Design and Analysis of Pool and Flow Boiling

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ABSTRACT

Pool boiling and flow boiling are two important heat transfer phenomena that occur in various engineering applications, including cooling systems, power generation, and refrigeration. Pool boiling involves heat transfer from a heated surface to a stagnant liquid pool, while flow boiling occurs when the liquid flows over a heated surface. Understanding the fundamental mechanisms and characteristics of these boiling processes is crucial for optimizing heat transfer performance and enhancing system efficiency.

INTRODUCTION

Pool boiling and flow boiling are two fundamental modes of heat transfer commonly encountered in engineering applications involving liquid-vapor systems. Understanding these modes is essential for optimizing the performance of various thermal systems, such as boilers, heat exchangers, and cooling systems.

Pool boiling occurs when a heated surface is submerged in a pool of liquid, typically with a relatively stagnant liquid phase. This mode is characterized by the formation and detachment of vapor bubbles on the heated surface, which significantly influence heat transfer rates. Pool boiling finds applications in domestic heating systems, industrial processes, and refrigeration.

Both pool boiling and flow boiling play vital roles in numerous engineering disciplines, and their understanding is crucial for designing and optimizing heat transfer systems to meet specific performance requirements. This introduction sets the stage for exploring the mechanisms, characteristics, and applications of these two important modes of heat transfer.

Pool boiling and flow boiling are two fundamental modes of heat transfer commonly encountered in various engineering applications. In pool boiling, heat transfer occurs when a heated surface is submerged in a stagnant pool of liquid, such as water or refrigerants. This mode is characterized by the formation of vapor bubbles at the heated surface, which detach and rise through the liquid, transferring heat away from the surface.

LITERATURE SURVEY

POOL BOILING HEAT TRANSFER, L.S. TONG AND Y.T. WONG: This book provides a comprehensive overview of pool boiling heat transfer mechanisms, including nucleate boiling, film boiling, and critical heat flux phenomena. It covers both experimental and theoretical aspects and is widely regarded as a foundational text in the field.

FLOW BOILING IN MICROGAP CHANNELS, L. LIU AND C.-J. KIM: Experiment, Visualization, and Analysis by L. Liu and C.-J. Kim. This work focuses on flow boiling in microchannels, which is particularly relevant for high heat flux applications such as microelectronics cooling. It covers experimental techniques, visualization methods, and analytical models for understanding and optimizing flow boiling heat transfer in microscale geometries.

JOURNAL OF HEAT TRANSFER: This peer-reviewed journal publishes a wide range of research articles on pool boiling and flow boiling heat transfer phenomena. Articles cover topics such as boiling heat transfer enhancement techniques, boiling on structured surfaces, and numerical simulations of boiling processes.

INTERNATIONAL JOURNAL OF MULTIPHASE FLOW: This journal is dedicated to the study of multiphase flow phenomena, including boiling and condensation. It features research articles on fundamental aspects of pool boiling and flow boiling, as well as practical applications in engineering systems.

HEAT TRANSFER HANDBOOK, A. BEJAN AND A.D. KRAUS: This handbook provides a comprehensive overview of heat transfer principles and applications, including chapters dedicated to pool boiling and flow boiling.

FUNDAMENTALS OF POOL AND NUCLEATE BOILING BY R. Q. T. LAHEY JR. AND V. H. LIETAL: This seminal work offers a thorough exploration of the fundamental principles underlying pool boiling, including mechanisms, models, and experimental techniques.

FUNDAMENTALS OF HEAT AND MASS TRANSFER: by Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, and David P. DeWitt: This textbook covers the basic principles of heat transfer, including extensive discussions on pool boiling and flow boiling phenomena.

HANDBOOK OF HEAT TRANSFER: edited by Warren M. Rohsenow, James P. Hartnett, and Young I. Cho: Another comprehensive reference book, this handbook provides in-depth coverage of various heat transfer topics, including chapters specifically focusing on pool boiling and flow boiling.

Research articles published in peer-reviewed journals such as the International Journal of Heat and Mass Transfer, Experimental Thermal and Fluid Science, and Journal of Heat Transfer. These articles often present the latest advancements, experimental findings, and theoretical analyses related to pool boiling and flow boiling.

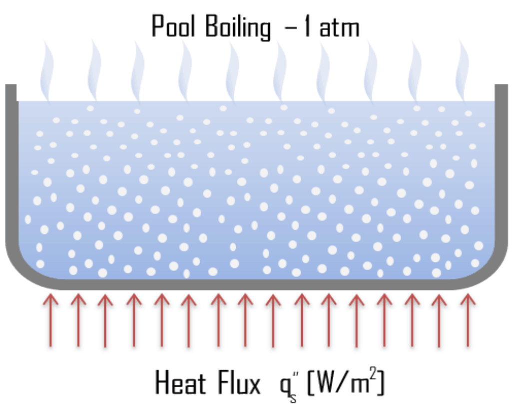
Review papers and conference proceedings that compile and analyze the existing literature on pool boiling and flow boiling, offering valuable summaries of key research findings and identifying future research directions.

Academic texts and handbooks on heat transfer and boiling phenomena, such as "Heat Transfer" by Yunus A. Cengel and "Heat Transfer Handbook" edited by Adrian Bejan, which provide foundational knowledge and theoretical frameworks for understanding pool boiling.

DISCRIPTION OF EQUIPMENTS

3.1 BOILING VESSEL

A container designed to hold the liquid to be boiled, usually made of stainless steel or glass. It should have provisions for heating, temperature measurement, and observation of the boiling process. Boiling vessels come in various sizes and configurations depending on the specific application, ranging from small laboratory-scale vessels to large industrial-scale equipment used in processes like distillation or chemical synthesis.



CAPACITY = 3L

FIGURE:1 BOILING VESSEL

3.2 HEATING ELEMENT

An electric or gas heater used to provide the necessary heat input to the liquid in the boiling vessel. This could be a coil, plate, or immersion heater depending on the design. The heating element is a crucial component of equipment for pool boiling. It's responsible for providing the necessary heat input to the liquid in the boiling vessel. Overall, the heating element plays a critical role in controlled and efficient pool boiling processes, whether in laboratory experiments, industrial applications, or everyday cooking.

WATTS = 1500 V

FIGURE : 2 HEATING ELEMENT

3.3 THERMOMETER

A thermometer is a device used to measure temperature. It typically consists of a temperature sensor connected to a scale that indicates the temperature based on the expansion or contraction of the sensor material in response to changes in temperature. Thermometers come in various forms, including digital, analog, infrared, and probe types, and are widely used in various industries, scientific research, medicine, and everyday applications to monitor and control temperature.

MIN.TEMP = 32.9°C MAX.TEMP = 65°C

FIGURE :3 THERMOMETER

3.4 COPPER TUBE

Copper tubes are commonly used in flow boiling applications due to their excellent thermal conductivity and corrosion resistance. In flow boiling, a fluid flows over a heated surface, typically inside a tube, leading to vaporization and convective heat transfer. The high thermal conductivity of copper enhances heat transfer efficiency, while its resistance to corrosion ensures durability in harsh environments. Flow boiling in copper tubes is utilized in various industries, including HVAC, refrigeration, and power generation, where efficient heat exchange is crucial.

DIA = 2CM, LENGTH = 5M

FIGURE: 4 COPPER TUBE

3.5 RESERVOIR

In flow boiling systems, the reservoir typically functions as a storage vessel for the liquid undergoing the boiling process. It ensures a continuous and controlled supply of liquid to the heated surface where boiling occurs. The reservoir's design and capacity depend on factors such as the flow rate, desired boiling performance, and system requirements. It's essential for maintaining stable operation and efficient heat transfer in flow boiling applications.

CAPACITY = 5 L

FIGURE : 5 RESERVOIR

3.6 TEMPERATURE SENSOR

A temperature sensor is a device that detects and measures the temperature of its environment. It typically converts temperature variations into electrical signals, which can then be processed and displayed in various formats such as analog voltage, digital signals, or temperature readings. These sensors play a crucial role in countless applications, including climate control systems, industrial processes, automotive systems, medical devices, and consumer electronics.

MIN.TRMP = 0℃, MAX.TEMP =99.9℃

FIGURE:6 TEMPERATURE SENSOR

3.7PIPE

A pipe used for flow boiling typically has features like enhanced surface roughness or structured surfaces to improve heat transfer efficiency. These features promote the generation of bubbles and their efficient departure from the heating surface, enhancing the boiling heat transfer coefficient. Additionally, the pipe material must be able to withstand the high temperatures and pressures associated with boiling processes. Materials like stainless steel or copper are commonly used for such applications due to their thermal conductivity and mechanical strength.

DIA = 2CM,LENGTH = 4M

FIGURE : 7 PIPE

3.8 PUMP

A pump is a machine that circulates water, gas or other fluids by creating a partial vacuum or pressure. Pumps have various types and functions depending on the fluid and application, such as water pumps, air pumps, and chemical pumps. They work by drawing a fluid into the pump and forcing it out through the pressure created by a mechanism like an impeller or piston. Pumps are widely used in systems such as irrigation, heating, cooling, and industrial processes.

Figure: 8 WATER PUMP

3.9 FACTORS DETERMINING THE CHOICE OF MATERIALS

The choice of materials for pool boiling and flow boiling depends on several factors, including:

3.9.1 THERMAL CONDUCTIVITY(w/m.k)

Materials with high thermal conductivity, such as copper or aluminum, are preferred because they facilitate efficient heat transfer between the heating surface and the boiling fluid.

In both pool boiling and flow boiling, high thermal conductivity materials are preferred to facilitate efficient heat transfer between the heating surface and the boiling fluid. This helps in enhancing heat transfer rates and overall system performance. However, in flow boiling, the presence of a flowing fluid can enhance heat transfer even with materials of lower thermal conductivity, as the flow helps in carrying heat away from the heating surface more effectively. Nonetheless, materials with higher thermal conductivity still offer advantages in both pool and flow boiling scenarios by promoting faster heat transfer and reducing temperature gradients across the system.

3.9.2 Corrosion resistance

Since boiling processes often involve contact with fluids that may be corrosive, materials with good corrosion resistance, like stainless steel or certain alloys, are chosen to ensure long-term durability.

Corrosion resistance is crucial in both pool boiling and flow boiling applications to ensure the longevity and reliability of the system. In pool boiling, where the heating surface is in direct contact with the boiling fluid, materials must withstand potential corrosion from the fluid over time. Similarly, in flow boiling, although the fluid is in motion, there is still the possibility of corrosion due to prolonged exposure to the flowing fluid. Therefore, materials with good corrosion resistance, such as stainless steel or certain alloys, are preferred for both pool and flow boiling applications to maintain system integrity and performance over their operational lifespan.

3.9.3 Mechanical strength

The material must be able to withstand the mechanical stresses associated with the operating conditions, including pressure variations and thermal cycling, without deforming or failing prematurely.

Material strength is important in both pool boiling and flow boiling applications to withstand mechanical stresses such as pressure and temperature variations. In pool boiling, the material must support the weight of the boiling fluid and any additional loads without deformation or failure. Similarly, in flow boiling, the material needs to withstand the forces exerted by the flowing fluid and any pressure fluctuations without compromising its structural integrity. Therefore, materials with adequate mechanical strength, such as stainless steel or other alloys, are commonly chosen for both pool and flow boiling systems to ensure reliability and safety under operating conditions.

3.9.4 COST EFFICTIVENESS

The overall cost of the material, including procurement, fabrication, and maintenance, is an important consideration in selecting materials for boiling applications.

Pool Boiling: In pool boiling, the cost-effectiveness of materials is primarily assessed based on their initial procurement and installation costs, as well as their long-term maintenance requirements. While materials with higher thermal conductivity and corrosion resistance may have higher upfront costs, they can offer better performance and durability, potentially resulting in lower maintenance and replacement expenses over the system's lifespan.

Flow Boiling: In flow boiling, the cost-effectiveness analysis extends beyond material procurement to include considerations such as energy efficiency, system complexity, and operational costs. While materials with higher thermal conductivity and corrosion resistance can improve heat transfer efficiency and reduce energy consumption, they may also come with higher initial costs. However, the overall cost-effectiveness of materials in flow boiling depends on their ability to optimize system performance and operational efficiency over time.

3.9.5 COMPATIABILITY WITH FLUID

The material must be compatible with the specific fluids being boiled to avoid chemical reactions or contamination that could affect performance or safety.

Pool Boiling: In pool boiling, the material must be resistant to corrosion or chemical degradation caused by the boiling fluid. This is particularly important because the material remains in constant contact with the fluid throughout the boiling process.

Flow Boiling: Similarly, in flow boiling, material compatibility is crucial as the fluid flows through the system, potentially increasing the risk of corrosion or chemical reactions. Materials must be able to withstand the fluid's properties without deteriorating over time. Additionally, in flow boiling, compatibility also extends to factors such as the flow rate and turbulence of the fluid, which can impact the material's performance and integrity.

3.9.6 MANUFACTURING FEASABILITY

The material should be readily available in suitable forms and sizes for the intended application, and it should be easy to fabricate into the required shapes and configurations.

Complexity of Design: The design complexity of components required for pool boiling and flow boiling systems can impact manufacturing feasibility. Simpler designs are generally easier and more cost-effective to manufacture.

Surface Treatment: Surface treatments such as roughening or coating may be necessary to enhance heat transfer efficiency in boiling applications. The feasibility of applying these treatments during manufacturing without compromising quality or increasing costs should be considered.

Quality Control: Manufacturing processes must ensure consistency and quality to meet performance requirements and safety standards. Quality control measures such as inspections and testing may be necessary to ensure the reliability of components.

Scalability: Manufacturing processes should be scalable to meet production demands as required for large-scale applications or mass production.

CONSTRUCTION AND WORKING PRINCIPLR

4.1.1 CONSTRUCTION OF POOL BOILING

Pool boiling involves boiling a liquid on a heated surface. The basic construction consists of a heating element or surface, a container for the liquid, and insulation to minimize heat loss. The surface may have enhancements like fins or coatings to improve boiling efficiency. As the liquid heats up, bubbles form and detach from the surface, carrying away heat. This process is crucial in various applications, from cooling electronics to power generation.

In pool boiling, the construction often includes a vessel containing the liquid to be boiled, a heating element or surface in contact with the liquid, and insulation to maintain temperature. The heating element can be electric, fueled by gas, or another heat source. The surface may be smooth or feature enhancements like microstructures or coatings to promote bubble nucleation and heat transfer. Understanding these elements helps optimize pool boiling systems for efficiency and performance in various industries.

4.1.2 WORKING PRINCIPLE OF POOL BOILING

Pool boiling works by heating a liquid in a container until it reaches its boiling point. When the liquid boils, bubbles of vapor form on the heated surface and rise to the surface. As these bubbles detach, they carry away heat, cooling the surface and allowing more liquid to come into contact with it. This cycle continues, creating efficient heat transfer. The rate of boiling depends on factors like temperature, pressure, and surface properties. Pool boiling is essential for cooling systems in many applications, from household kettles to industrial heat exchangers.

In pool boiling, several key processes occur simultaneously. First, the liquid near the heated surface reaches its boiling point and forms small vapor bubbles, a process known as nucleation. These bubbles grow as more heat is transferred from the surface to the liquid. Eventually, the bubbles detach and rise to the surface, releasing the heat they carry with them. This continuous cycle of bubble formation, growth, and detachment facilitates efficient heat transfer from the heated surface to the liquid. Various factors such as surface roughness, liquid properties, and operating conditions influence the efficiency and performance of pool boiling systems. Understanding these principles is crucial for optimizing heat transfer in practical applications.

4.2.1 CONSTRUCTION OF FLOW BOILING

Flow boiling involves boiling a liquid as it flows over a heated surface or through a heated tube. The construction typically includes a channel or tube where the liquid flows, a heating element or surface along the path, and insulation to minimize heat loss. The heating element can be embedded within the channel walls or externally applied. Additionally, flow control devices like valves or pumps may be included to regulate the liquid flow rate. This setup allows for efficient heat transfer and is commonly used in heat exchangers, refrigeration systems, and power plants.

In flow boiling, the construction often includes a tube or channel through which the liquid flows, a heating element or surface in contact with the liquid, and insulation to maintain temperature. The liquid is typically pumped or circulated through the system to ensure a continuous flow. The heated surface may feature enhancements like fins or coatings to enhance heat transfer efficiency. As the liquid flows over or through the heated surface, it absorbs heat, undergoes phase change, and exits the system as a vapor. Understanding the construction and principles of flow boiling is crucial for designing and optimizing heat transfer systems in various industries.

4.2.2 WORKING PRINCIPLE OF FLOW BOILING

In flow boiling, the construction often includes a tube or channel through which the liquid flows, a heating element or surface in contact with the liquid, and insulation to maintain temperature. The liquid is typically pumped or circulated through the system to ensure a continuous flow. The heated surface may feature enhancements like fins or coatings to enhance heat transfer efficiency. As the liquid flows over or through the heated surface, it absorbs heat, undergoes phase change, and exits the system as a vapor. Understanding the construction and principles of flow boiling is crucial for designing and optimizing heat transfer systems in various industries.

In flow boiling, several key processes occur simultaneously. As the liquid flows over the heated surface or through the heated tube, it undergoes phase change from liquid to vapor due to the heat transfer. This phase change releases latent heat, which further contributes to cooling the surface. As vapor bubbles form and detach, they create turbulence in the liquid, enhancing heat transfer by promoting mixing and increasing the contact area between the liquid and the heated surface. The flow rate, heat flux, and properties of the liquid and surface all influence the efficiency and performance of flow boiling systems. Understanding these principles is essential for designing and optimizing heat exchangers and other thermal management systems.

MERITS AND DEMERITS

5.1.1 MERITS OF POOL BOILING

Simple Construction: Pool boiling systems have a straightforward design, typically consisting of a container, a heating element, and insulation, making them easy to implement and maintain.

High Heat Transfer Rates: The boiling process allows for efficient heat transfer due to the phase change from liquid to vapor, making pool boiling effective for cooling applications.

Self-Sustaining: Once initiated, pool boiling can continue as long as there is sufficient heat input, requiring minimal external energy input to maintain the process.

Versatility: Pool boiling can be applied to various liquids and surfaces, making it adaptable to different industries and applications, from household appliances to industrial processes.

Cost-Effectiveness: Compared to other cooling methods, pool boiling can be a cost-effective solution due to its simplicity and efficiency, especially in applications where continuous cooling is required.

5.1.2 MERITS OF FLOW BOILING

Efficient Heat Transfer: Flow boiling allows for efficient heat transfer due to the continuous movement of the liquid over the heated surface or through the heated tube, enhancing heat exchange rates.

Compact Design: Flow boiling systems can be designed to be compact, making them suitable for applications where space is limited, such as in refrigeration systems and heat exchangers.

Controllable Heat Transfer: The flow rate of the liquid can be adjusted to control the heat transfer rate, providing flexibility in managing thermal loads and system performance.

Reduced Hot Spot Formation: The uniform flow of liquid over the heated surface helps to distribute heat evenly, reducing the likelihood of hot spots and improving system reliability.

Versatility: Flow boiling can be applied to a wide range of fluids and operating conditions, making it adaptable to various industries and thermal management requirements.

5.2.1 DEMERITS OF POOL BOILING

Limited Heat Transfer: Pool boiling may not be as efficient as other methods in transferring heat, especially compared to flow boiling, due to limitations in the contact area between the heated surface and the liquid.

Potential for Surface Dry out: If the heat flux is too high or the liquid level is insufficient, the heated surface may dry out, leading to decreased heat transfer efficiency and potential damage to the equipment.

Risk of Boiling Instabilities: Pool boiling systems can experience boiling instabilities such as nucleate boiling, film boiling, or departure from nucleate boiling (DNB), which can impact heat transfer performance and system reliability.

Sensitivity to Surface Condition: The efficiency of pool boiling can be affected by the surface condition, including roughness, cleanliness, and surface coatings, requiring careful design and maintenance to optimize performance.

Space Requirement: Pool boiling systems may require a larger physical footprint compared to other cooling methods, making them less suitable for applications where space is limited.

5.2.2 DEMERITS OF FLOW BOILING

Complexity: Flow boiling systems can be more complex to design, operate, and maintain compared to pool boiling systems due to the need for additional components such as pumps, valves, and control systems.

Pressure Drop: Flow boiling often results in pressure drops along the flow path, which can require additional energy input to maintain desired flow rates and system performance.

Potential for Flow Instabilities: Flow boiling systems may experience flow instabilities such as flow maldistribution, flow oscillations, or flow regime transitions, which can affect heat transfer efficiency and system reliability.

Sensitivity to Flow Conditions: The performance of flow boiling systems can be sensitive to flow rates, flow patterns, and fluid properties, requiring careful consideration during system design and operation.

Risk of Flow Blockage: Flow boiling systems may be susceptible to flow blockage due to the accumulation of vapor or particulate matter, which can impair heat transfer and system performance if not adequately addressed.

5.3.1 APPLICATIONS OF POOL BOILING

Home Appliances: Pool boiling is used in everyday appliances like electric kettles, rice cookers, and steam irons for heating liquids efficiently.

Industrial Cooling Systems: It's employed in industrial cooling systems for heat removal in processes such as distillation, chemical reactions, and power generation.

Refrigeration: Pool boiling is utilized in refrigeration systems for evaporative cooling, such as in air conditioners, refrigerators, and heat pumps.

Nuclear Power Plants: It's crucial in nuclear power plants for cooling reactor cores by transferring heat away from the fuel rods.

Thermal Management in Electronics: Pool boiling is used for cooling electronic components like computer CPUs, where efficient heat dissipation is essential to prevent overheating.

5.3.2 APPLICATIONS OF FLOW BOILING

Refrigeration and Air Conditioning: Flow boiling is extensively used in refrigeration and air conditioning systems for evaporative cooling, where a refrigerant absorbs heat from a space or substance while evaporating.

Power Generation: It's employed in power generation systems, such as steam turbines and nuclear reactors, for efficient heat transfer and power generation.

Chemical Processing: Flow boiling is used in chemical processing industries for tasks like chemical synthesis, distillation, and fractionation processes.

Heat Exchangers: Flow boiling is utilized in heat exchangers for heating or cooling liquids or gases in various industrial processes, such as in petroleum refining and pharmaceutical manufacturing.

Food and Beverage Industry: Flow boiling finds applications in food and beverage processing for tasks like sterilization, pasteurization, and concentration of liquid products.

Water Treatment: It's used in water treatment processes for desalination, where seawater or brackish water is evaporated to separate pure water from salts and other impurities.

Electronics Cooling: Flow boiling is employed in electronics cooling systems, such as in data centers and high-performance computing, to dissipate heat generated by electronic components efficiently.

Aerospace Applications: Flow boiling is utilized in aerospace applications for thermal management systems in spacecraft, where precise temperature control and efficient heat transfer are crucial.

RESULT

Pool boiling and flow boiling are two different modes of heat transfer in which a liquid is boiled to remove heat. In pool boiling, the liquid is heated in a container, and bubbles form directly on the heated surface due to the temperature difference between the surface and the liquid.

Pool boiling readings typically involve analyzing parameters such as heat flux, wall temperature, bubble dynamics, and heat transfer coefficients. In flow boiling, the liquid flows over a heated surface, and boiling occurs as the liquid passes over the surface.

Flow boiling readings often include measurements of pressure drop, flow rate, heat transfer coefficient, and boiling heat transfer coefficient along the flow channel. Both modes of boiling have their unique characteristics and applications, and research in this area aims to optimize heat transfer efficiency, understand bubble dynamics, and improve the design of heat exchangers and cooling systems.

When conducting boiling tests on pool water, it is important to measure both the temperature reading at the surface of the water and the flow rate of the water being heated. This is known as both "surface boiling" and "flow boiling" readings respectively.

Surface boiling readings are typically measured using a thermometer or thermocouple placed at the surface of the water, while flow boiling readings are measured using a flow rate meter to measure the rate of water being heated. Both readings are important for ensuring that the pool is adequately heated and for maintaining a consistent temperature.

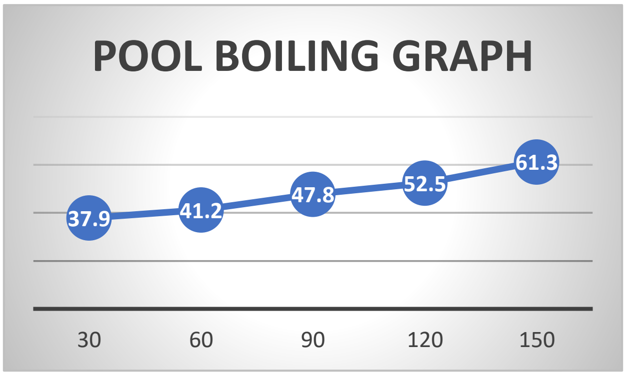
TABLE 1.1 POOL BOILING READINGS

S.NO	TIME (sec)	TEMPERATURE (°C)
1	30	37.9
2	60	41.2
3	90	47.8
4	120	52.5
5	150	61.3

GRAPH 1

TEMP

(K)



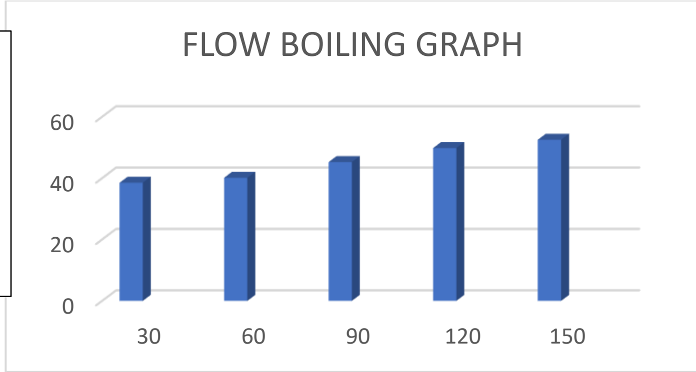
TIME (Sec)

TABLE 2 FLOW BOILING READINGS

S.NO	TIME (sec)	TEMPERATURE (°C)
1	30	38.5
2	60	40.1
3	90	45.2
4	120	49.8
5	150	52.5

TEMP

K



TIME (Sec)

CONCLUSION

In this study investigates the optimization of laser beam welding process parameters through Response Surface Methodology (RSM) based on central composite face centred design. Laser beam welding process parameters like laser power, welding speed and shielding gas flow rate on the maximum ultimate tensile strength of dissimilar metal joints were determined in this parametric study. The maximum ultimate tensile strength (478.02 N/mm^2) obtained by the conditions like laser power (599.99 W), shielding gas flow rate (1.70 bar) and low travel speed (100.15 mm/min). A conformation experiment was also conducted in order to validate the optimal process parameters values. The developed relationship can be effectively used to predict the ultimate tensile strength of laser beam welded joints at 95% confidence level.

REFERENCES

1.Nukiyama, S. "The maximum and minimum values of the heat Q transmitted from metal to boiling water under atmospheric pressure." International Journal of Heat and Mass Transfer 9.12 (1966): 1419-1433.

2.Rohsenow, W. M., et al. "A method of correlating heat transfer data for surface boiling of liquids." Transactions of the ASME 74.3 (1952): 969-976.

3.Cooper, M. G. "Saturation nucleate pool boiling—a simple correlation." International Journal of Heat and Mass Transfer 18.3 (1975): 267-272.

4.Kandlikar, Satish G. "Heat transfer mechanisms during flow boiling in microchannels." ASME Journal of Heat Transfer 123.5 (2001): 1073-1080.

5.Thome, John R. "Engineering data book III: Two-phase heat transfer." (2003): 1-101.

6.Cavallini, Alberto, et al. "Boiling heat transfer and two-phase flow in microchannels." International Journal of Thermal Sciences 43.7 (2004): 709-718.