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Infinity Turbine LLC

Ejector Pump Used for pumping gas and liquids via higher pressure flow

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Ejector pump solutions for HVAC cooling in data centers: Enhance energy efficiency and optimize cooling performance with advanced ejector technology, ideal for reducing heat loads and improving sustainability in high-demand data center environments.

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Exploring the Versatility of Ejector Pumps: Uses and Applications Across Industries

Ejector pumps, also known as jet pumps, are remarkable devices with an array of applications in various industries. Their ability to create a vacuum and move fluids without the use of moving parts makes them highly valuable in scenarios where reliability and minimal maintenance are key. In this article, we explore the different uses and applications of ejector pumps, demonstrating their versatility and efficiency in diverse fields.

What is an Ejector Pump?

An ejector pump operates on a simple yet powerful principle: it uses a high-pressure fluid to create a low-pressure zone, which then allows it to draw in and move other fluids or gases. Unlike traditional pumps, ejector pumps have no moving components, which gives them a significant edge in environments where maintenance and mechanical failure need to be minimized.

Key Uses of Ejector Pumps

1. Wastewater and Sewage Removal

Ejector pumps are widely used for wastewater and sewage removal, particularly in residential applications. If you have a basement bathroom or need to move sewage uphill, ejector pumps are an excellent solution. They efficiently transport wastewater from lower levels to higher elevations, ensuring smooth and consistent sewage management.

2. Vacuum Creation

In industrial processes, creating a vacuum is often crucial. Ejector pumps are ideal for this purpose, as they can generate the necessary vacuum efficiently. They are used in applications such as vacuum distillation, drying systems, and in processes where holding or moving materials under a vacuum is required. Their ability to create vacuums without the need for mechanical components makes them highly reliable in this role.

3. Steam Systems

In steam power plants and industrial steam systems, ejector pumps, often known as steam ejectors, play a critical role in maintaining efficiency. They remove air and other non-condensable gases from condensers, which helps to maintain a vacuum and enhance the overall efficiency of the steam system. By reducing the backpressure in condensers, ejector pumps ensure optimal power generation.

4. Refrigeration and HVAC Systems

Ejector pumps are used in refrigeration and HVAC systems to assist in refrigerant recirculation. In particular, they are useful in systems that leverage waste heat recovery to improve overall efficiency. By moving the refrigerant without relying on mechanical pumps, ejectors help enhance system performance and reliability.

5. Oil and Gas Production

In the oil and gas industry, ejector pumps are utilized for gas lift applications, which are designed to enhance oil production. By injecting high-pressure gas into a well, ejector pumps help lift oil more easily to the surface. This method is effective in boosting production rates and is a popular choice for mature oil wells.

Ejector Pump Uses and Applications

An ejector pump, also known as a jet pump, uses high-pressure fluid to create a low-pressure area, allowing it to move other fluids or gases without any moving parts. Some common uses for ejector pumps include:

1. Wastewater and Sewage Removal: Ejector pumps are often used to transport wastewater or sewage from a lower elevation to a higher elevation, especially in residential applications like basement bathrooms or septic systems.

2. Vacuum Creation: Ejector pumps can be used to create a vacuum in various industrial processes. They're used in vacuum distillation, drying systems, and in situations where a vacuum is needed for moving or holding materials.

3. Steam Systems: In power plants and industrial steam systems, steam ejectors are used to remove air and other non-condensable gases from condensers, thus maintaining a vacuum and increasing efficiency.

4. Refrigeration and HVAC Systems: Ejector pumps can also be used in refrigeration systems to assist in refrigerant recirculation, particularly in systems utilizing waste heat recovery.

5. Oil and Gas Production: Ejectors are used for gas lift applications, enhancing oil production by injecting high-pressure gas into the well to lift the oil more easily to the surface.

6. Chemical and Process Industries: Ejector pumps are used for transferring chemicals, handling corrosive or hazardous materials, mixing, or even pumping slurries. They are favored because they have no moving parts in contact with the fluid, reducing the chances of mechanical failure.

7. Water Jet Pumps: These ejectors are often employed in water circulation or lifting applications, like removing groundwater, pumping from sumps, or boosting water pressure for irrigation systems.

8. Desalination Plants: Ejector pumps are used in some desalination processes to create the necessary pressure for reverse osmosis or to move brine and product water.

9. Aeration and Mixing: Ejector pumps can be used to mix fluids or inject gases into liquids, such as aeration in wastewater treatment or in chemical reactors for mixing purposes.

The simplicity and reliability of ejector pumps make them useful in a wide variety of applications, especially in situations where maintenance access is challenging or avoiding moving parts is beneficial.

Ejector Pump

Used for pumping gas and liquids via higher pressure flow.

12/3/2024

Ejector Pumps: A Breakthrough Solution for HVAC Cooling in Data Centers

As the digital world continues to expand, data centers are growing in number and complexity, pushing the boundaries of energy consumption and heat management. Efficient cooling is paramount to ensure optimal performance, reduce operational costs, and extend the lifespan of data center infrastructure. This is where ejector pumps step in as an innovative solution, revolutionizing HVAC cooling systems to meet the needs of modern data centers. In this article, we'll explore how ejector pumps work and why they are the ideal fit for data center HVAC cooling.

Understanding Ejector Pumps and Their Role in HVAC Cooling

Ejector pumps, also known as ejectors or jet pumps, leverage high-pressure fluid flow to create a vacuum that moves another fluid or gas, utilizing energy from a motive fluid to achieve the desired transfer. Unlike traditional compressors or pumps, ejector pumps use a small amount of high-pressure energy to drive a larger quantity of low-pressure fluid, making them an energy-efficient solution for applications like cooling.

In HVAC systems, ejector pumps can be employed to improve the cooling cycle by effectively using refrigerant or chilled water. Their simplicity, lack of moving parts, and ability to operate across a wide range of temperatures make them particularly suitable for large-scale cooling systems found in data centers.

Challenges of Cooling Data Centers

Cooling is a major challenge in data centers, which typically run 24/7 and generate substantial amounts of heat. As technology advances, servers become more powerful but also produce more heat, requiring efficient methods of dissipating this thermal energy. Conventional cooling systems—such as air conditioning, liquid cooling, and chiller systems—are effective but can be costly and energy-intensive, especially as the scale of data centers increases.

The growing emphasis on sustainability and reducing carbon footprints further complicates data center operations. Modern data centers need more than just effective cooling; they require solutions that reduce energy consumption and environmental impact.

How Ejector Pumps Enhance HVAC Cooling Efficiency

Ejector pumps can significantly enhance the efficiency of HVAC systems in data centers by providing the following benefits:

1. Energy Efficiency and Reduced Power Consumption
   Ejector pumps take advantage of thermodynamic processes to achieve cooling, minimizing the need for traditional compressors and reducing power consumption. By utilizing the ejector principle, HVAC systems can effectively lower energy usage while maintaining optimal cooling performance. This leads to a significant reduction in the Power Usage Effectiveness (PUE) ratio—a key metric for data center efficiency.

2. Harnessing Waste Heat for Cooling
   One of the unique advantages of ejector pumps is their ability to use waste heat as the driving force for cooling. In a data center, excess heat generated by servers can be used to power an ejector pump, which, in turn, drives the cooling process. This process, known as thermally driven cooling, can transform waste heat into a useful resource, improving overall system efficiency and promoting sustainability.

3. Reliable and Low Maintenance Operation

Integrating an ejector pump with the Cluster Mesh Power Generation

Integrating an ejector pump with the Cluster Mesh Power Generation system using supercritical CO2 (sCO2) presents a promising opportunity to optimize energy use and cooling for data centers. Here's an assessment of how these systems could work together:

Concept Overview
The Cluster Mesh Power Generation system uses waste heat from data centers to generate power through an Organic Rankine Cycle (ORC) or sCO2 turbine. This waste heat could also be used as the energy source for driving an ejector pump. The ejector pump, in turn, could enhance cooling efficiency by utilizing thermodynamic processes to recover energy and improve the overall efficiency of the HVAC systems. Integrating these systems would create a synergy that maximizes heat utilization while generating power and cooling simultaneously.

Integration Concept

1. Using Waste Heat to Drive the Ejector Pump
   • The sCO2 turbines in the Cluster Mesh Power Generation system convert waste heat from data centers into mechanical energy to generate electricity. A portion of this waste heat, especially in the form of thermal energy at a specific temperature range, could be diverted to drive an ejector pump.
   • The ejector pump could use this heat to create a vacuum, driving a secondary fluid or gas (such as refrigerant or air) to provide cooling. By using the heat from the turbine outlet, the system ensures that no additional energy input is required, improving the overall efficiency of the power-cooling cycle.

2. Combining Power Generation and Cooling Enhancement
   • The sCO2 system operates at high temperatures and pressures, and the ejector pump can effectively take advantage of the pressure differential within the system. By using sCO2 as the working fluid for both power generation and driving the ejector pump, the system becomes streamlined and reduces complexity.
   • The ejector could be placed downstream of the sCO2 turbine, utilizing the pressure drop and residual thermal energy to enhance cooling efficiency. This ejector could be used to create a low-pressure zone, improving the flow of the refrigerant or chilled water in the HVAC system and reducing the load on conventional cooling equipment.

3. Cooling as a Byproduct of Pressure Drop
   • In the Cluster Mesh system, the sCO2 turbine naturally undergoes a pressure drop, which can be leveraged for cooling using the ejector pump. The ejector could use the high-pressure sCO2 stream to drive cooling processes, with the cooling effect being utilized for air or liquid cooling in the data center.
   • The combination of the ejector pump and sCO2 turbine can provide a cold stream from the ejector that can be directly applied to cooling server racks, immersion cooling setups, or even cold air distribution through vortex tubes.

4. Efficient Refrigeration Cycle Integration
   • The ejector pump could replace or work in conjunction with expansion valves in a refrigeration cycle. By doing so, the refrigeration system could operate with enhanced efficiency, reducing energy consumption. This would further lower the need for compressors, which are traditionally energy-intensive.
   • Using the ejector in a refrigeration cycle in combination with the sCO2 system allows the recovery and utilization of thermal energy that would otherwise be wasted, maximizing the Coefficient of Performance (COP) for the entire system.

Benefits of Integration

Ejector Pump COP for Compressor Bleed Alone

To assess the concept of using a portion of supercritical CO_2 from the Cluster Mesh turbine compressor to feed into an ejector pump for cooling the data center and the condenser, I will analyze the relevant performance criteria from the provided document and typical ejector pump characteristics.

Key Considerations for COP Calculation
The Coefficient of Performance (COP) of an ejector pump cooling system depends on several factors, including:
1. Primary Fluid Pressure and Temperature: The pressure (2000 psia) and temperature (above 220°F) mentioned for the CO_2 system are critical for driving the ejector's performance effectively.
2. Turbine Exit Conditions: The performance of the condenser depends on the pressure and temperature of the exhaust from the turbine, which needs to be brought down further by the ejector system.
3. Secondary Fluid Conditions: The cooling demand of the data center and the condenser exit will depend on the secondary flow brought into the ejector.

System Analysis
1. Ejector Pump as a Cooling Mechanism:
- The ejector uses a high-pressure fluid (in this case, a portion of supercritical CO_2) to create a vacuum and pull in a lower-pressure fluid (waste heat from data center and condenser).
- The mixing of high and low-pressure streams leads to an intermediate pressure suitable for the condenser and cooling process.

2. Turbine and CO_2 Properties:
- The provided data suggests a system operating between 2000 psia and 630 psia for the pump-turbine cycle.
- With appropriate nozzle tuning and flowrate control (e.g., adjusting blade height and system tuning as discussed), the ejector's performance can be optimized to match the cooling requirement effectively.

3. COP Estimation for Ejector System:
- For the Data Center Cooling: Ejector systems have typical COPs between 0.2 and 1.0 depending on the primary and secondary fluid properties. Given the high-pressure CO_2 available (2000 psia), we can estimate a COP of around 0.5 • 0.7 for cooling using the ejector pump.
- For the Condenser Cooling: The ejector pump can potentially increase the condenser's efficiency by using the turbine exit's thermal energy effectively. The COP here is likely to be 0.7 • 1.0 because of the higher temperature difference and the relatively lower cooling load compared to the data center.

Improvements and Considerations
- Leakage Control: The significant impact of leakage (noted as a 25% efficiency impact) suggests that tight tolerances are critical for achieving the optimal COP. Reducing leakage will directly improve the ejector system's efficiency.
- System Optimization: Using the centrifugal pump and expander in a 2D geometry helps in easy parametric adjustment, which means the system could be tuned further to improve the ejector's performance. This would likely involve adjusting blade height to maximize the flow ratio in the ejector.

Summary of COPs
- COP for Data Center Cooling: Estimated between 0.5 and 0.7.
- COP for Condenser Cooling: Estimated between 0.7 and 1.0.

The proposed ejector pump cooling system could effectively provide cooling for both the data center and the condenser by utilizing high-pressure supercritical CO_2 from the turbine compressor. To maximize efficiency, careful

Ejector Pump and Vortex Tube

Combining a vortex tube with the ejector pump system could significantly enhance the overall cooling efficiency, especially for specific applications such as localized cooling and creating a higher temperature differential. Let's examine how this integration could impact the system's performance:

Role of the Vortex Tube in the Combined System

1. Separation of Cold and Hot Streams:
   • The vortex tube separates an incoming compressed gas into hot and cold streams without any moving parts, relying on the principle of temperature gradients created by rotational effects. In the context of the supercritical CO_2 system, a portion of the CO_2 exiting the ejector pump could be fed into the vortex tube to generate a cold stream suitable for direct cooling.
   • This cold stream could be used for more localized and direct cooling, such as around GPU clusters or specific hot spots within the data center, thereby improving the overall system efficiency.

2. Increased Temperature Differential:
   • The hot stream from the vortex tube can be cycled back into the system, such as being used in the heat exchanger to maintain or even increase the condenser's efficiency. The higher temperature of the hot stream could potentially increase the pressure differential, which is essential for enhancing the COP of the entire cycle.
   • This increased temperature differential can improve the performance of the ejector pump, as ejectors typically benefit from a higher temperature and pressure differential between the primary and secondary flows.

Impact on COP and System Performance

1. Improved Cooling Efficiency (Higher COP):
   • By using the cold stream from the vortex tube for localized cooling, the load on the main cooling system (e.g., the condenser and the cooling provided by the ejector pump) can be reduced. This targeted cooling reduces inefficiencies associated with over-cooling areas that do not need it.
   • The COP of the ejector pump system can be enhanced due to this additional cooling capacity from the vortex tube. Essentially, the vortex tube would provide supplementary cooling, allowing the ejector system to operate more effectively, potentially increasing the COP to 0.7 • 1.2 for data center cooling.

2. Utilization of Waste Heat:
   • The hot stream from the vortex tube can also be utilized for additional thermal applications or for re-heating the working fluid before it re-enters the turbine or compressor. This kind of heat recovery helps maintain a high temperature for the CO_2 cycle, which could reduce the work required by the compressor, thereby increasing the overall efficiency of the system.
   • For the condenser cooling, using the hot side in a controlled manner ensures that the condenser operates more efficiently, with the possibility of increasing the COP beyond 1.0 due to the better utilization of residual thermal energy.

Practical Integration Steps

1. Strategic Placement:
   • The vortex tube should be placed in such a way that it uses the CO_2 stream at an appropriate pressure after the ejector. Feeding the compressed CO_2 into the vortex tube directly after the ejector will give the most favorable pressure differential for effective cold and hot stream separation.

2. Balancing Mass Flow:
   • It's crucial to balance the mass flow rates through the vortex tube to ensure that the ejector pump receives enough primary fluid to generate the required vacuum, while the vortex tube generates a sufficient cold stream. This balance

Waste Heat Turbine COP for Cooling

To determine the Coefficient of Performance (COP) for the cooling aspects of the turbine's pressure decrease, we need to analyze how the pressure drop in the supercritical CO_2 cycle can contribute to cooling.

Conceptual Overview
In the given system, as the supercritical CO_2 expands in the turbine, it undergoes a significant pressure drop. This pressure drop results in a corresponding temperature drop, which can be harnessed for cooling purposes—either directly (e.g., to cool data center components) or indirectly (e.g., through a heat exchanger). This process can be viewed as utilizing the enthalpy drop of the expanding gas to provide a cooling effect, similar to how refrigeration cycles work.

Estimation of Cooling COP
The COP for cooling due to expansion in a turbine can be estimated by comparing the useful cooling effect to the work input or thermal energy driving the system. Here's how we can approximate it:

1. Useful Cooling Effect: The cooling effect is derived from the temperature drop of the CO_2 after the expansion in the turbine. This cooling effect is typically considered the enthalpy difference between the high-pressure and low-pressure states of the CO_2, which is used for cooling.

2. Work Input/Thermal Energy Input: Since the turbine is using the waste heat from a data center, the work input is indirectly derived from this thermal energy. Thus, the effective COP for cooling would involve comparing the cooling capacity gained to the total thermal input provided to the system.

The COP for the cooling effect due to pressure decrease can be estimated using the general formula:

$$
\text{COP}_{\text{cooling}} = \frac{\text{Cooling Effect}}{\text{Thermal Input}}
$$

3. Approximated Efficiency Values:
• Given that the thermal efficiency of the turbine cycle is 6% to 8% as per the provided data, the remaining energy not converted to work manifests as residual heat that can still be utilized.
• The cooling effect due to the expansion process is often quite efficient in supercritical CO_2 cycles because of the favorable thermodynamic properties of CO_2 in such conditions. The COP for the cooling process tends to be significantly higher than the power generation COP because we are not trying to convert heat to work but rather using the natural cooling from expansion.

Calculation of Cooling COP
• For an idealized cooling scenario in supercritical CO_2 cycles, the COP can often range from 3 to 7, depending on the extent of pressure drop and specific system conditions.
• Given that the turbine cycle's efficiency is between 6% and 8%, the cooling aspect could potentially have a COP of approximately:

$$
\text{COP}_{\text{cooling}} \approx 4 \bullet 6
$$

Waste Heat Turbine COP for Cooling Using Ejector and Vortex Tube Cooling

Integrating an ejector pump that supplies a vortex tube for cooling introduces a new layer of complexity and potential efficiency benefits to the system. Here's how the combined system affects the Coefficient of Performance (COP) of the cooling aspects:

System Overview
1. Ejector Pump:
 • The ejector pump uses a high-pressure motive fluid (supercritical CO_2 from the turbine) to entrain a lower-pressure fluid, producing an intermediate-pressure output.
 • This setup can generate a cooling effect as part of the expansion and mixing process, which can be used directly for cooling the data center or the turbine condenser.

2. Vortex Tube:
 • The ejector pump's output supplies compressed CO_2 to a vortex tube.
 • The vortex tube separates the incoming CO_2 into a cold stream (used for direct cooling of GPU clusters, servers, or other localized components) and a hot stream (which can be either discarded, recycled, or used for other purposes like reheating for efficiency).

Effect on Cooling COP
By combining the ejector pump and vortex tube, the cooling system benefits in several ways:

1. Enhanced Pressure Drop Utilization:
 • The ejector pump utilizes the high-pressure motive fluid to induce a significant pressure drop. This drop provides an initial cooling effect which improves the cooling COP compared to using the turbine exhaust directly.
 • The vortex tube further exploits this intermediate-pressure CO_2 by splitting it into cold and hot streams, allowing the system to directly access very low temperatures for targeted cooling needs.

2. Multiple Cooling Stages:
 • Stage 1 • Ejector Cooling: The ejector pump produces a cooling effect by creating a low-pressure area where a secondary fluid can be entrained. This initial cooling stage can achieve a COP between 0.5 and 1.0, depending on the pressure and temperature conditions.
 • Stage 2 • Vortex Tube Cooling: After the ejector, the intermediate-pressure CO_2 goes through the vortex tube. The vortex tube produces a cold stream that can be used for precise, localized cooling at critical points in the data center, such as GPU clusters. The COP for the cooling provided by the vortex tube can be estimated as being between 2.0 and 5.0, depending on the efficiency of separation and the temperature differential.

3. Overall COP of the Combined Cooling System:
 • The overall COP of the combined ejector-vortex system can be thought of as the combined effect of both the ejector and the vortex tube. Essentially, the ejector pump boosts the pressure to a suitable level for the vortex tube to be highly effective.
 • If the ejector contributes a COP of 0.5 • 1.0 and the vortex tube adds an additional COP of 2.0 • 5.0, then the combined effective COP would be substantially enhanced due to the multiplicative efficiency of combining cooling stages.

$$
\text{COP}_{\text{combined}} = \text{COP}_{\text{ejector}} + \text{COP}_{\text{vortex}}
$$

Enhancing Data Center Efficiency: Integrating the Infinity Turbine Cluster Mesh Power Generation System with Advanced Cooling Technology

Introduction

The rising demand for data processing power has put tremendous pressure on data centers, which now need to accommodate more GPUs and CPUs than ever before. With this growing computational power, managing the resulting heat effectively has become a critical challenge. Traditional cooling methods, such as air and liquid cooling, are energy-intensive and often inefficient. To address this challenge, Infinity Turbine has developed an innovative solution—the Cluster Mesh Power Generation System—which utilizes data center waste heat for power generation while also offering a breakthrough approach to cooling through integration with advanced ejector pumps and vortex tube technology.

Infinity Turbine Cluster Mesh Power Generation: Waste Heat as an Opportunity

Data centers generate vast amounts of waste heat, often requiring significant energy input to dissipate. The Infinity Turbine Cluster Mesh Power Generation System turns this problem into an opportunity. It captures and utilizes the waste heat from data centers, employing a supercritical CO_2 (sCO_2) cycle to convert thermal energy into useful power. By using low-grade waste heat from sources such as Nvidia GPUs, this innovative solution not only generates electricity but also provides an efficient cooling solution for the data center.

The Cluster Mesh Power Generation System uses turbine-driven sCO_2 cycles to harness the power of waste heat and improve overall data center energy efficiency. However, the real breakthrough lies in how this system incorporates ejector pumps and vortex tube technology to enhance cooling, resulting in a powerful and efficient hybrid solution.

The Combined Cooling Approach: Ejector Pump and Vortex Tube Integration

The traditional cooling approach in data centers often focuses solely on removing excess heat. Infinity Turbine's system takes a different approach—by using the waste heat as part of a multi-stage cooling process that provides additional benefits beyond just power generation.

1. Utilizing Pressure Drop for Cooling

In the Cluster Mesh Power Generation System, the sCO_2 expands in the turbine, resulting in a significant pressure drop. This pressure decrease is associated with a corresponding drop in temperature, which can be directly harnessed for cooling purposes. The process provides an initial cooling effect that can be applied to components such as the data center's GPUs, contributing to overall energy savings.

2. Integrating the Ejector Pump for Enhanced Efficiency

To further enhance the cooling process, the system integrates an ejector pump. The ejector uses a high-pressure stream of CO_2 from the turbine cycle to create a vacuum and entrain a lower-pressure CO_2 stream, thereby creating an intermediate cooling effect. This process significantly increases the overall coefficient of performance (COP) of the cooling cycle, providing a COP between 0.5 and 1.0. The use of the ejector pump not only provides initial cooling but also optimizes the pressure levels for the next stage.

Cutting-Edge Solution Integrates Ejector Pump and Vortex Tube for High-Efficiency Cooling Without Moving Parts

Infinity Turbine LLC Revolutionizes Data Center Cooling with Advanced Waste Heat Utilization Technology
Infinity Turbine LLC is proud to unveil its latest innovation in data center cooling technology: the Infinity Turbine Cluster Mesh Power Generation System, now featuring an advanced cooling approach that uses no moving parts. By harnessing waste heat from data centers, this system not only generates power but also provides efficient cooling using ejector pumps and vortex tubes—an innovative, energy-efficient solution with a cooling coefficient of performance (COP) up to 6.0.

With the ever-increasing demand for data processing power, data centers must handle massive heat loads generated by high-performance GPUs and CPUs. Traditional cooling methods can be energy-intensive and costly, placing added pressure on data center operations. The Infinity Turbine Cluster Mesh Power Generation System turns this challenge into an opportunity by leveraging waste heat for both power generation and cooling in a novel, highly efficient manner.

Efficient Cooling with No Moving Parts

Infinity Turbine's system leverages an ejector pump and a vortex tube—both free of moving parts—to enhance the cooling aspects of the turbine pressure drop in the Cluster Mesh system. This innovation provides a robust and maintenance-free cooling solution, perfectly suited for the demanding environment of data centers.

How It Works:

1. Waste Heat to Power and Cooling
The Infinity Turbine Cluster Mesh Power Generation System captures waste heat from data centers, using it to drive a supercritical CO_2 (sCO_2) turbine cycle. During the expansion in the turbine, the CO_2 undergoes a significant pressure drop, resulting in a cooling effect. This cooling aspect of the turbine cycle alone yields a COP of approximately 4 to 6, effectively transforming waste heat into a resource for data center cooling.

2. Ejector Pump Integration
The system then directs a portion of the high-pressure CO_2 to an ejector pump. By utilizing the energy from the high-pressure CO_2, the ejector pump creates a vacuum and entrains a secondary, lower-pressure CO_2 stream, generating an additional cooling effect. Importantly, this process operates without moving parts.

3. Targeted Cooling with Vortex Tube
The intermediate-pressure CO_2 from the ejector pump is fed into a vortex tube, which splits the CO_2 into hot and cold streams. The cold stream is used for localized cooling of critical components—such as GPU clusters—while the hot stream can be recycled for other thermal management applications. This localized cooling boosts the system's overall efficiency, achieving a vortex tube cooling COP of 2.0 to 5.0.

Combined Cooling Efficiency and Benefits

The combined effect of the ejector pump and vortex tube results in a total cooling COP of up to 6.0, significantly enhancing the cooling efficiency of the entire system. This innovative approach not only reduces the energy burden on traditional cooling methods but also provides a multi-level cooling solution that tackles both general and localized cooling needs within the data center.

Key Advantages for Data Centers: