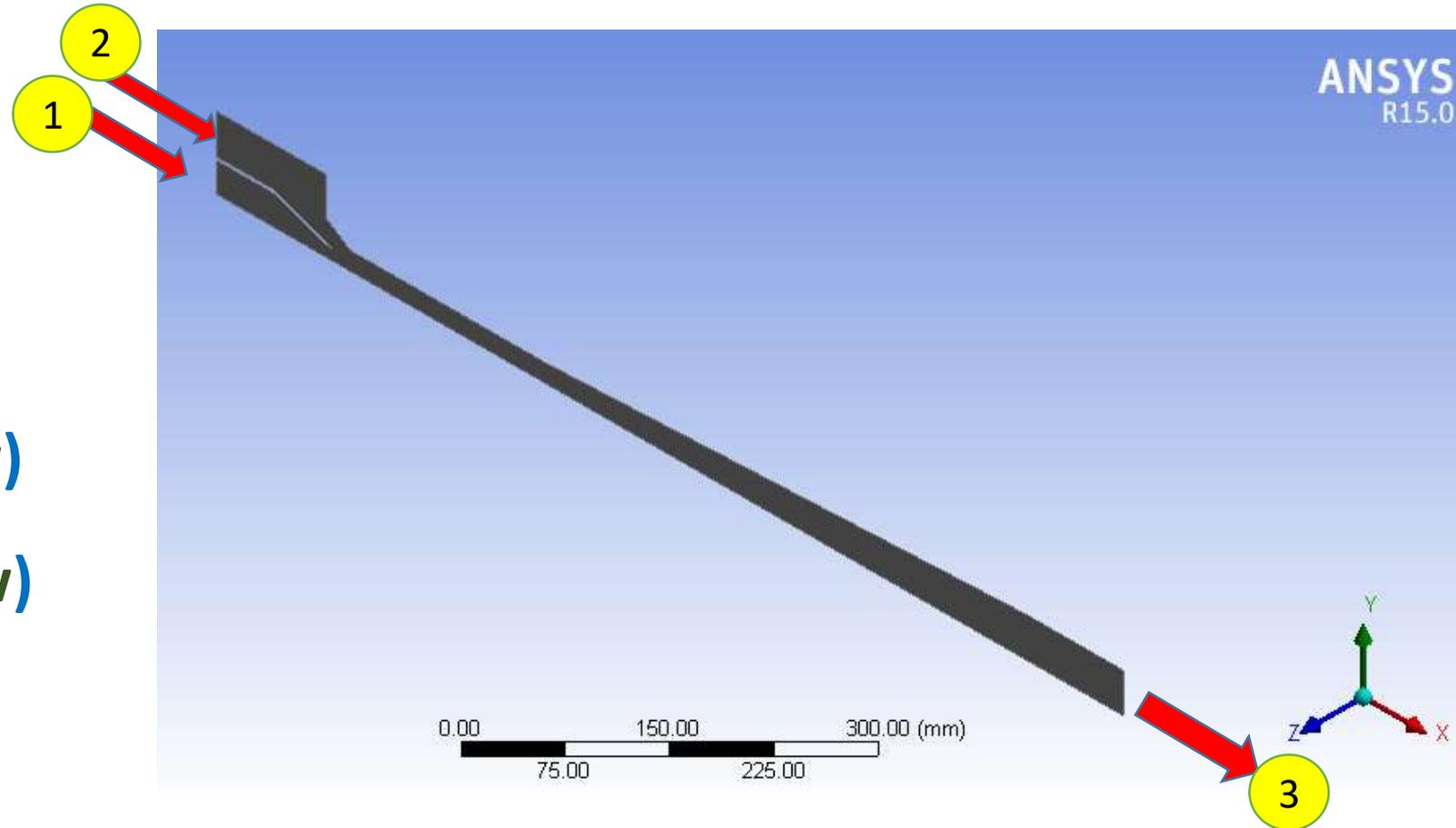
➤ PHYSICAL DOMIAN (Geometry)

▪ Internal flow domain

1)- Water Inlet (Motive Flow)

2)- Water Inlet (Suction Flow)

3)- Water outlet (Total Flow)



➤ Boundary condition

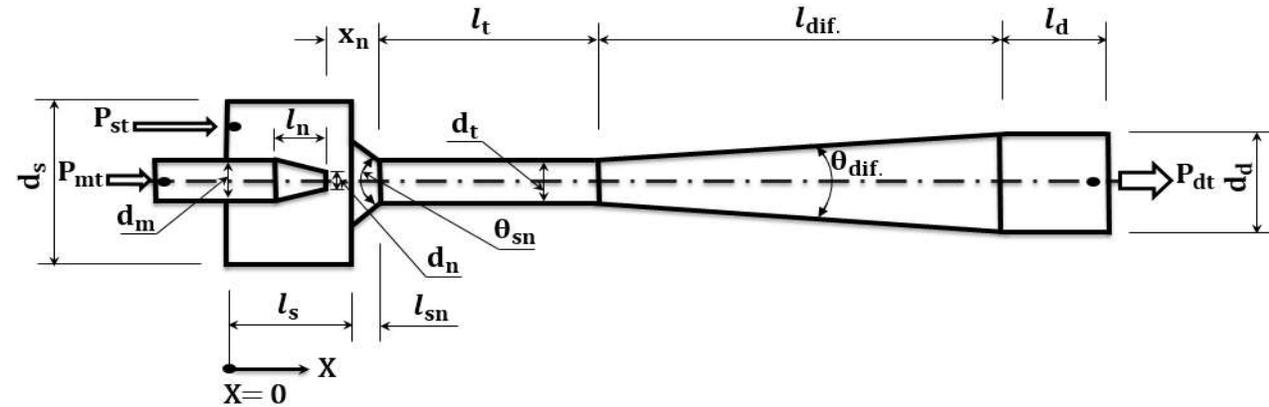
□ Inlet Boundary Conditions

- Motive Flow (Inlet Pressure)
- Suction Flow (Inlet Pressure)

□ Outlet Boundary Conditions

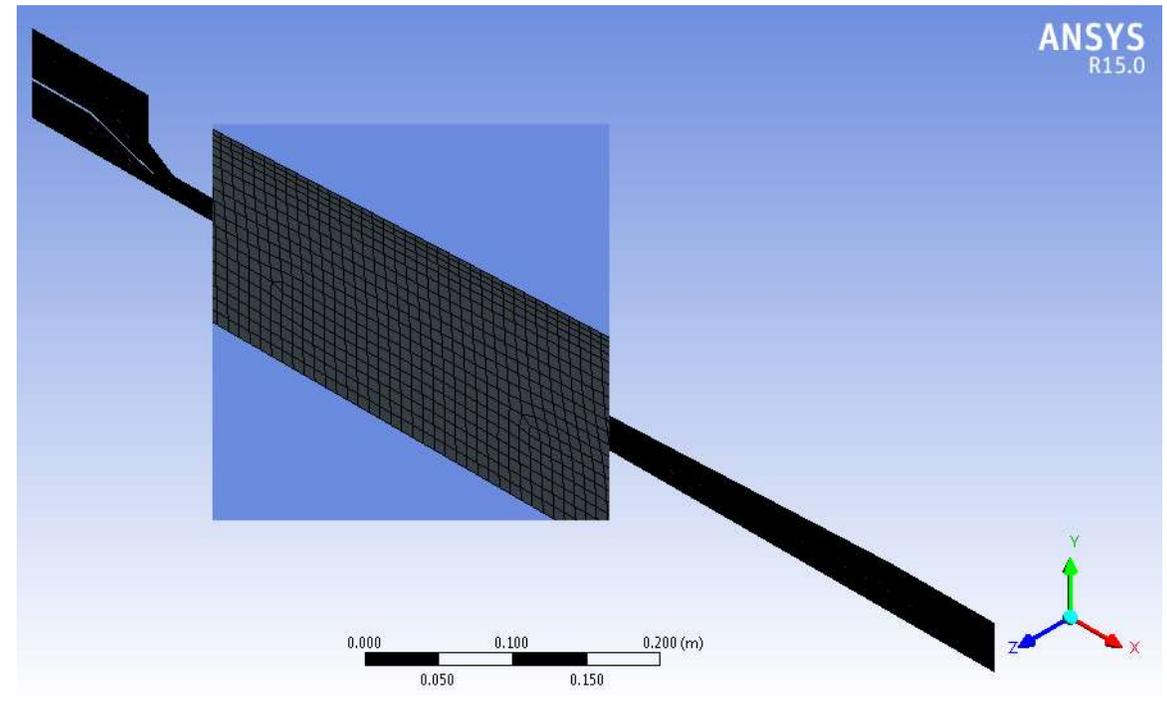
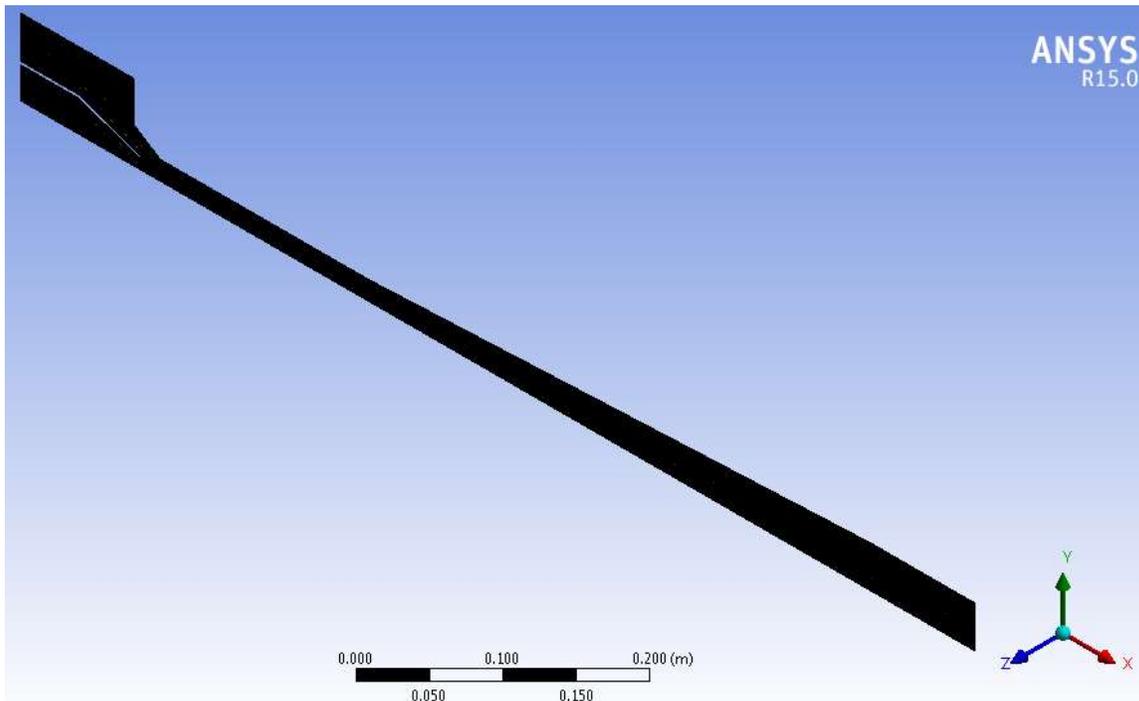
- Total Flow (Outlet Pressure)

□ Symmetry at symmetry axis



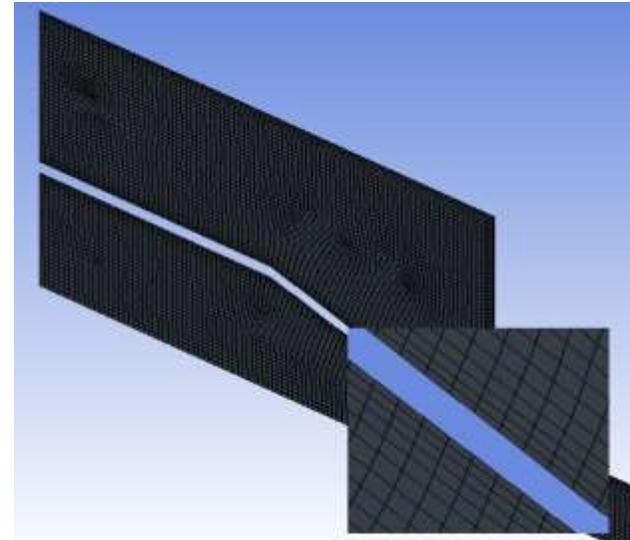
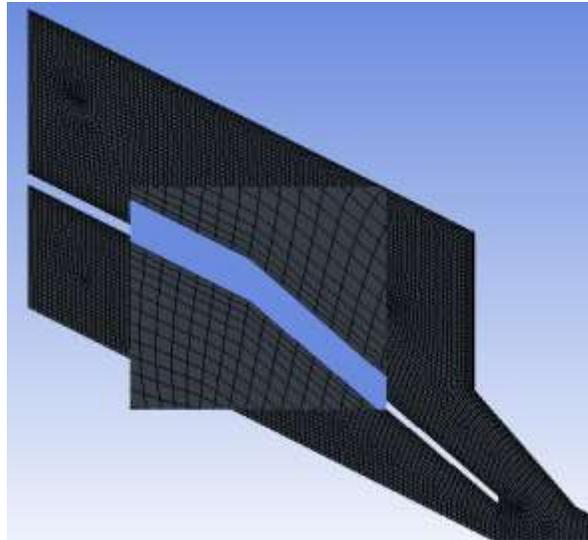
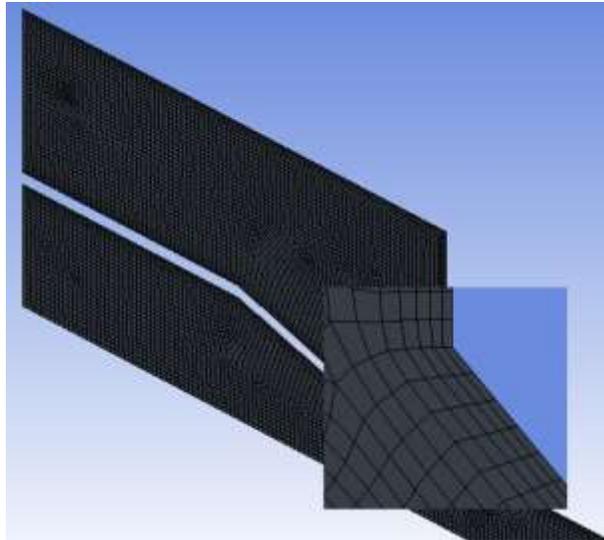
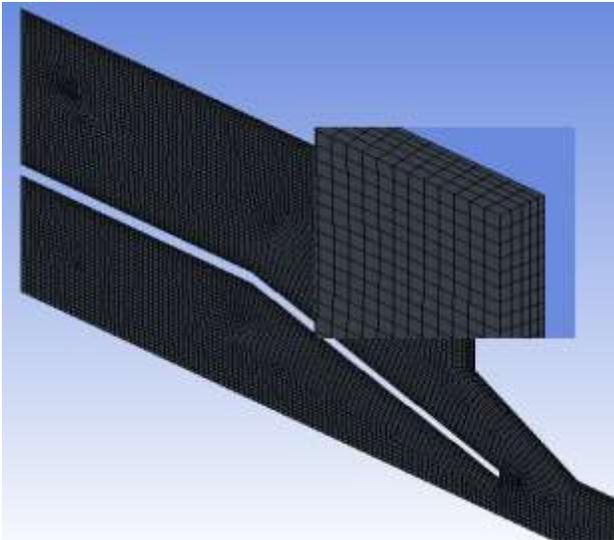
➤ Computational domain

- **Structured** mesh is used.
- Total number of cells = **22000** cells.
- Max. Aspect ratio = **2.8011**
- Min. Aspect ratio = **1.0002**



➤ Computational domain cont.

- **Inflated mesh** is used near the wall boundaries to improve accuracy.
- For inflation a **first layer height** of **45 mm** and a **growth rate** of **1.2** are used.



□ Dimensionless Parameters That Characterize the Operation Mode of Jet Pump

➤ Area Ratio (A_r)

The ratio of the motive nozzle outlet area to that of mixing chamber is given as:

$$A_r = \frac{A_n}{A_t}$$

➤ Mass Flow Ratio (M_r)

The ratio of the entrained fluid mass flow rate to that of motive fluid is given as:

$$M_r = \frac{\dot{m}_s}{\dot{m}_m}$$

➤ Pressure Ratio (P_r)

The ratio of the increase in total pressure of entrained fluid to the decrease in total pressure of motive fluid is given as:

$$P_r = \frac{(P_d - P_s)}{(P_m - P_d)}$$

➤ Efficiency (η)

The jet pump efficiency is found by multiplying mass flow ratio by pressure ratio.

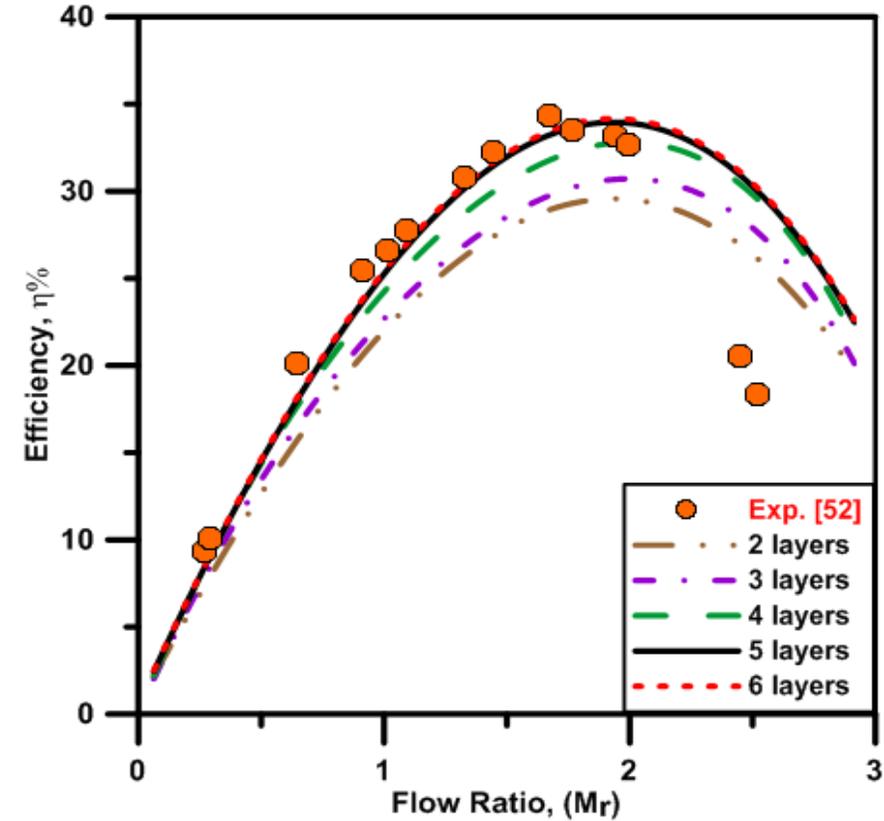
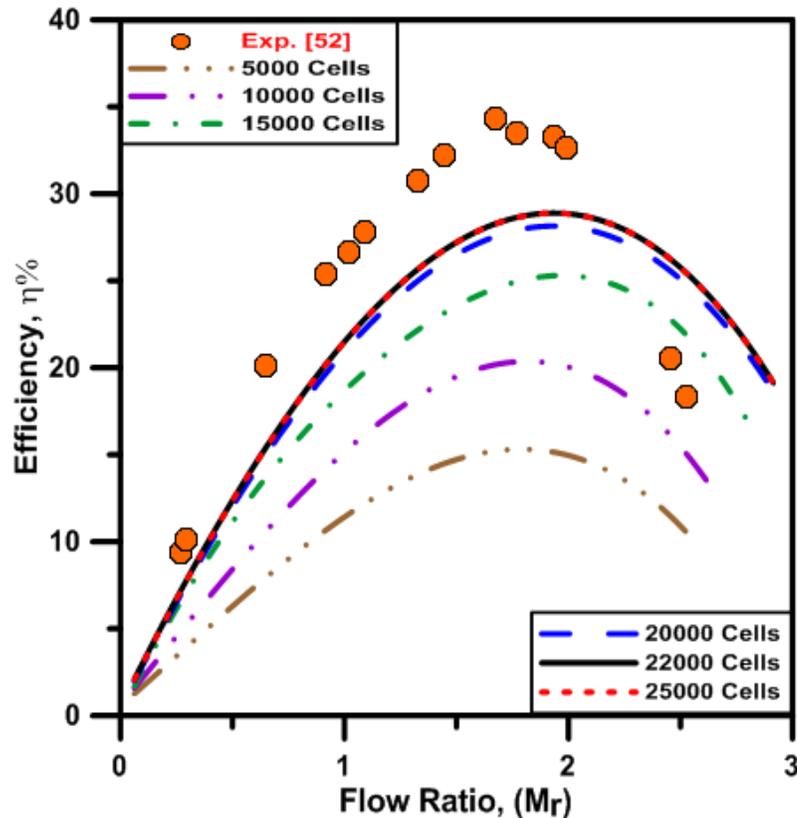
$$\eta = M_r \cdot P_r$$

Mesh Independent Solution

■ **Mesh or grid independence study** is carried out to determine this **optimum point** where a fairly accurate solution for the problem is found at the expense of least computational resources.

■ **Mesh independent solution**

■ **Layers inflation independent solution**

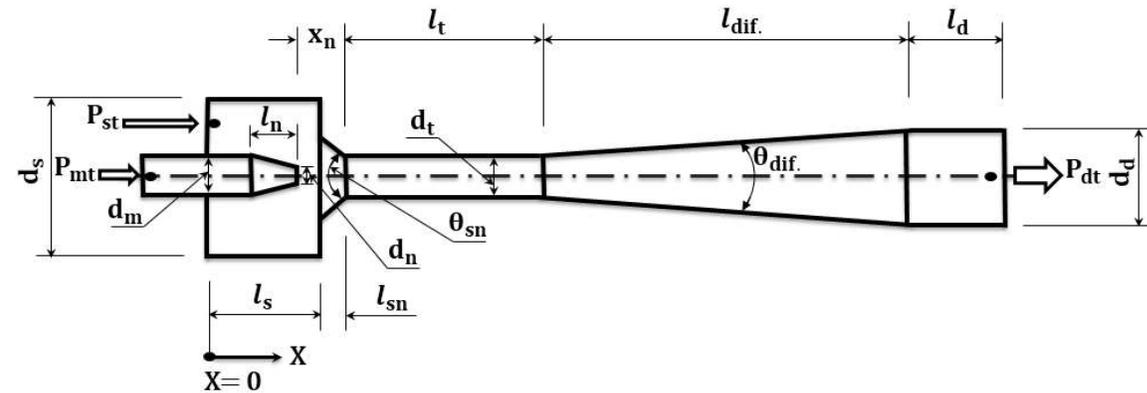


CFD

Code Validation

- The numerical, **2D code** is validated with the experimental and numerical, **3D data** of Aldas and Yapici [2014] in case of single phase flow (water flow in axial jet pump) at the **same geometry** and the **same boundary conditions**.

- The dimensions of the model used in validation

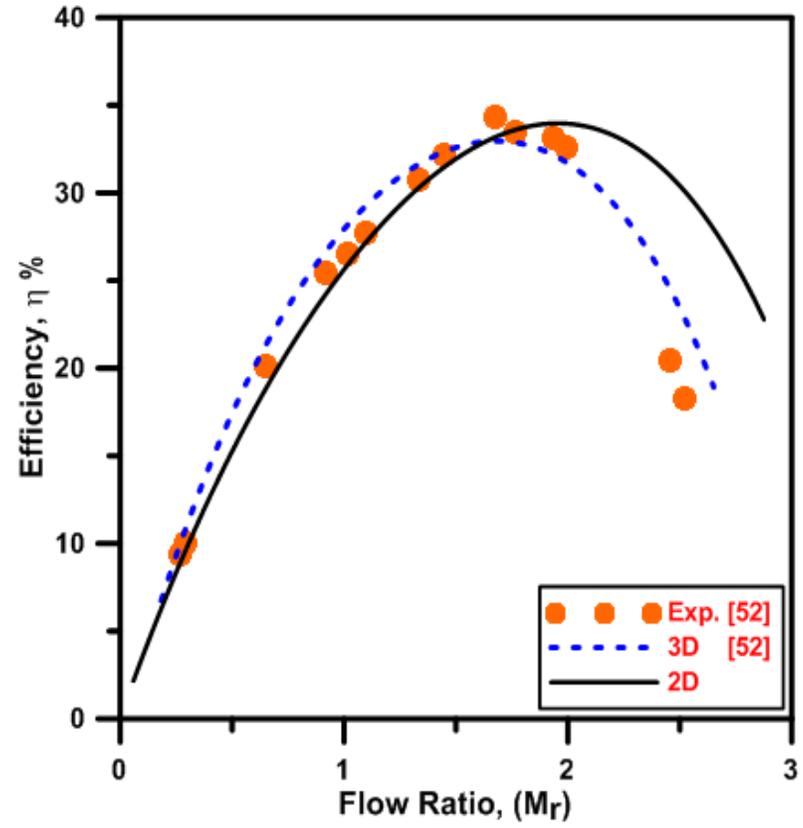


l_s	d_s	l_{sn}	θ_{sn}	l_n	d_m	d_n	l_t	d_t	$l_{dif.}$	$\theta_{dif.}$	l_d	d_d
110	152.4	25	86°	60	60	15	270	36.5	315	7.6°	100	80

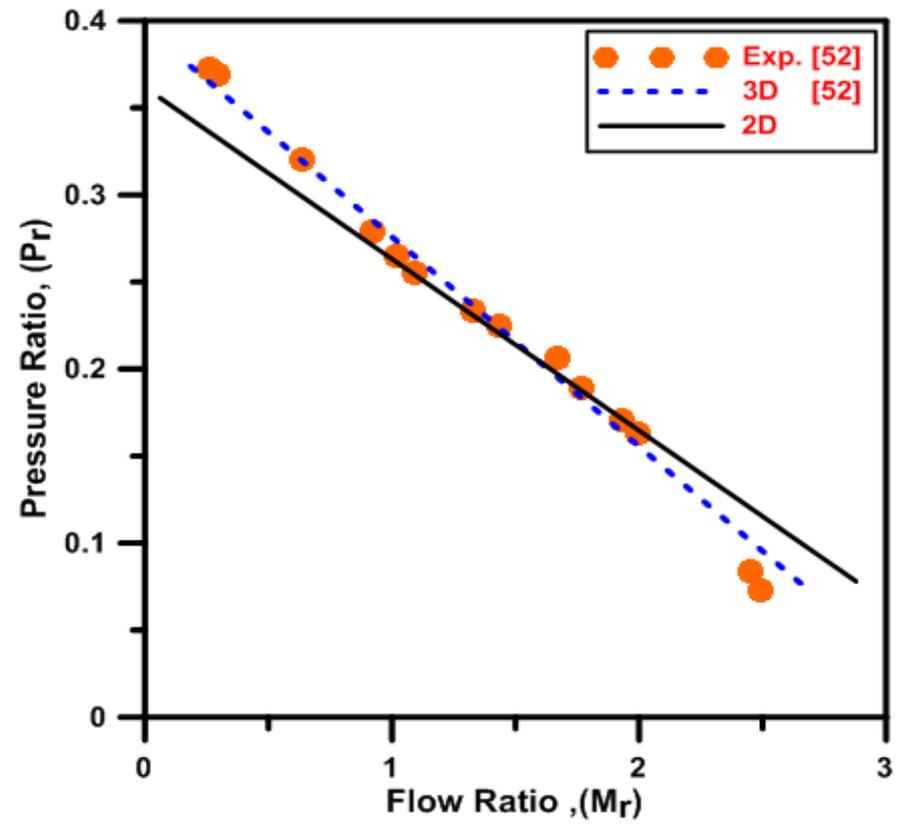
All Dimensions Are in (mm).

- Comparison between numerical, 2D results and (experimental – numerical, 3D) data; Aldas and Yapici [2014].

- The efficiency curve**

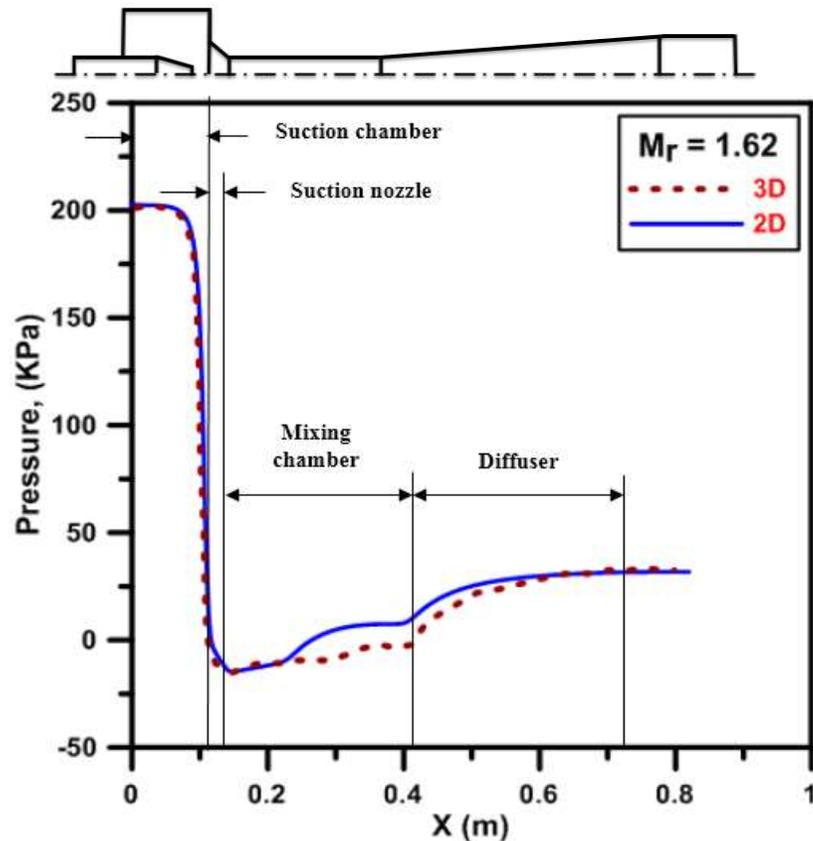


- The head ratio curve**

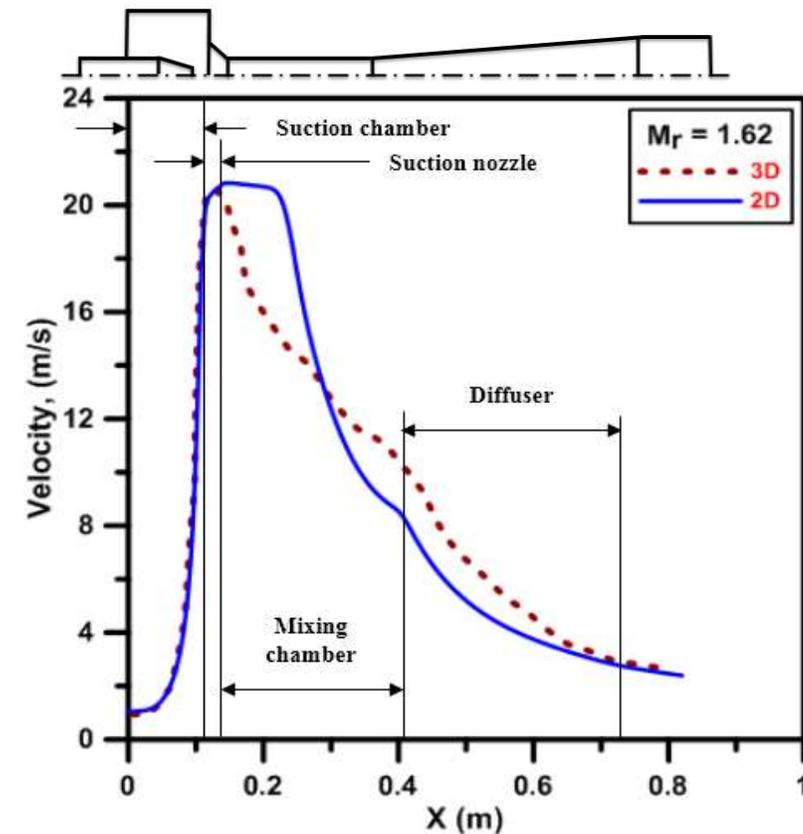


- Comparison for pressure and velocity between numerical, 2D results and numerical, 3D data; Aldas and Yapici [2014].

- The pressure curve a long C.L of the pump



- The velocity curve a long C.L of the pump



Optimization Results

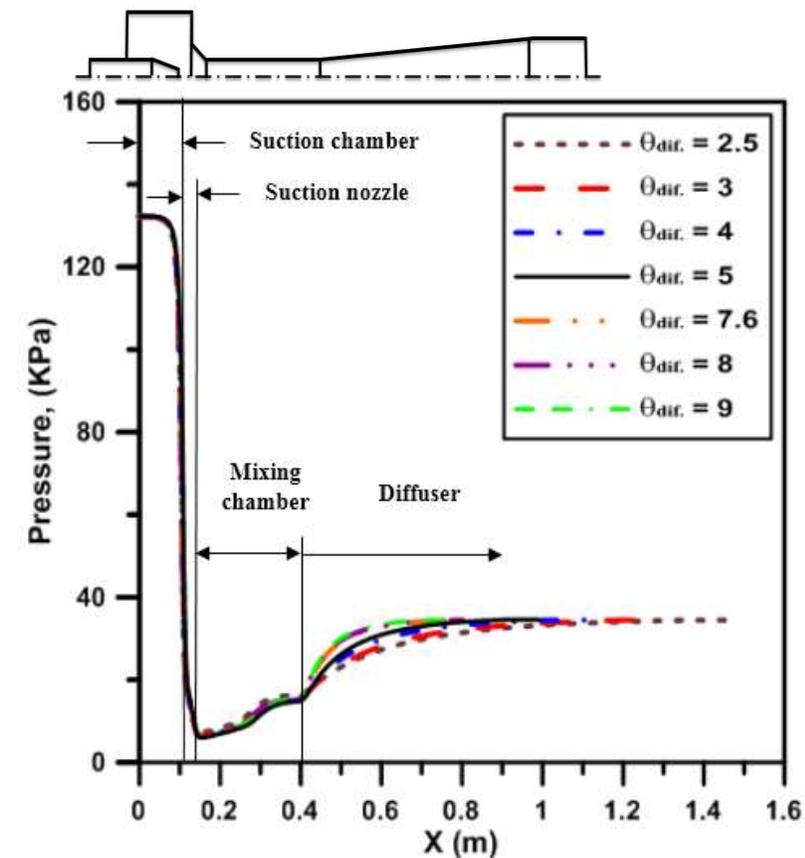
□ EFFECTS OF GEOMETRICAL AND OPERATIONAL PARAMETERS ON THE PERFORMANCE OF JET PUMP

1)- Effect of The Diffuser Angle

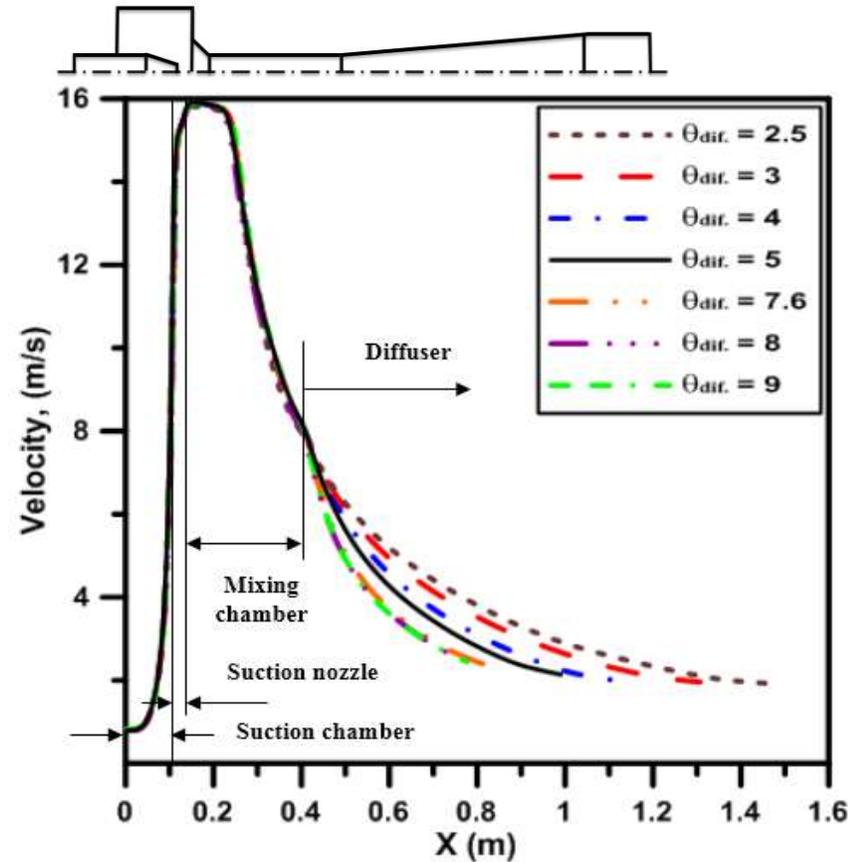
- Constant area ratio ($A_r = 0.169$), constant mixing chamber length ($L_t = 270$ mm), diffusers inlet diameter ($d_t = 36.5$ mm), diffusers outlet diameter ($d_d = 80$ mm) and constant nozzle relative position ($Z = 1.87$) are used.
- **seven** diffuser angles in values of 2.5° , 3° , 4° , 5° , 7.6° , 8° and 9° are selected in the current study at the lengths of **950**, **800**, **600**, **485**, **315**, **299** and **270** mm respectively.

■ Pressure and velocity variations along centerline (C.L) and pressure variation along the outer wall (O.W) of jet pump.

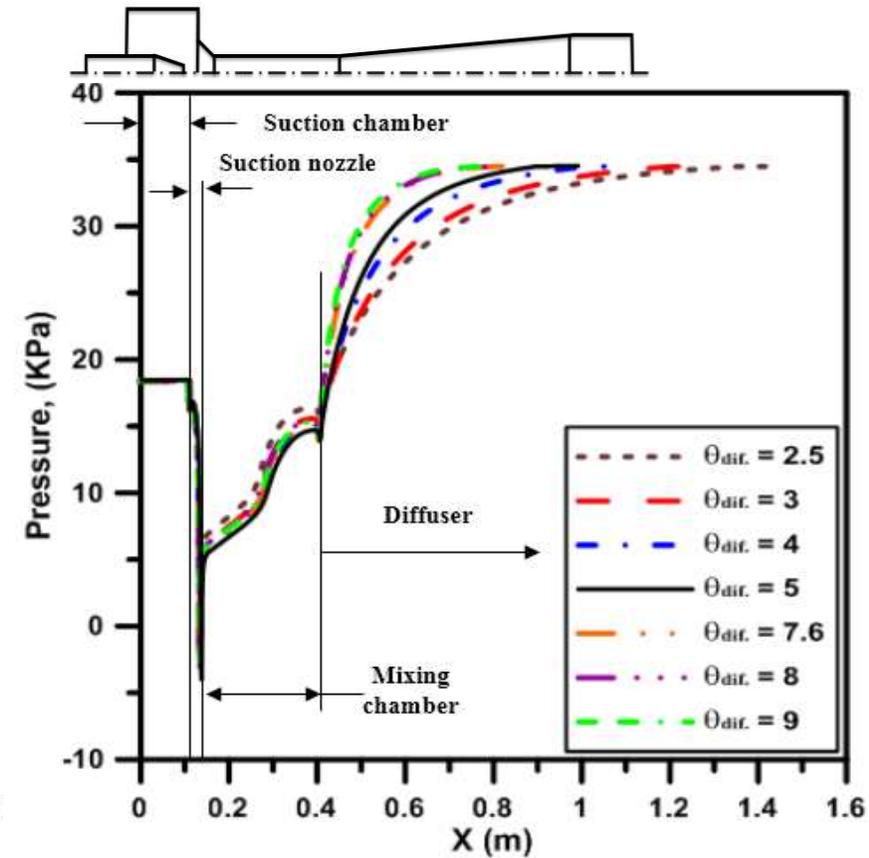
■ The pressure variation along C.L of jet pump



■ The velocity variation along C.L of jet pump



■ The pressure variation along O.W of jet pump

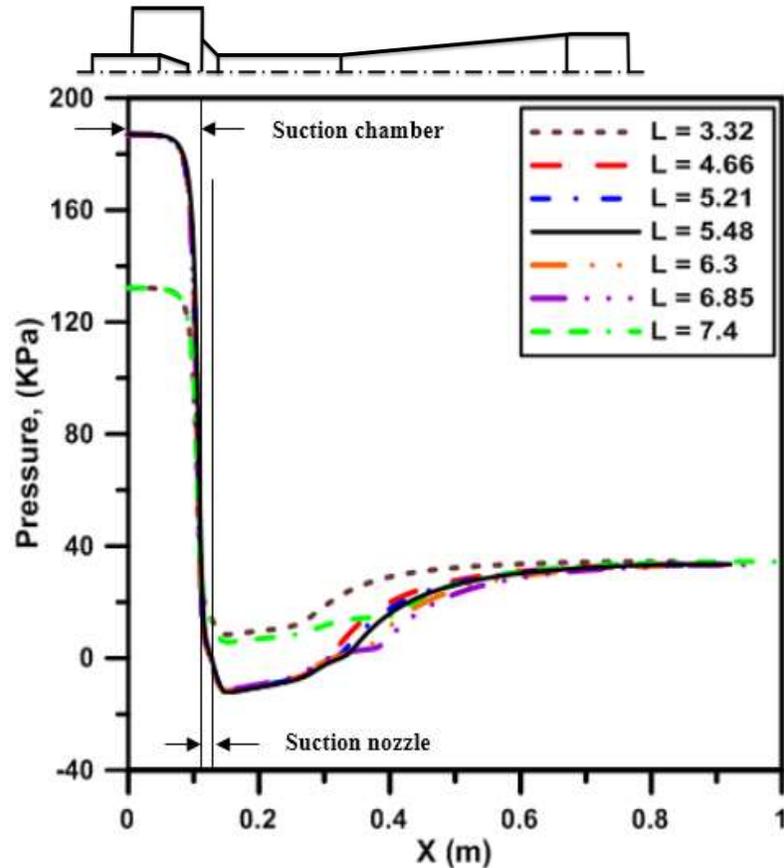


2)- Effect of The Mixing Chamber Length

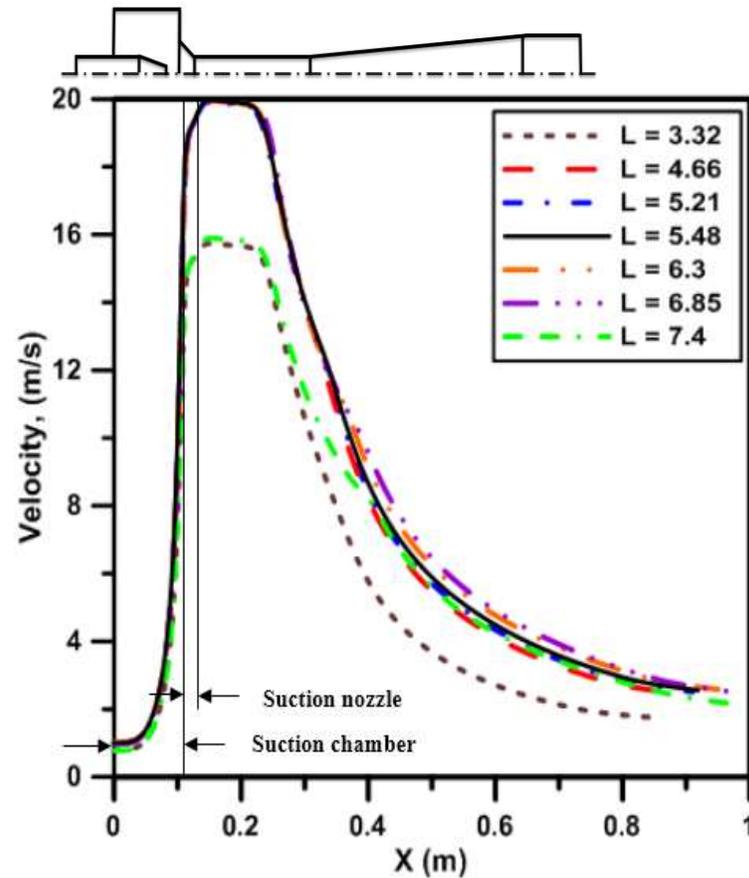
- Constant area ratio ($A_r = 0.169$), constant diffuser length ($L_{dif.} = 485$ mm), constant diffuser angle ($\theta_{dif.} = 5^\circ$) and constant nozzle relative position ($Z = 1.87$) are used.
- seven mixing chambers/tubes in lengths of **121 mm, 170 mm, 190 mm, 200 mm, 230 mm, 250 mm** and **270 mm** are selected in the current study.
- **The relative length** of the mixing chamber **L** is defined as the ratio of its length to its diameter (l_t/d_t).

Pressure and velocity variations along centerline (C.L) and pressure variation along the outer wall (O.W) of jet pump.

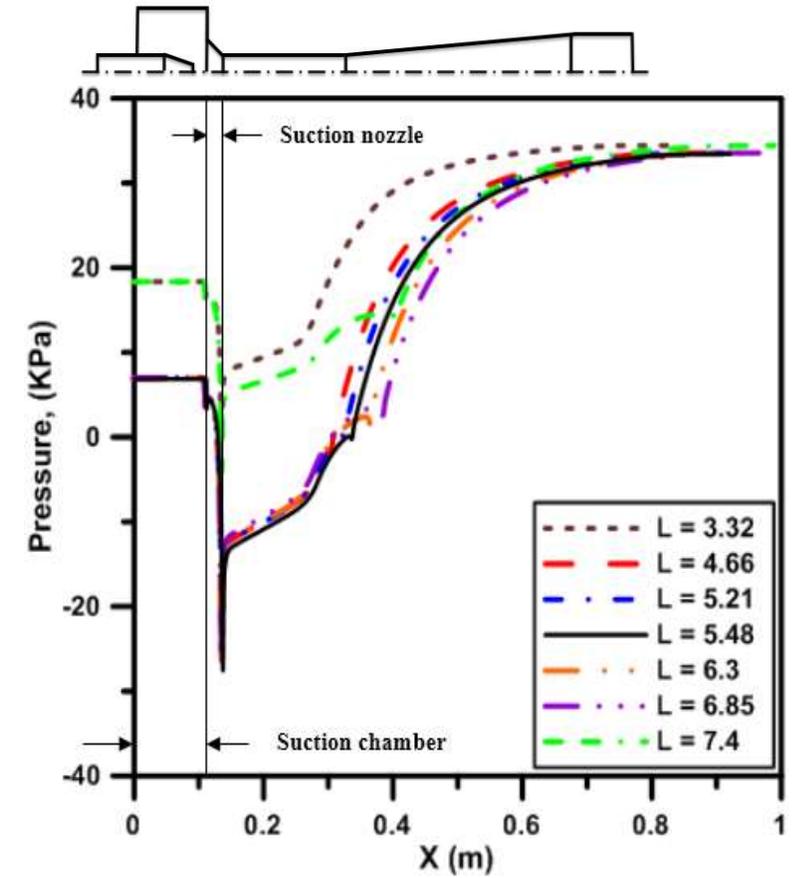
The pressure variation along C.L of jet pump



The velocity variation along C.L of jet pump



The pressure variation along O.W of jet pump

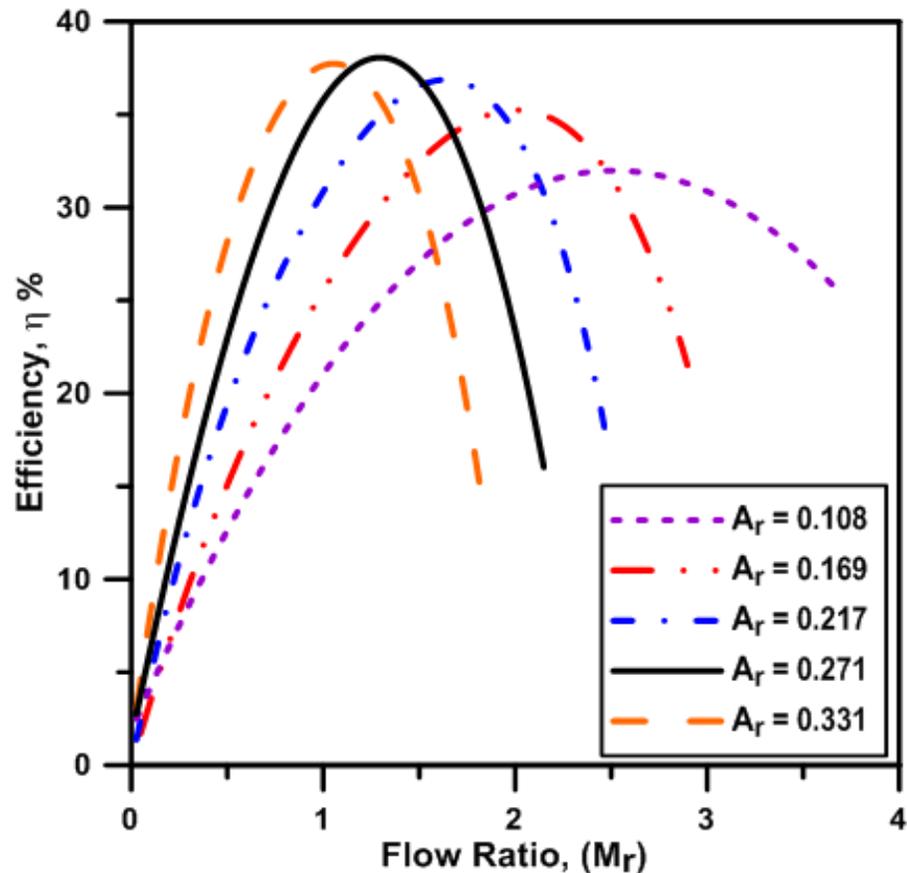


3)- Effect of The Area Ratio

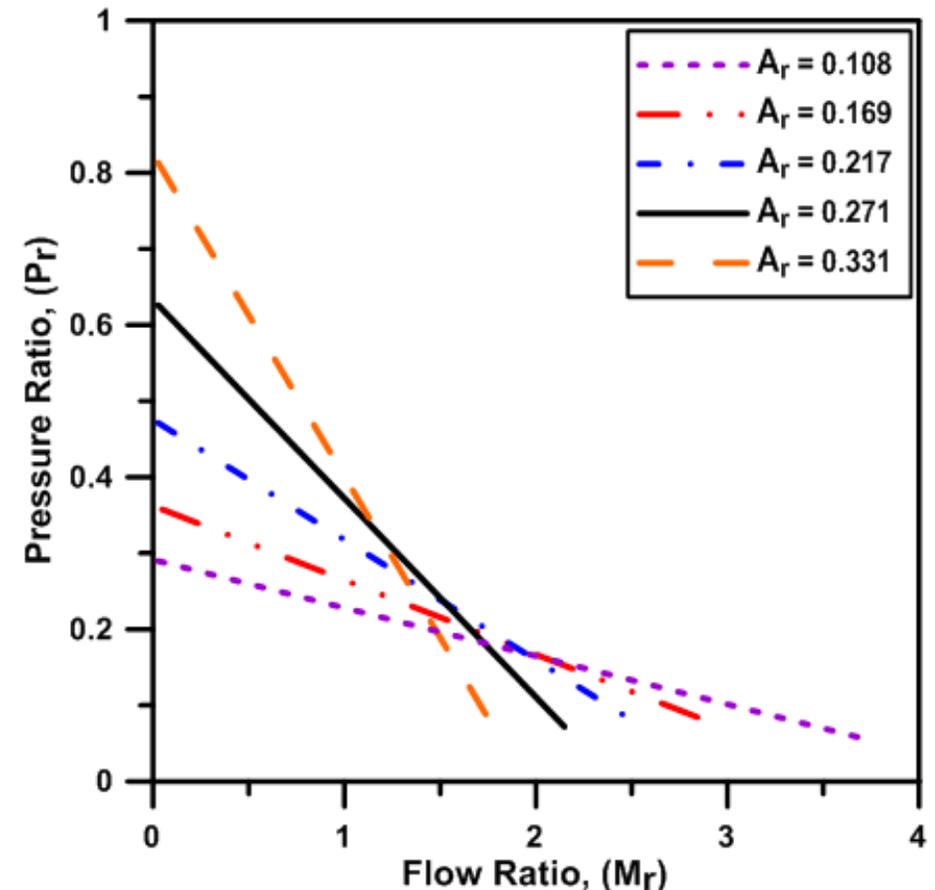
- Using the optimum values.
- Constant mixing chamber relative length of ($L = 5.48$), constant diffuser length ($L_{\text{dif.}} = 485 \text{ mm}$), constant angle of diffuser of ($\theta_{\text{dif.}} = 5^\circ$), and constant nozzle relative position ($Z = 1.87$) are used.
- Five area ratios of 0.108, 0.169, 0.217, 0.271 and 0.331 are used.

- The area ratio of ($A_r = 0.271$) showed the highest efficiency.

- **The efficiency curve**

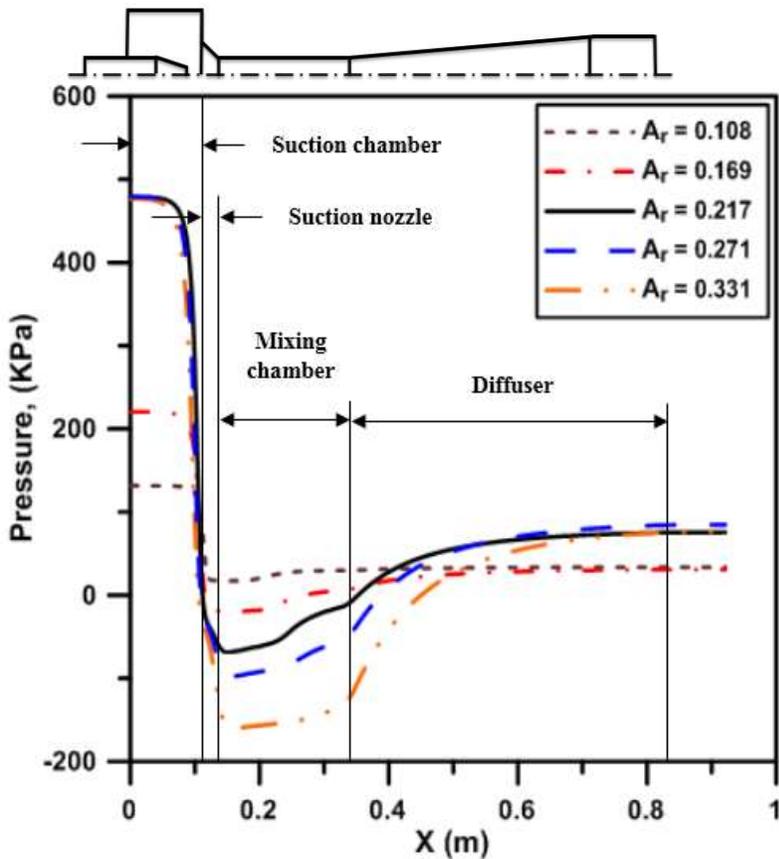


- **The head ratio curve**

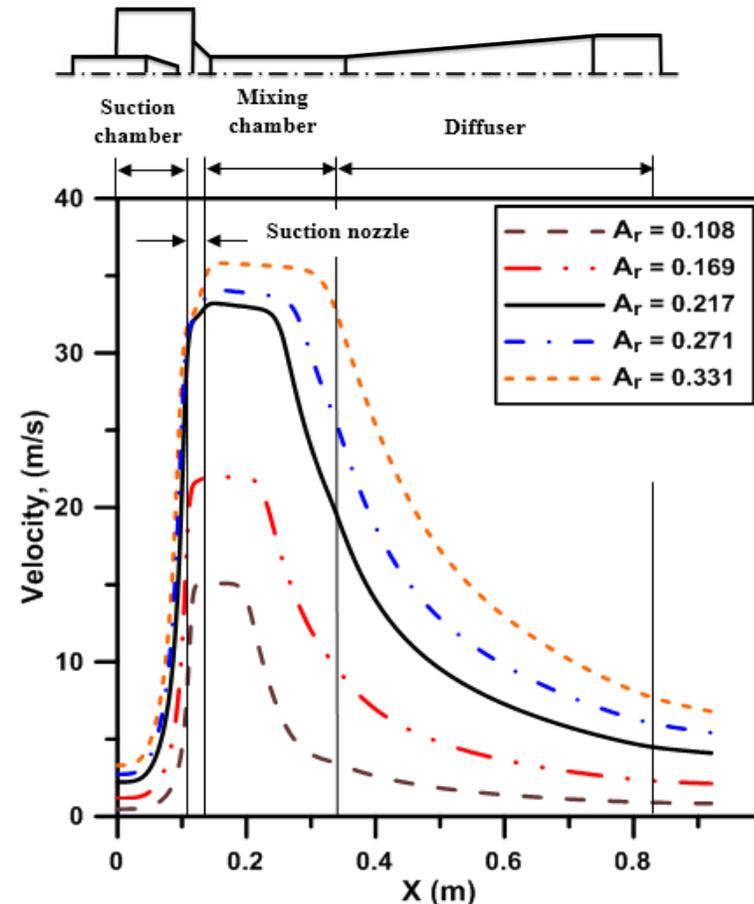


Pressure and velocity variations along centerline (C.L) and pressure variation along the outer wall (O.W) of jet pump.

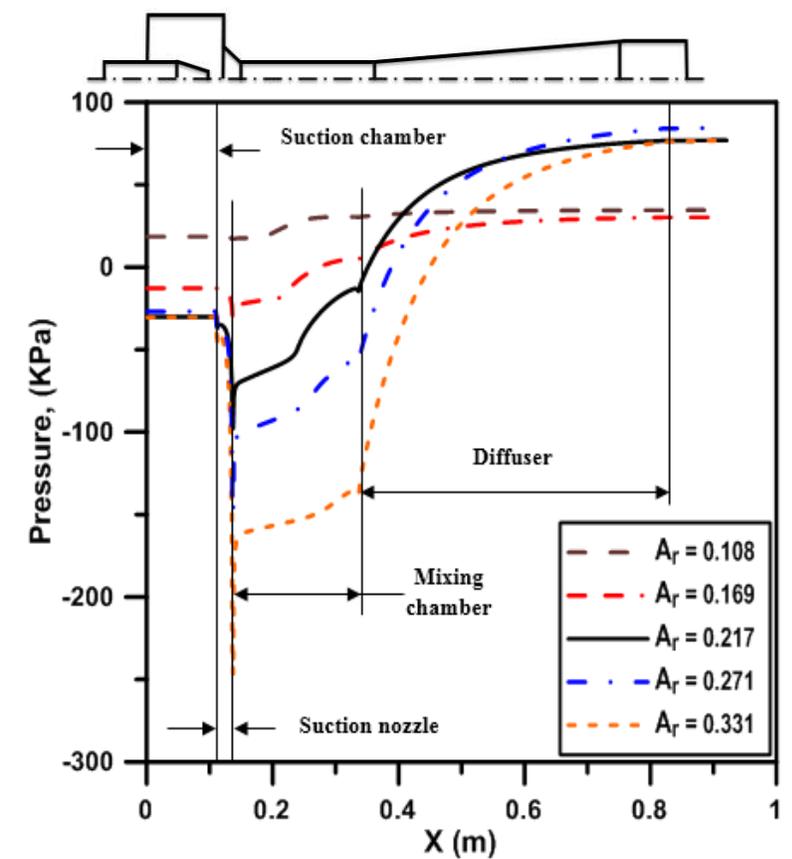
The pressure variation along C.L of jet pump



The velocity variation along C.L of jet pump



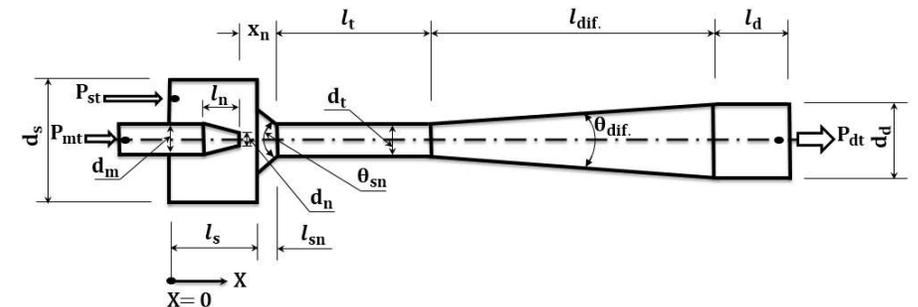
The pressure variation along O.W of jet pump



4)- Effect of The Driving Nozzle Position

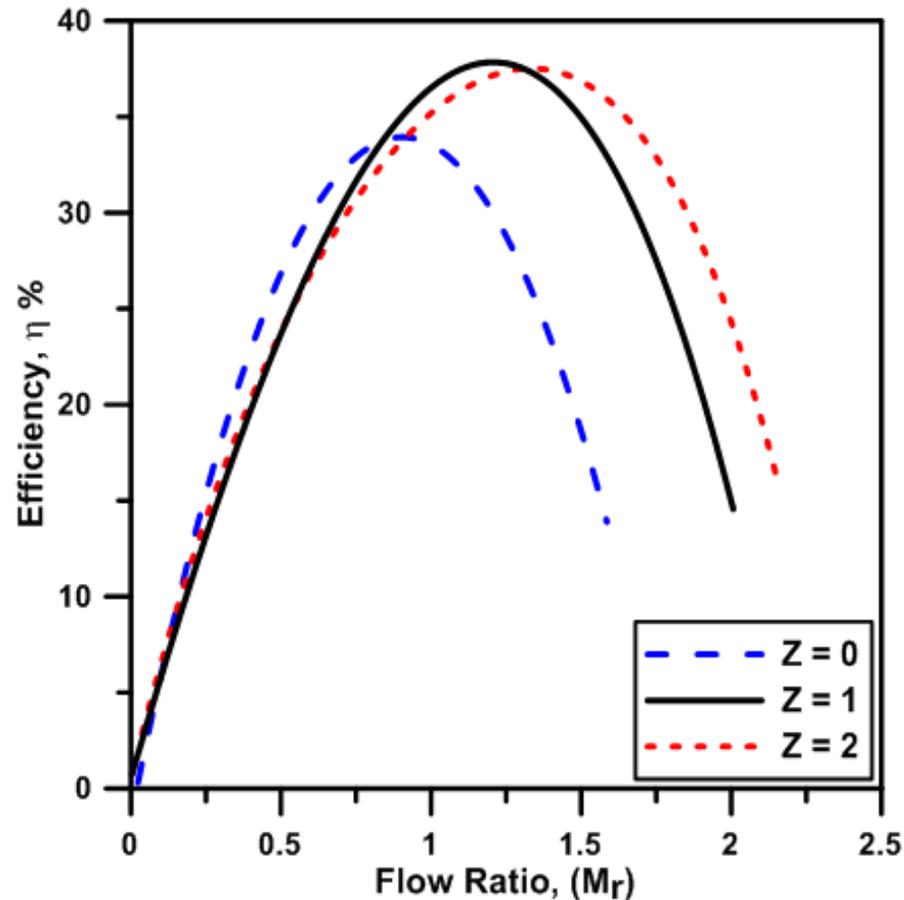
- Using the optimum values.
- Constant mixing chamber relative length of ($L = 5.48$), constant diffuser length ($L_{\text{dif.}} = 485 \text{ mm}$), constant angle of diffuser of ($\theta_{\text{dif.}} = 5^\circ$) and area ratio ($A_r = 0.271$) are used.
- **Three** nozzle relative positions of $Z = 0, 1$ and 2 are used.

- Where, $Z = x_n / d_n$.

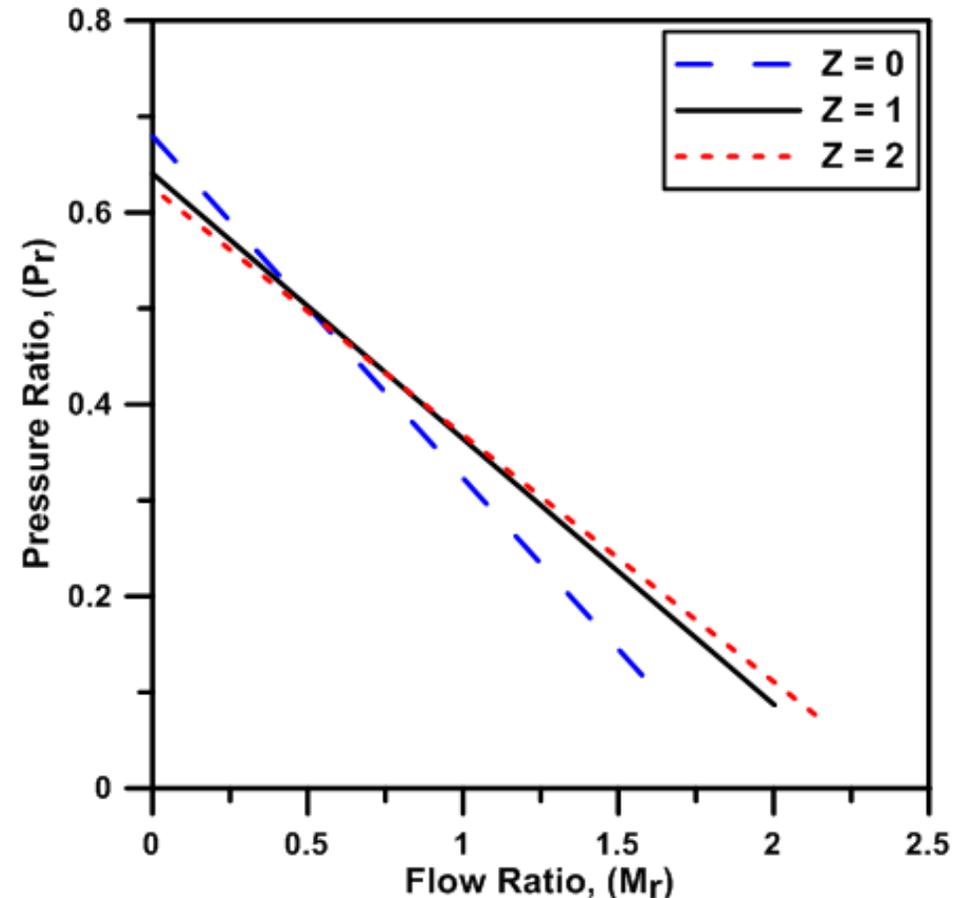


■ The nozzle relative position of $Z = 1$ showed the highest efficiency.

■ The efficiency curve

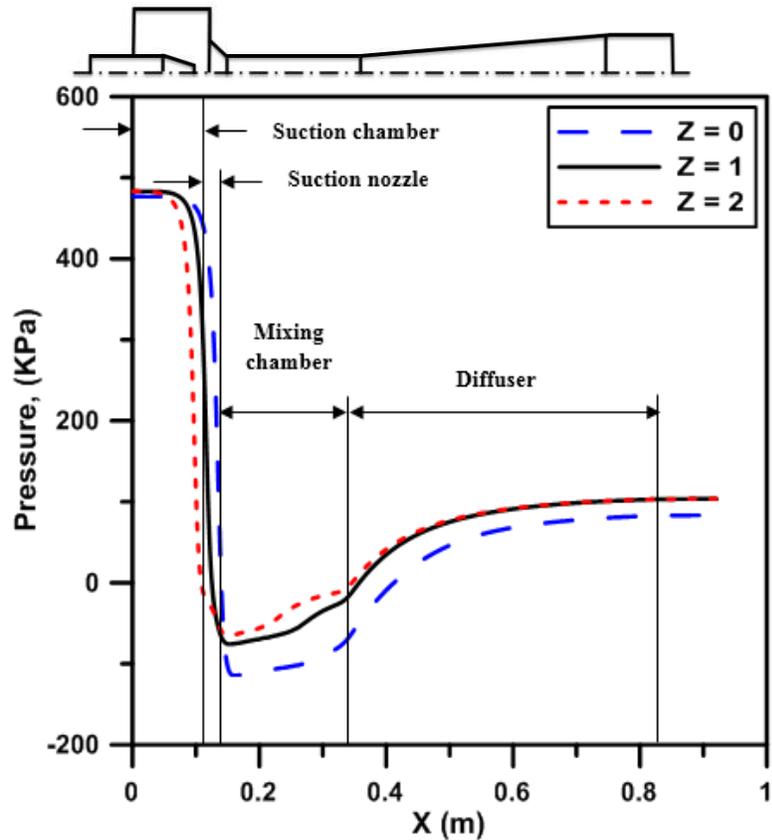


■ The head ratio curve

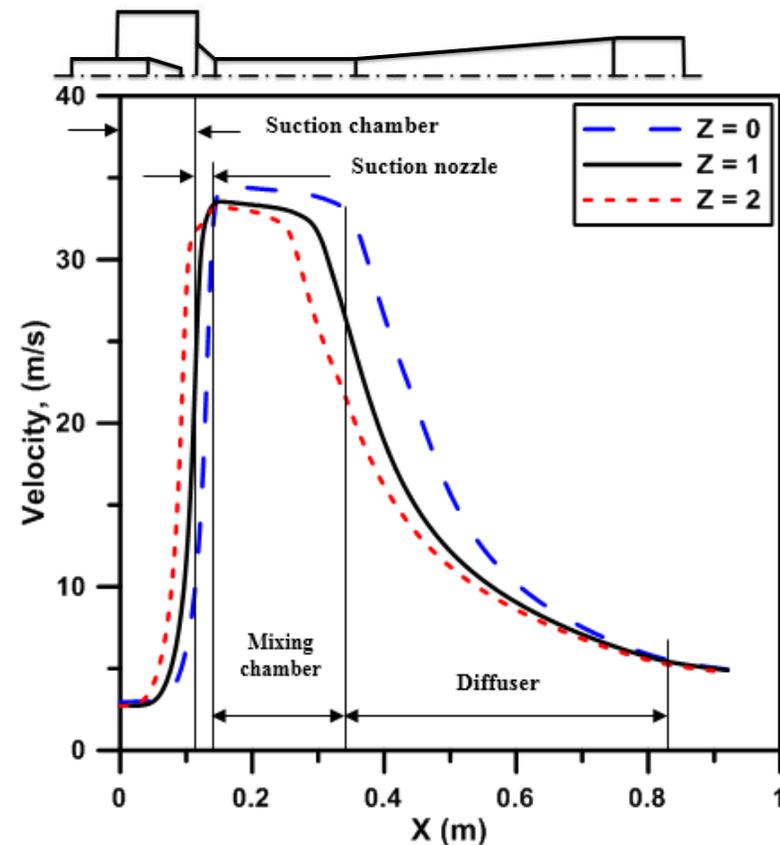


Pressure and velocity variations along centerline (C.L) and pressure variation along the outer wall (O.W) of jet pump.

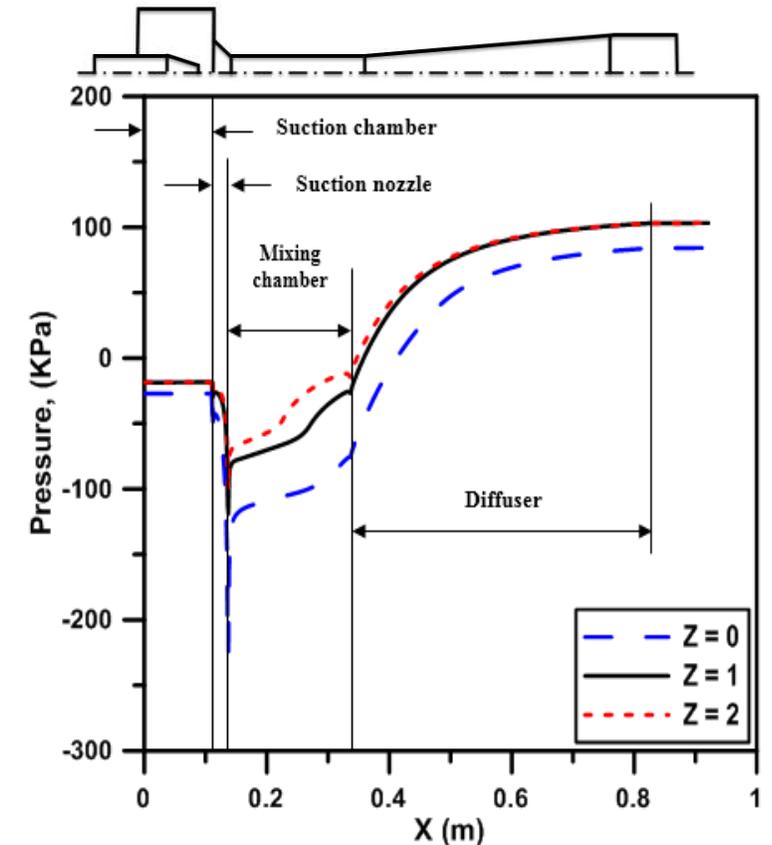
The pressure variation along C.L of jet pump



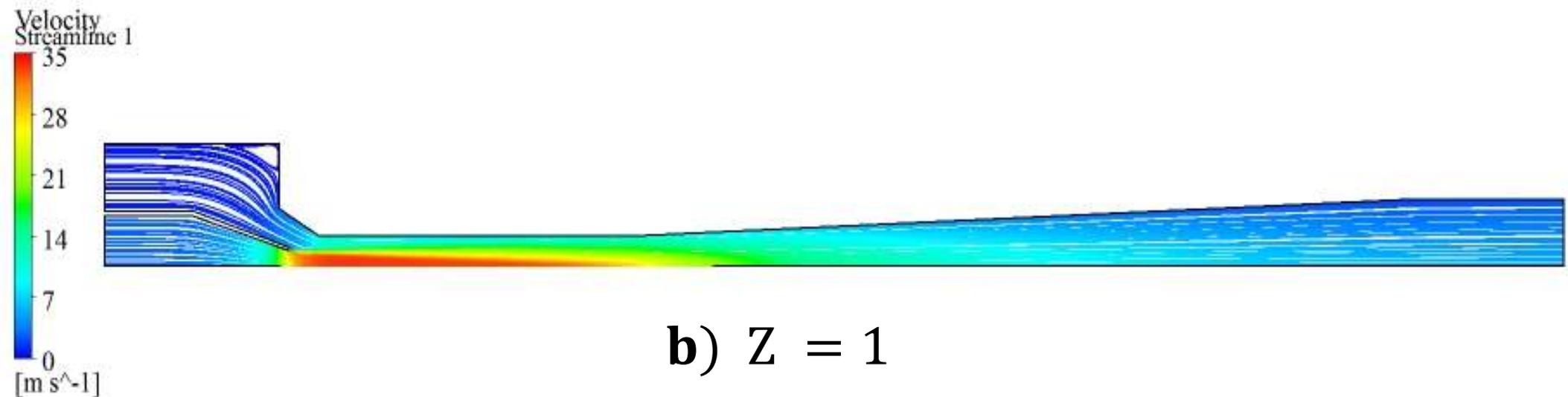
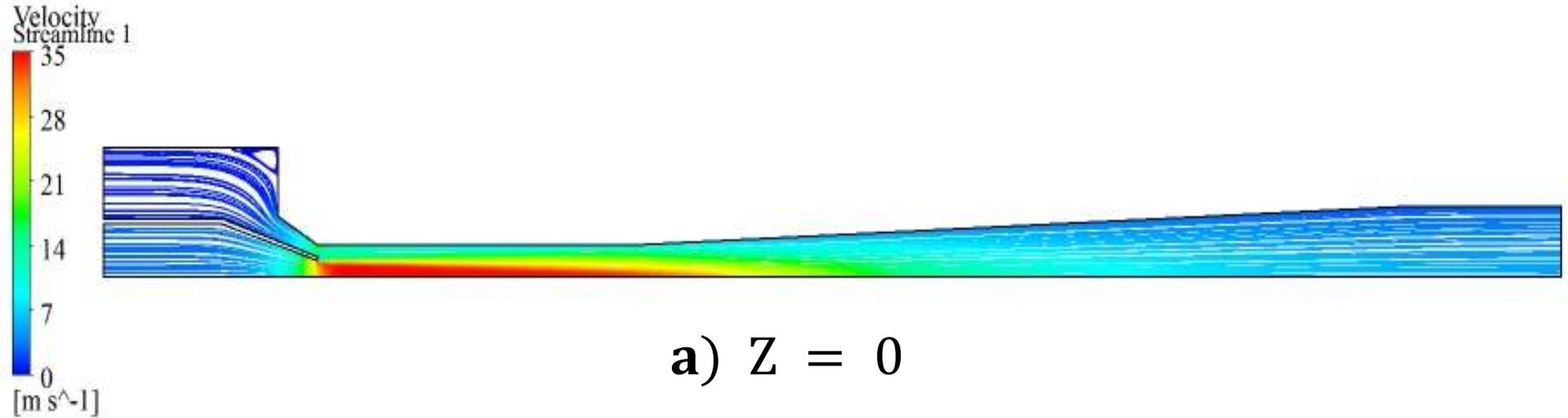
The velocity variation along C.L of jet pump

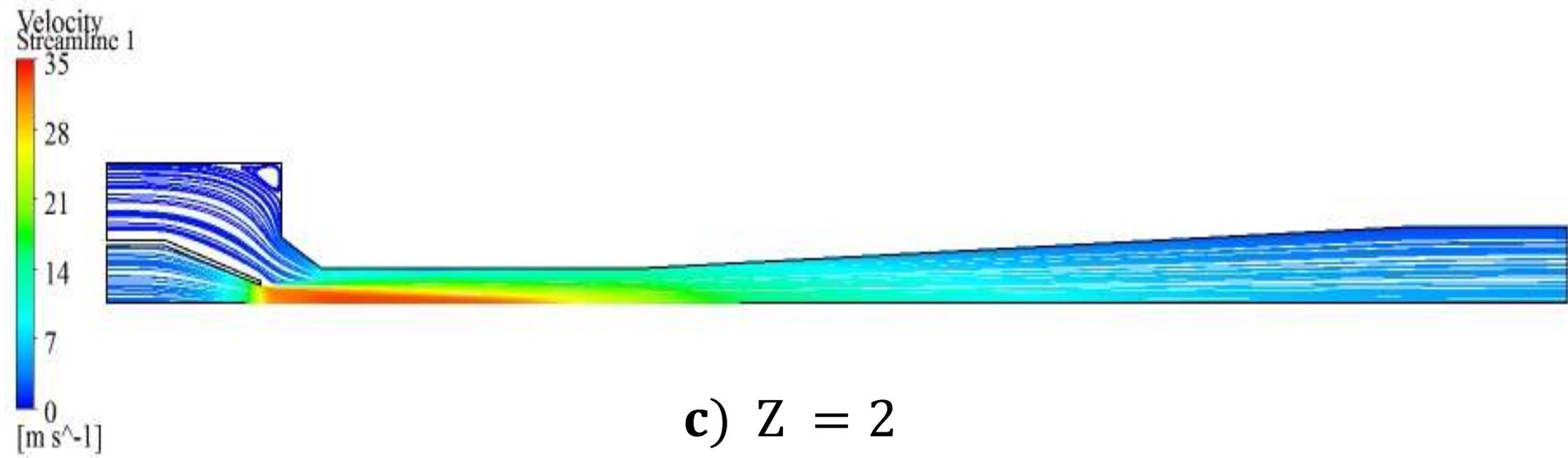


The pressure variation along O.W of jet pump



□ The flow field within the pump is viewed by utilizing the outstanding visualization ability of CFD at const. ($M_r = 1.19$)





Experimental Work

➤ Aim of Experimental Work

- 1)- **Investigating** the effect of the major controlling parameters that have direct effects on the axial jet pump performance. **These parameters are: the inflow motive pressure and nozzle spacing.**
 - 2)- **provide** experimental data for **extensive model validation and optimum model verification.**
- **Test rig** was constructed in the advanced fluid mechanics laboratory.
 - **The optimum** model obtained from numerical investigation is used.

➤ Photograph of experimental manufactured optimum model



Trestle



Motive Line
&
Motive Nozzle



Suction Chamber
&
Suction nozzle

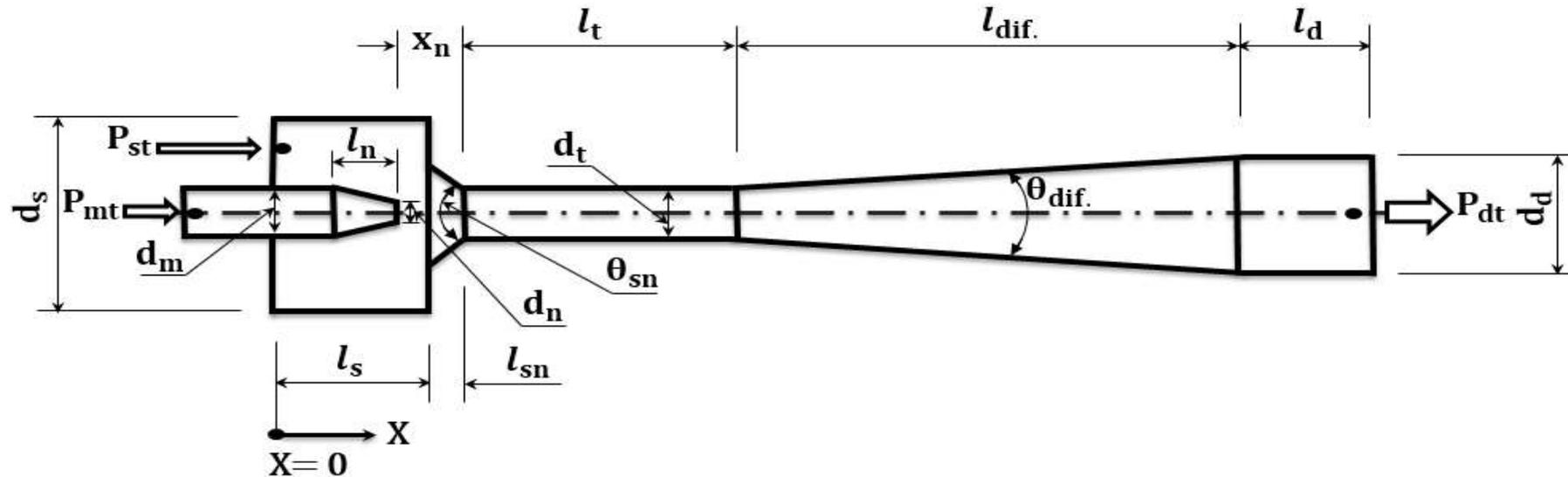


Mixing
Chamber
(9 tabs)



Diffuser
(26 tabs)

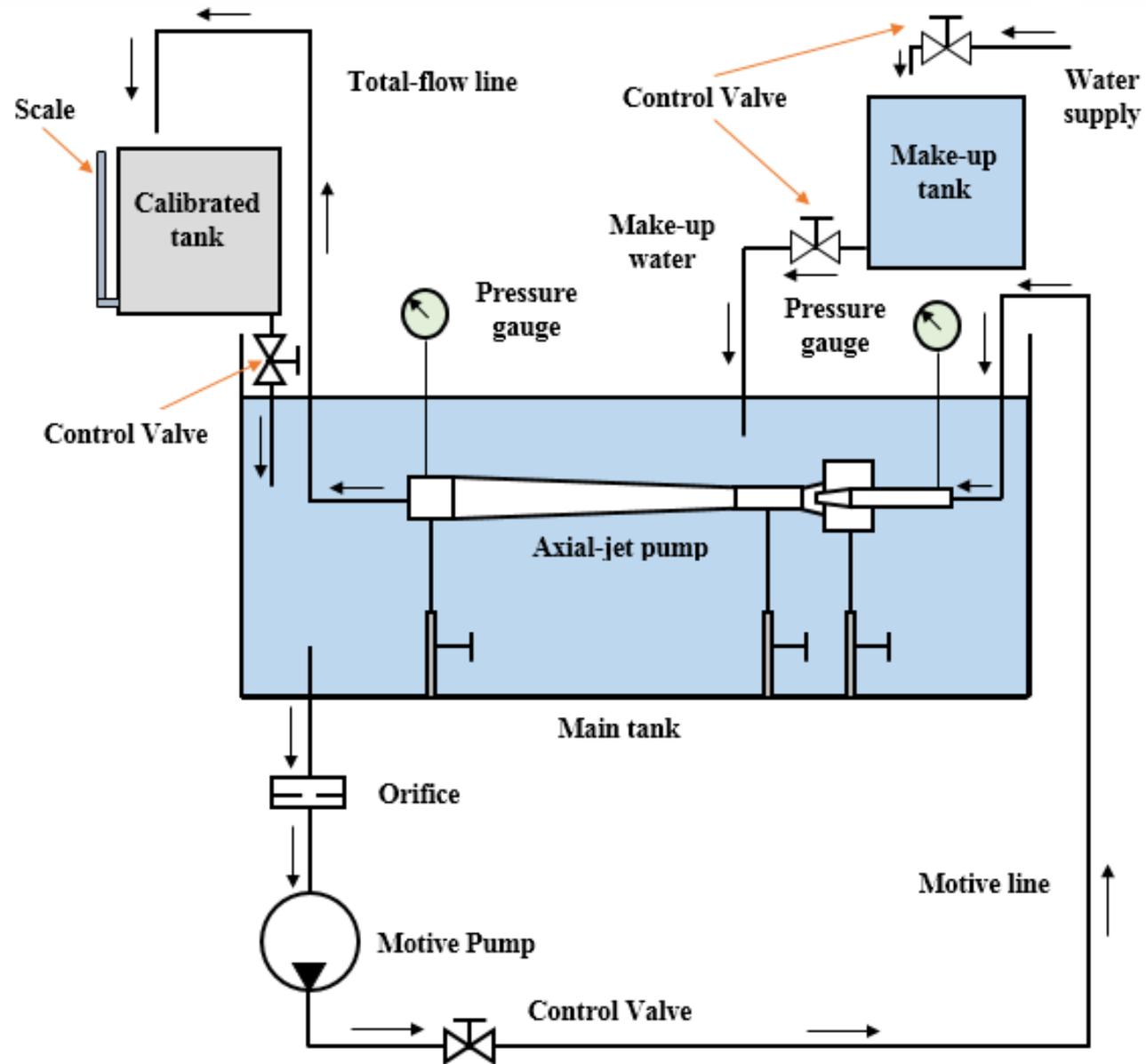
➤ The dimensions of experimental manufactured model



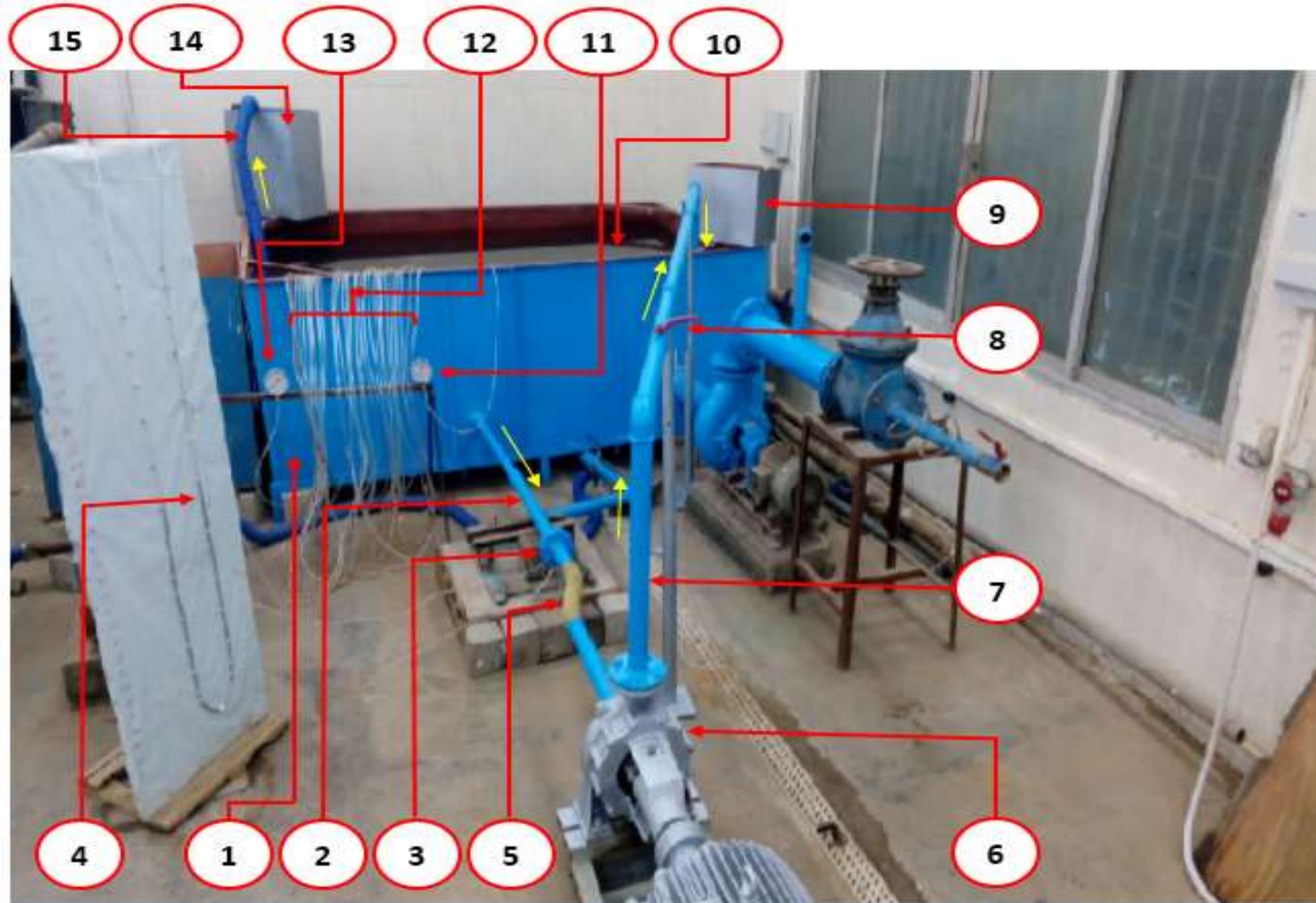
l_s	d_s	l_{sn}	θ_{sn}	l_n	d_m	d_n	l_t	d_t	$l_{dif.}$	$\theta_{dif.}$	l_d	d_d
110	152.4	25	86°	60	60	19	200	36.5	485	5°	100	80

All Dimensions are in (mm).

➤ Schematic view of the experimental test rig



➤ Experimental Test Rig



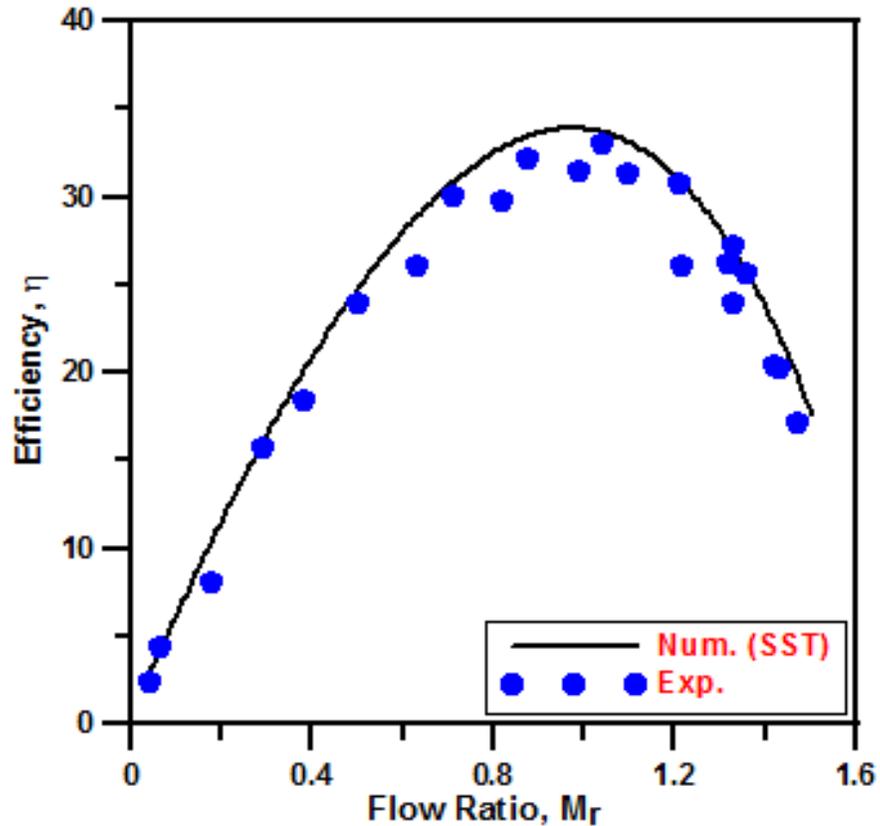
- | | | |
|--------------------------------------|----------------------------------|---------------------------------|
| 1. Main tank | 2. Suction line | 3. Orifice-meter |
| 4. U-tube manometer | 5. Flexible joint | 6. Motive pump |
| 7. Motive line | 8. Control valve | 9. Make-up tank |
| 10. Jet-pump model | 11. Motive pressure gauge | 12. Multi-tube manometer |
| 13. Total-flow pressure gauge | 14. Calibrated tank | 15. Total-flow line |

**Experimental Results
Compared with
Numerical Results**

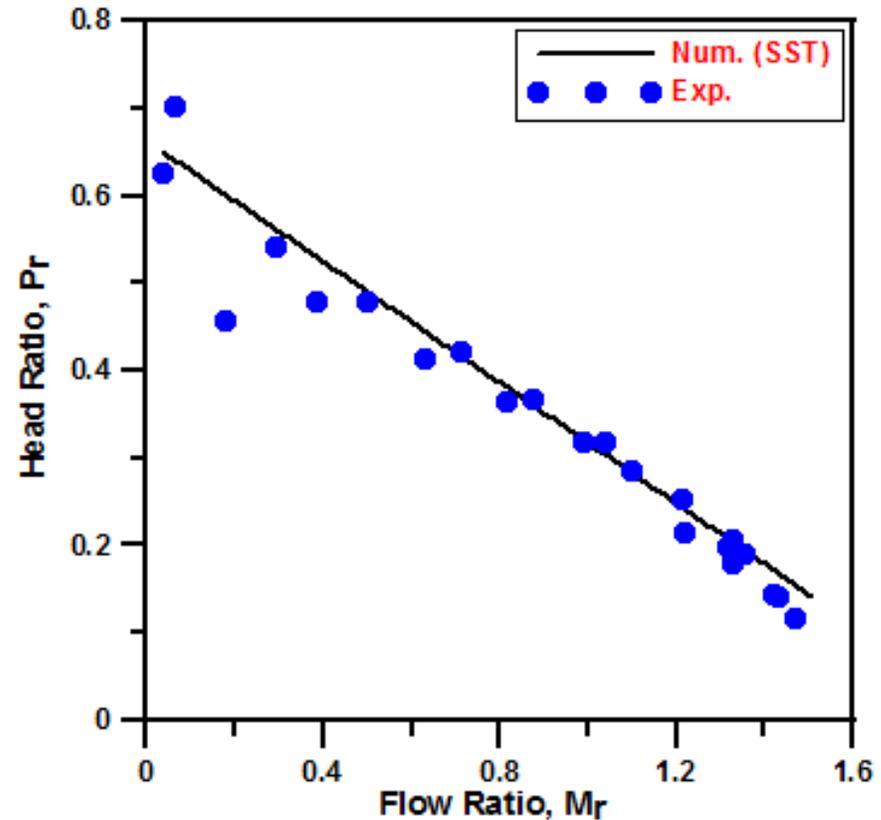
- A comparison is held between **calculated experimental efficiency** curve and **numerical efficiency** curve calculated numerically for the same model dimensions
- A comparison is held between the **measured experimental pressure values** and **numerical pressure values** calculated numerically at the **same geometry** and the **same operating conditions**.

1)- At Nozzle Relative Position of ($Z = 0$)

■ The efficiency curve

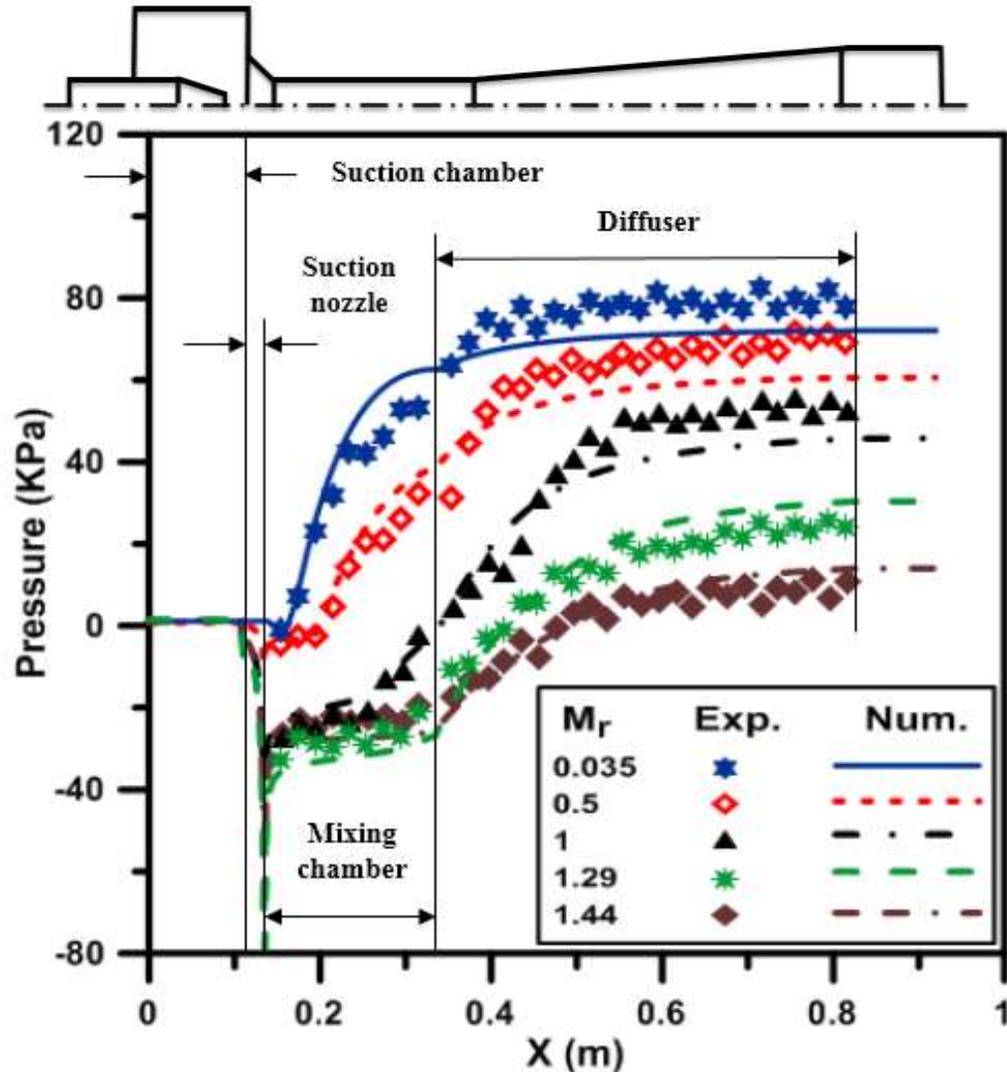


■ The head ratio curve



➤ The comparison showed that there is reasonable agreement between **exp. efficiency** curve and **num. efficiency**.

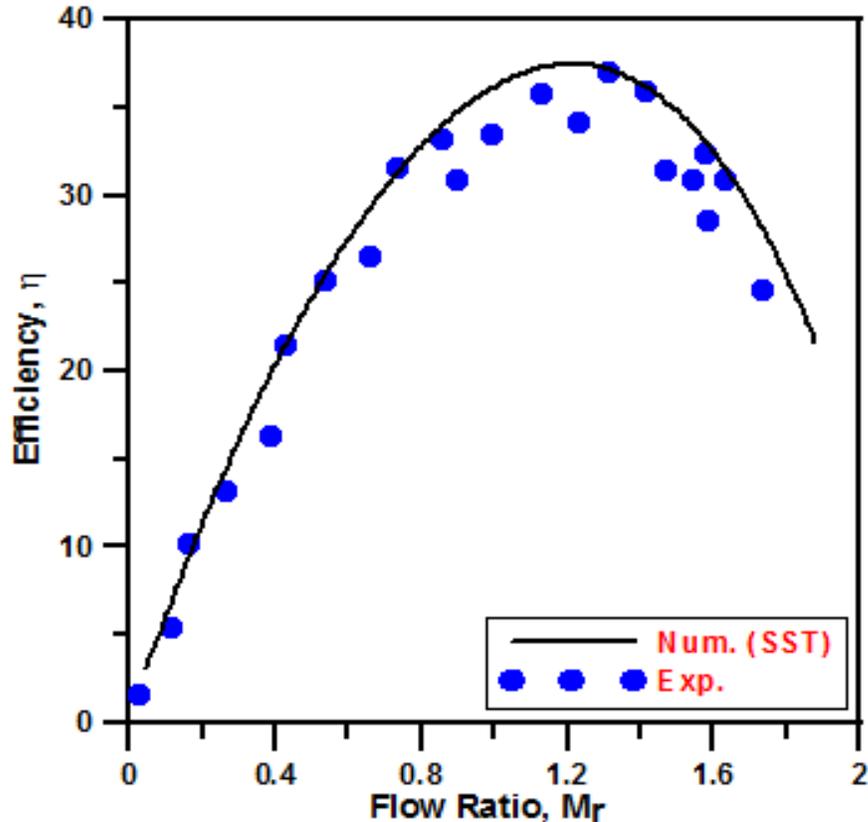
➤ The comparison between the measured experimental pressure values and numerical pressure values at ($Z = 0$).



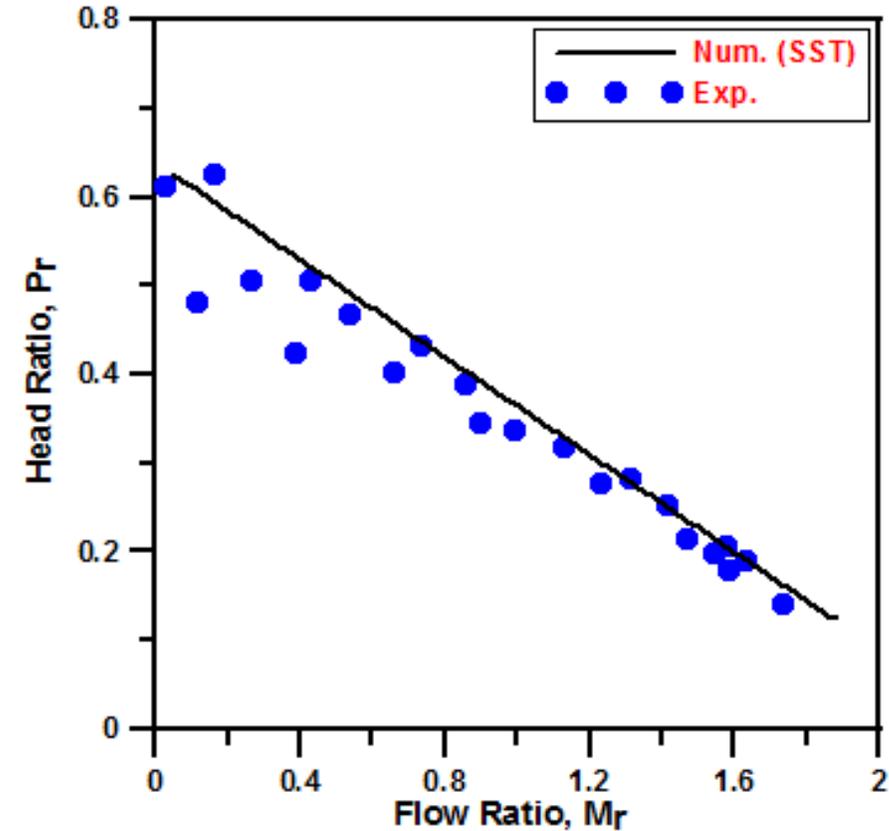
➤ The comparison showed that there is reasonable agreement between the exp. Pressure values and num. Pressure values.

2)- At Nozzle Relative Position of ($Z = 1$)

■ The efficiency curve

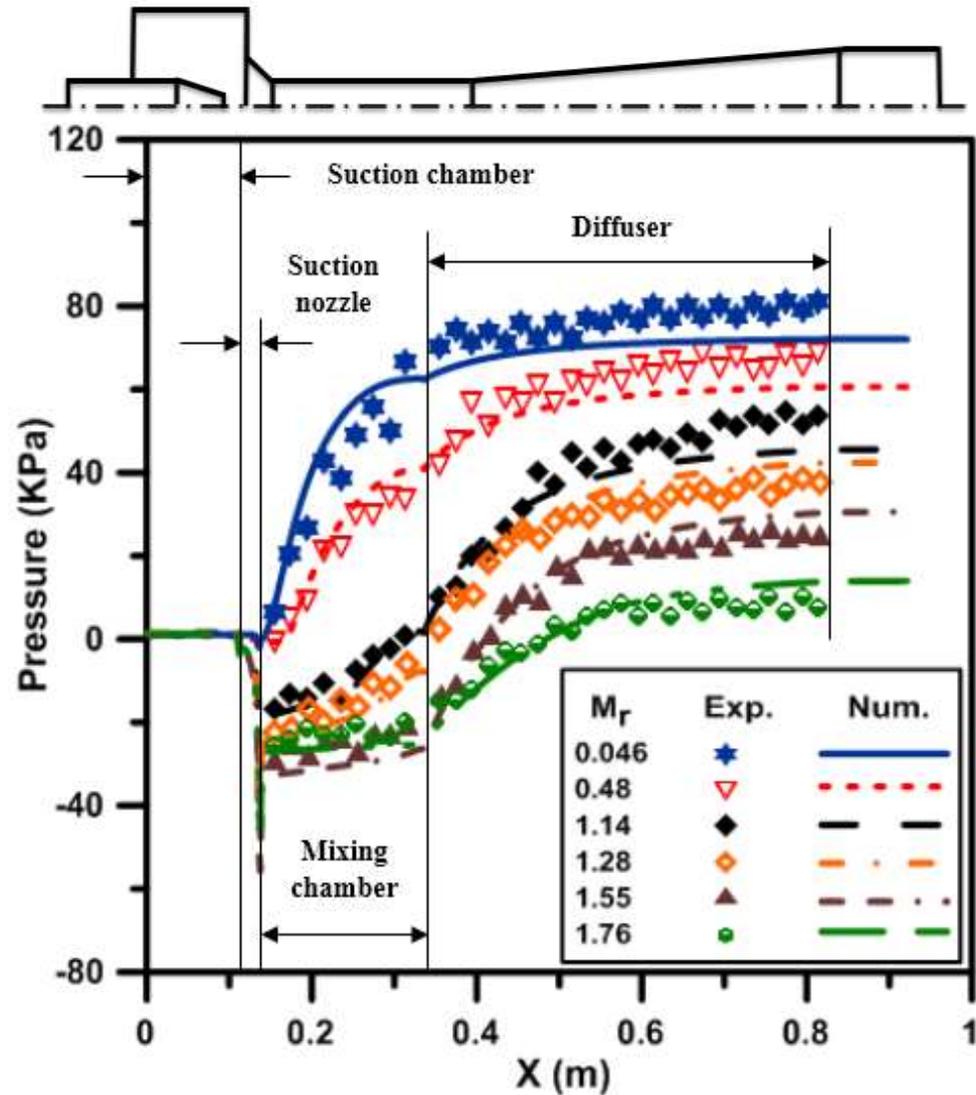


■ The head ratio curve



➤ The comparison showed that there is reasonable agreement between **exp. efficiency curve** and **num. efficiency**.

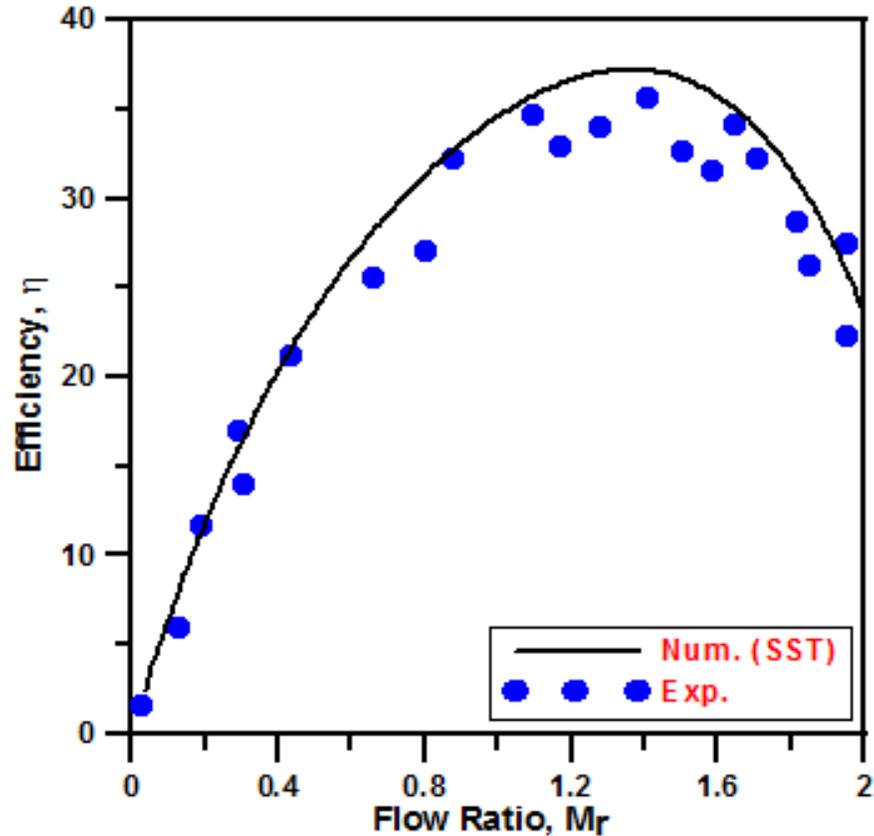
➤ **The comparison** between the measured experimental pressure values and numerical pressure values at ($Z = 1$).



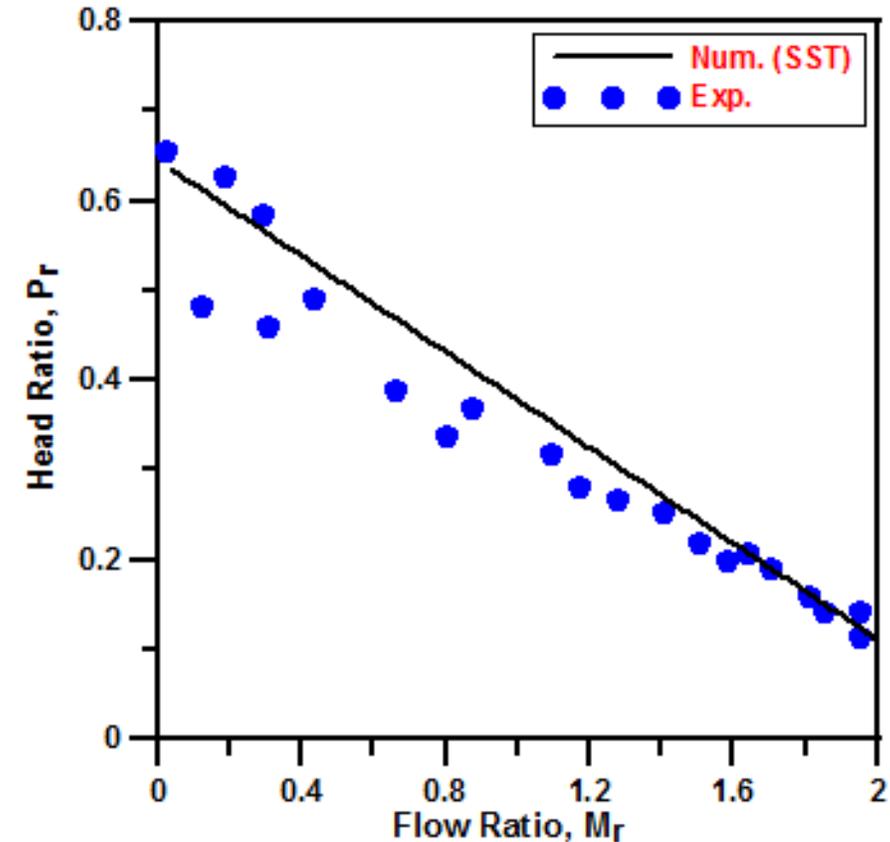
➤ **The comparison** showed that there is **reasonable agreement** between the **exp. Pressure values** and **num. Pressure values**.

3)- At Nozzle Relative Position of ($Z = 2$)

■ The efficiency curve

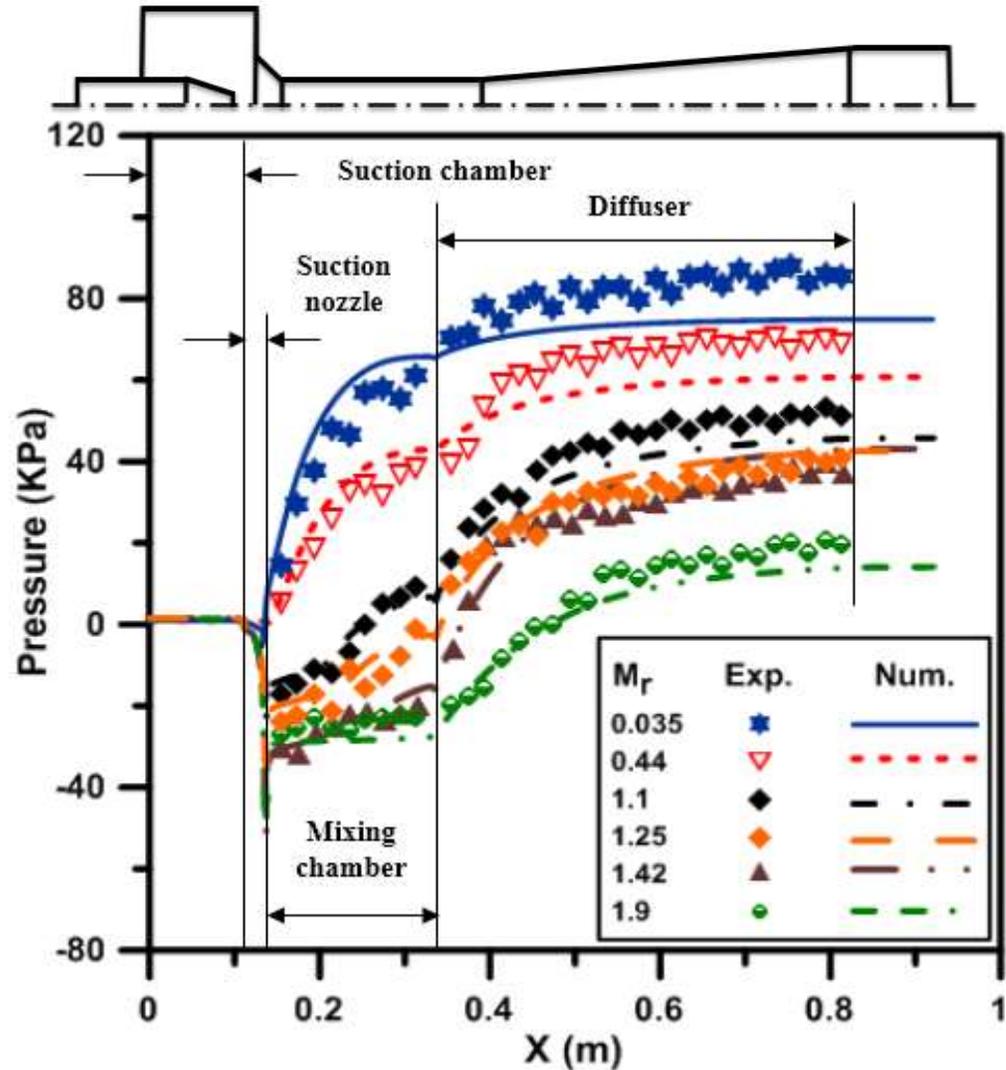


■ The head ratio curve



➤ The comparison showed that there is reasonable agreement between **exp. efficiency curve** and **num. efficiency**.

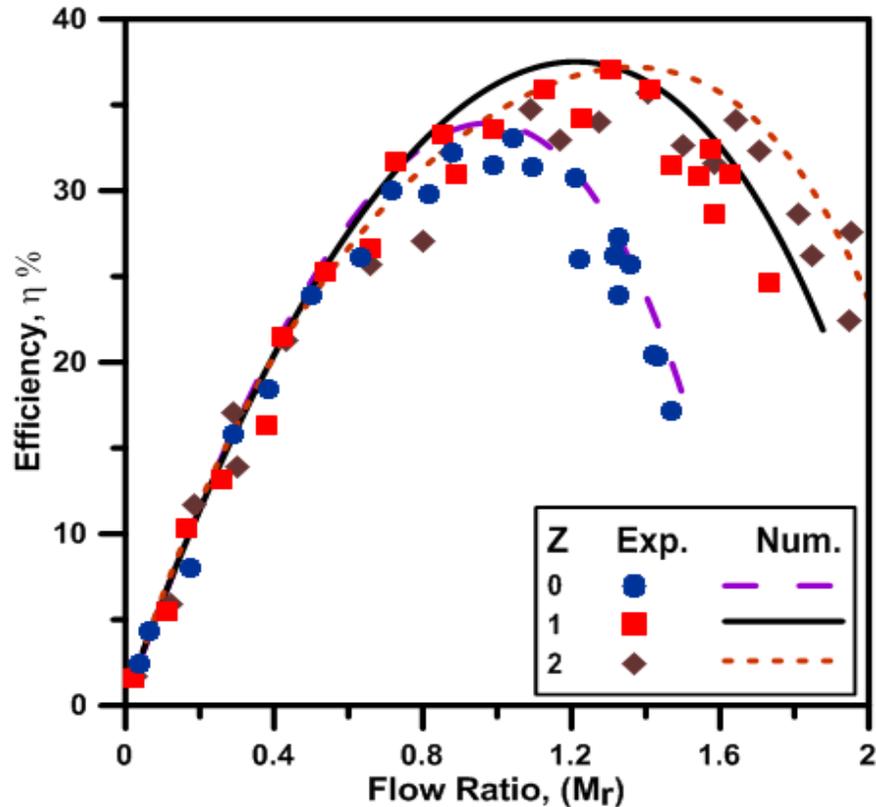
➤ The comparison between the measured experimental pressure values and numerical pressure values at ($Z = 2$).



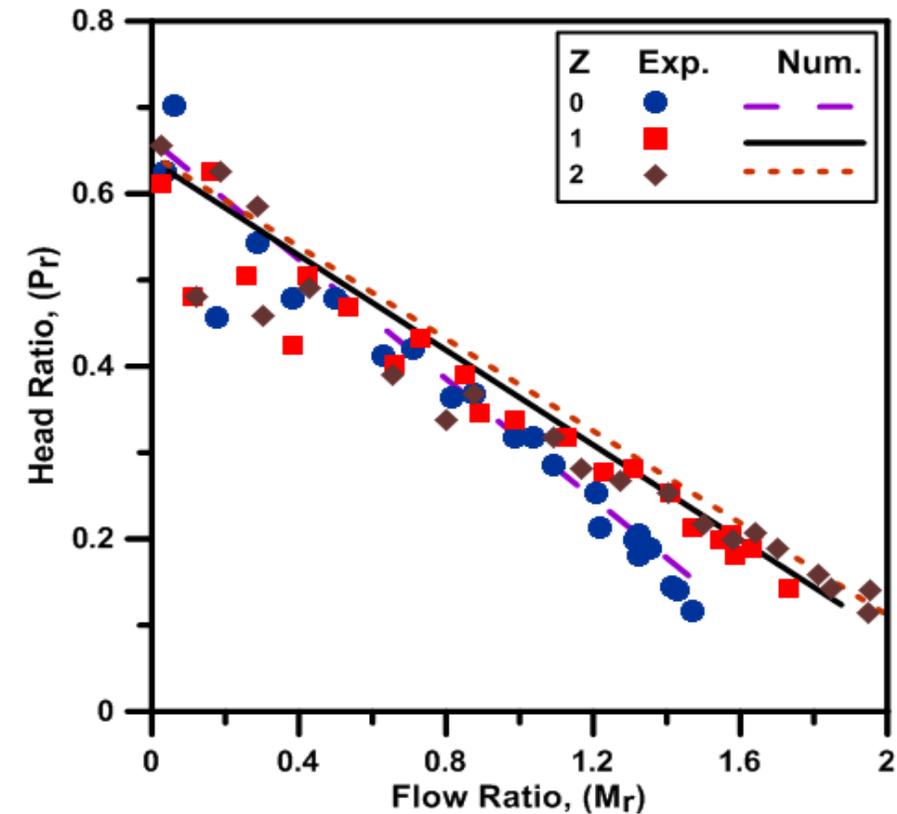
➤ The comparison showed that there is reasonable agreement between the exp. Pressure values and num. Pressure values.

□ General Comparison between three Nozzle Relative Positions of ($Z = 0, 1$ and 2)

■ The efficiency curve

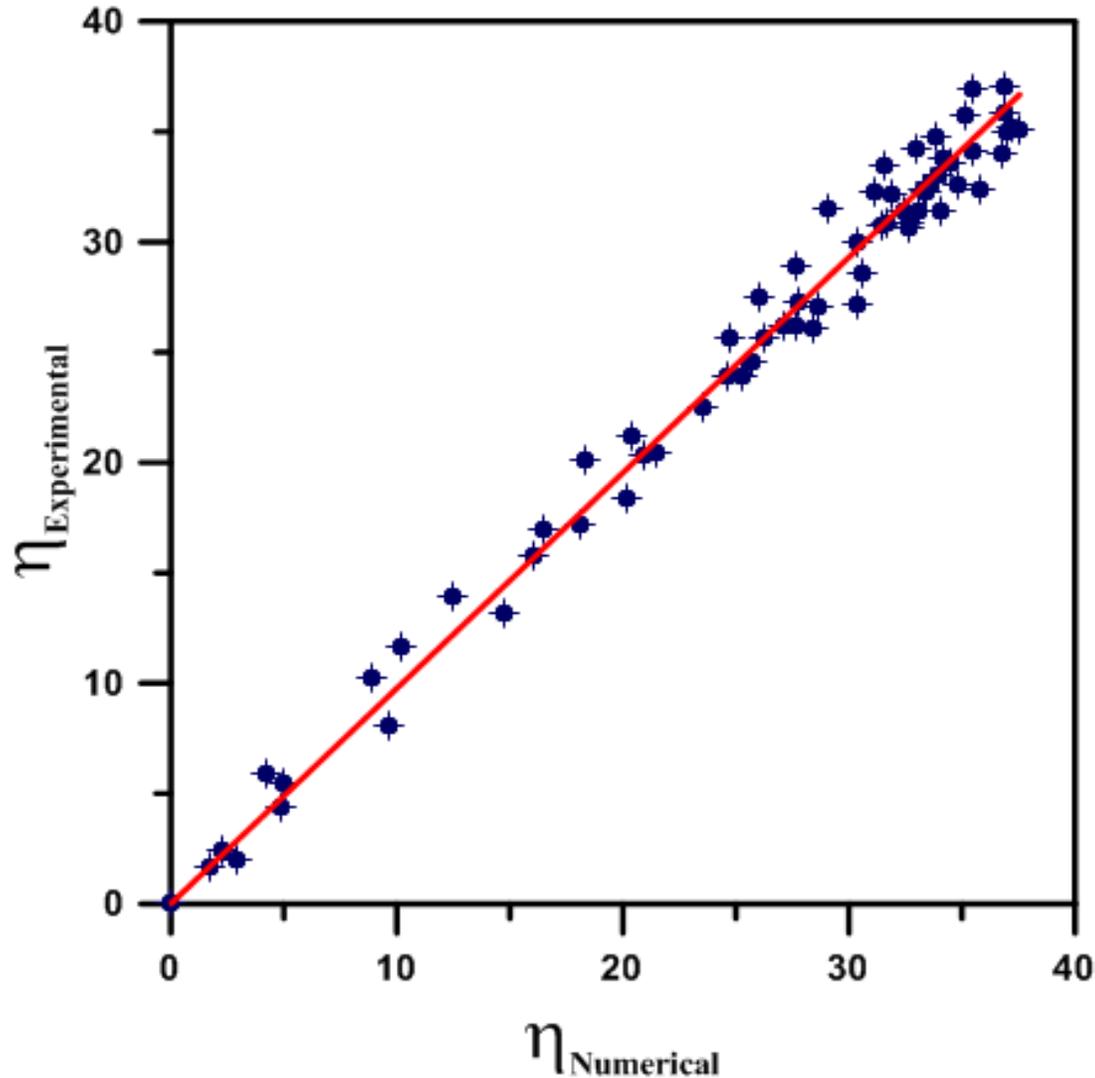


■ The head ratio curve



➤ The comparison showed that there is reasonable agreement between **exp. efficiency curve** and **num. efficiency**.

□ The Relationship between Theoretical Efficiency and Experimental Efficiency



➤ After Calculating coefficient of determination

➤ The equation is:

$$\eta_{\text{Experimental}} = 0.97785 * \eta_{\text{Numerical}}$$

□ Experimental Uncertainty of Jet Pump Performance

Parameter	Percentage uncertainty (\pm %)	
	Min. uncertainty	Max. uncertainty
Total discharge of jet pump (Q_t)	0.571	1.01
Motive discharge for jet pump (Q_m)	0.613	1.12
Efficiency of jet pump (η)	0.145	0.698

- Uncertainty in the Manometer Head (Length): The uncertainty in the length is ± 0.5 mm.
- Uncertainty in the Pressure: The uncertainty in the pressure is ± 0.1 kPa.
- Uncertainty in the time: The uncertainty in the time is ± 0.5 second.

Conclusions and Recommendations

خلاصة البحث:

1): إشتمل البحث الحالى على عمل محاكاة للسريان خلال المضخة النفاثة (**Jet Pump**) ، حيث تم تصميم خمسة وثلاثين نموذج للمضخة النفاثة المائية وعمل دراسة عليهم وتم إنتقاء التصميم الأفضل من بينهم. حيث شملت التصاميم زوايا ناشر تراوحت في نطاق ($2.5^\circ - 9^\circ$) ، وأطوال نسبية لغرفة الخلط تراوحت في نطاق ($3.32 - 7.4$) ونسب مساحات تراوحت في النطاق ($0.108 - 0.331$) باستخدام نموذج الاضطراب الانتقالي *Transition SST Turbulence model* بتقنية ثنائية الأبعاد.

خلاصة البحث:

(2): للتحقق من صحة الكود العددي المستخدم ، تمت مقارنة نتائج الكود العددي ثنائية الأبعاد لأعمال تحسين التصميم مع نتائج عملية مسبقة ونتائج ثلاثية الأبعاد عند نفس الأبعاد ونفس ظروف التشغيل. أظهرت النتائج العددية ثنائية وثلاثية الأبعاد توافقًا جيدًا لنفس أبعاد التصميم المتعلق بالنتائج العملية وكانت جميع النتائج تقريبًا في نفس نطاق منحنى الكفاءة للمضخة النفاثة المحورية المستخدمة في عملية المقارنة، وبالتالي تم التحقق من صحة النتائج ثنائية الأبعاد التي تم الحصول عليها باستخدام نموذج الاضطراب **Transition SST Turbulence model**. على الرغم من أن نموذج الاضطراب **Transition SST Turbulence model** بشكل عام يقلل بشكل طفيف من الكفاءة المثلى ، إلا أنه يوفر رؤية مفصلة للتأثيرات الهندسية التصميمية على أداء المضخات النفاثة المائية.

خلاصة البحث:

(3): تم تحسين كفاءة المضخة النفاثة والوصول إلى أعلى كفاءة بنسبة % 37.82 باستخدام

نموذج اضطراب Transition SST Turbulence model عند الأبعاد التصميمية الآتية: نسبة

المساحة ($A_r = 0.271$)، الطول النسبي لغرفة الخلط ($L = 5.48$)، زاوية الناشر ($\theta_{dif.} = 5^\circ$)،

موضع الفوهة النسبي ($Z = 1$)، نسبة التدفق ($M_r = 1.19$)، ونسبة الضغط ($P_r = 0.317$).

(4): أثبت البحث أنه يمكن استخدام منحنيات التصميم العددي المثلى الناتجة من الدراسة في

تصميمات المضخات النفاثة المائية.

(5): أظهرت النتائج العددية التي تم الحصول عليها أن القيمة التصميمية الأفضل لزاوية الناشر التي

تكون عندها كفاءة المضخة قيمة قصوى هي 5° . بالإضافة إلى أن الطول النسبي الأمثل لغرفة الخلط

هو ($L = 5.48$).

خلاصة البحث:

(6): أظهرت المقارنة بين النتائج العملية المقاسة معملياً والنتائج العددية للمتغيرات المختلفة عند نفس الأبعاد التصميمية ونفس ظروف التشغيل أن هناك تقارباً جيداً بينهما ، وبالتالي يمكن استخدام هذا النموذج في الحياة العملية.

(7): يمكن تحليل فيزياء التدفق داخل المضخات النفاثة المائية المحورية ويمكن إجراء التحسين بسهولة باستخدام **CFD, 2D technique** بدلاً من استخدام **CFD, 3D technique** وذلك بدقة نتائج مرضية من أجل توفير الوقت والمجهود والتكلفة الحسابية العددية. كما أنه يساعد في توفير الجهود المبذولة في المختبرات المعملية من أجل التنبؤ بتأثير عامل أو أكثر من العوامل الهندسية والتشغيلية على كفاءة المضخة النفاثة.

خلاصة البحث:

(8): يمكن استخدام **CFD, 2D technique** في التنبؤ بأداء المضخة النفائة المحورية الزيتية المستخدمة في حقول النفط. أيضاً ، حيث يمكن استخدام تلك التقنية للتنبؤ بتأثير عامل أو أكثر من العوامل الهندسية والتشغيلية على كفاءة المضخة.

(9): أثبتت الدراسة الحالية أنه يمكن استخدام **CFD, 2D technique** في تحسين أداء المضخة النفائة المحورية الزيتية المستخدمة في حقول النفط وزيادة كفاءتها وزيادة معدل الإنتاج للزيت الخام الناتج من الآبار.

Recommendation

إستخدام التصميم الأمثل لإنتاج الزيت الخام من الآبار القديمة والحديثة فى حقول النفط وذلك عند الأبعاد التصميمية الآتية: نسبة المساحة ($A_r = 0.271$)، الطول النسبي لغرفة الخلط ($L = 5.48$)، زاوية الناشر ($\theta_{dif.} = 5^\circ$)، موضع الفوهة النسبي ($Z = 1$)، نسبة التدفق ($M_r = 1.19$)، ونسبة الضغط ($P_r = 0.317$).



Thank
You

