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In the realm of engineering marvels, hydrostatic transmission (HST) stands as a testament to human ingenuity and technological prowess. At its core, HST harnesses the power of hydraulic fluid to transmit force from an engine to a load with unparalleled precision and efficiency. This article embarks on an exploratory journey into the world of hydrostatic transmission, unveiling its underlying principles, advantages, and diverse applications in modern industries. Before discussing hydrostatic transmission, it is crucial to grasp the fundamentals of fluid power. Fluid power systems rely on the use of pressurized fluids to transmit power, and they are classified into two main types: hydraulic systems, which utilize liquid fluids like oil, and pneumatic systems, which employ gases like air. Hydrostatic transmission falls under the umbrella of hydraulic systems, and its effectiveness stems from the incompressible nature of hydraulic fluid, allowing it to maintain constant force during transmission. Hydrostatic Transmission Defined Hydrostatic transmission, often abbreviated as HST, can be defined as a method of power transmission that employs hydraulic fluid to transfer energy between an engine and a load. The primary purpose of HST is to provide seamless control over speed and torque, making it an ideal choice for various applications in industries where precise motion control is paramount. The roots of hydrostatic transmission can be traced back to the mid-19th century when engineers and inventors began experimenting with fluid power concepts. It was in the early 20th century when HST technology truly started to take shape, with advancements in hydraulic pumps, motors, and control valves. The breakthroughs in metallurgy and material sciences during the mid-20th century further propelled HST's development, leading to its integration into a wide range of machinery and vehicles. How Hydrostatic Transmission Works At the heart of the mechanism lie its fundamental principles. An HST system comprises several crucial components working in harmony to enable power transfer with remarkable efficiency. Hydrostatic transmission operates on the principle of Pascal's law, which states that pressure exerted at any point on a confined fluid is transmitted undiminished throughout the fluid in all directions. By leveraging this principle, HST systems ensure consistent force distribution within the hydraulic circuit, resulting in smooth and controlled motion. Components of an HST System The key components of an HST system include: Hydraulic Pump: The hydraulic pump is responsible for converting mechanical energy from the engine into hydraulic energy. It pressurizes the hydraulic fluid, creating the force necessary for power transmission. Hydraulic Motor: The hydraulic motor is the recipient of the pressurized fluid, which it converts back into mechanical energy to drive the load. Its direction of rotation and speed depend on the flow and pressure of the hydraulic fluid. Control Valves: Control valves regulate the flow and pressure of the hydraulic fluid, allowing precise control over the speed and direction of the load. They are essential for achieving the desired motion control in HST systems. Fluid Reservoir and Filters: The fluid reservoir stores the hydraulic fluid, while filters ensure its cleanliness and longevity. Proper fluid management is crucial for maintaining the efficiency and reliability of the HST system. Types of Hydrostatic Transmissions There are two primary types of HST systems: open-circuit and closed-circuit. Open-Circuit HST Systems In an open-circuit HST system, the hydraulic fluid flows from the pump to the motor and back to the reservoir without being reused. This simplicity makes open-circuit systems more cost-effective and easy to maintain, making them suitable for various low-power applications. Closed-Circuit HST Systems Closed-circuit HST systems, on the other hand, recycle the hydraulic fluid, leading to increased efficiency and performance. These systems are further categorized based on their construction. Swash Plate Type: Swash plate HST systems utilize a tilted swash plate to control the displacement of the hydraulic pump, allowing variable speed and direction control. Bent Axis Type: Bent axis HST systems use a bent-axis piston design, enabling high power-to-weight ratios and exceptional efficiency for heavy-duty applications. Variable Displacement Type: Variable displacement HST systems allow adjustments to the pump's displacement, providing precise control over speed and torque, especially in complex applications. Advantages of Hydrostatic Transmission The adoption of hydrostatic transmission brings forth a plethora of benefits, making it a preferred choice for many industries. Superior Efficiency and Energy Savings: HST systems excel in energy efficiency due to their ability to transmit power with minimal energy losses. The on-demand control of fluid flow ensures energy is utilized only when required, resulting in reduced fuel consumption and lower emissions. Precise Speed and Torque Control: One of the most significant advantages of HST lies in its precise motion control capabilities. Operators can smoothly and accurately adjust the speed and torque, allowing for enhanced productivity and maneuverability. Increased Vehicle Maneuverability: Hydrostatic transmission enhances the maneuverability of vehicles and machinery, enabling seamless direction changes and precise operation in tight spaces. This advantage proves invaluable in industries like construction and agriculture, where space constraints are common. Applications of Hydrostatic Transmission HST finds widespread use in various industries, driving progress and efficiency across different sectors. Construction Equipment: In the construction industry, HST is employed in excavators, loaders, and bulldozers, enabling operators to handle heavy loads with precision and ease. Agricultural Machinery: Agricultural equipment such as tractors and harvesters benefit from HST's ability to provide smooth and controlled power delivery, contributing to efficient farming practices. Automotive and Off-Highway Vehicles: In the automotive sector, hydrostatic transmission is utilized in certain specialized vehicles, like forklifts and industrial machinery, to enhance performance and maneuverability. Comparison with Other Transmission Technologies Hydrostatic transmission is often compared to other transmission technologies, each offering unique advantages and disadvantages. Hydrostatic vs. Gear Transmission Unlike gear transmission, which uses mechanical gears to transmit power, HST offers smoother speed control and requires less maintenance, making it suitable for applications requiring variable speed. Hydrostatic vs. Continuously Variable Transmission (CVT) Continuously Variable Transmission (CVT) also provides variable speed control but operates on a different principle. While CVT uses belts and pulleys, HST uses hydraulic fluid for power transmission. Both technologies have their distinct advantages, with CVT being more compact and HST excelling in heavy-duty applications. Hydrostatic vs. Automated Manual Transmission (AMT) Automated Manual Transmission (AMT) combines the convenience of automatic transmission with manual control. In comparison, HST offers seamless and precise motion control, often favored in applications where consistent speed adjustments are vital. FAQs 1. What is the lifespan of an HST system?The lifespan of an HST system depends on several factors, including proper maintenance, operating conditions, and the quality of components. With regular maintenance and care, HST systems can last for thousands of operating hours. 2. How does hydrostatic transmission differ from hydrodynamic transmission?Hydrostatic transmission employs hydraulic fluid to transmit power, providing precise control over motion. On the other hand, hydrodynamic transmission uses a fluid coupling to transfer power, which relies on the momentum of the fluid to transmit torque without precise control over speed. 3. Can I retrofit an existing machine with an HST system?Yes, in many cases, existing machines can be retrofitted with an HST system. However, it requires careful engineering and integration to ensure compatibility with the machine's existing components and to optimize performance. 4. What are the common maintenance mistakes to avoid?One common maintenance mistake is neglecting fluid inspections and replacements. Contaminated or degraded fluid can lead to reduced efficiency and premature wear of components. Regularly cleaning and replacing filters are also crucial to prevent damage from debris and ensure smooth operation. 5. What is a common problem with hydrostatic transmission?A common problem with hydrostatic transmission is fluid leakage, which can occur due to worn seals or damaged components. Addressing leaks promptly is vital to prevent further damage and ensure the system's efficiency. A hydrostatic transmission (HST) is simply a pump and motor connected in a circuit. Other components are added to obtain certain operating features. The four basic configurations of hydrostatic transmissions are : 1. In-line (Fig. 6.10a) 2. U-shape (Fig. 6.10b) 3. S-shape (Fig. 6.10c) 4. Split (Fig. 6.10d) Fact Checked Content Last Updated: 07.12.2023 11 min reading time Content creation process designed by Content cross-checked by Content quality checked by Save Article Save Article Hydrostatic transmission is an integral component of many modern engineering systems, particularly in the field of fluid power technology. It plays a crucial role in the operation of heavy machinery, enabling smooth and efficient control. Let's delve into its world and discover what it is, how it works, and the principles underlying its function. At its core, a hydrostatic transmission is a type of transmission system that uses pressurised hydraulic fluid to power mechanical operations. Unlike traditional mechanical transmissions that employ gears and clutches, hydrostatic transmissions leverage the physics of fluid power to transfer energy and effect motion. Hydrostatic Transmission: A type of transmission system that utilises pressurised hydraulic fluid to transmit power between the source and the load. This system eliminates the need for mechanical gears and clutches, replacing them with hydraulic pumps and motors. Brief Overview of Hydrostatic Transmission A hydrostatic transmission, being a closed-loop system, operates by transmitting power from the engine to the load or the output device through the cyclic flow of hydraulic fluid. The engine drives the hydraulic pump, and the ensuing fluid pressure activates the hydraulic motor, propelling the end-loaded device. For instance, in a bulldozer, the engine activates the hydraulic pump, which then pressurises the hydraulic fluid. The high-pressure fluid triggers the hydraulic motor to drive the tracks, thereby enabling smooth movement and better maneuverability. A hydrostatic transmission comprises several crucial components, each playing a distinct role in its operation. These primarily include a hydraulic pump, hydraulic motor, hydraulic fluid, and a set of control valves. Let's inspect their individual roles and how they collectively constitute the working mechanism of hydrostatic transmission. How does a Hydrostatic Transmission Operate? The operating sequence of hydrostatic transmission begins with the engine transmitting power to the hydraulic pump. The pump, in turn, pressurises the hydraulic fluid, which passes through the control valves. These valves, manipulable by the operator, regulate both the direction and speed of fluid flow, thus determining the trajectory and pace of the output device. In the case of a lawnmower equipped with hydrostatic transmission, the operator can control the speed and direction of the mower's movement by manipulating the valves. The mow height can also be adjusted by regulating the volume of the fluid. Hydrostatic Transmission Principles in Detail The mechanism of hydrostatic transmission hinges on the principle of fluid power, particularly encapsulated by Pascal's law. According to this law, any pressure applied to an incompressible fluid confined in a closed system will transmit evenly in all directions. Pascal's Law: A principle in fluid mechanics which states that any change in pressure exerted at any point in a confined fluid, will be equally transmitted to all other points in the fluid. In the context of hydrostatic transmission, the incompressible fluid is the hydraulic fluid and the closed system the hydraulic circuit comprising the pump, motor and the connecting lines. Mathematically, the pressure P in a hydraulic system is defined by the formula: $$P = \frac{\text{Force (F)}}{\text{Area (A)}}$$ Hence, by regulating the applied force and the operational area, one can seamlessly control the resulting pressure, thereby effectively managing the power transferred between the engine and the load. The extensive application of hydrostatic transmissions in varied fields, from construction and agriculture to manufacturing and mining, testifies to its efficiency and versatility. Its seamless energy transition, precise control, and minimal mechanical wear contribute to improving the overall productivity and longevity of machinery. Any technological system inevitably presents a mix of benefits and potential challenges. Hydrostatic transmissions are no exception. They offer an array of advantages that make them preferable in many applications, but they also come with a set of limitations that may influence their suitability for certain tasks. Hydrostatic transmissions have many favourable characteristics, making them immensely popular in an array of heavy-duty applications. Specific Benefits of Hydrostatic Transmission Let's delve into some of the specific merits of employing hydrostatic transmissions. Smooth Operation: Hydrostatic transmissions are renowned for their smooth and seamless operation. This attribute emerges from the absence of mechanical gears and clutches which typically cause jerkiness in traditional mechanical transmissions. It allows for the smooth acceleration and deceleration of machines. Superb Flexibility: Hydrostatic transmissions provide remarkable flexibility, with capacity to alter speed and direction swiftly, even under heavy loads. This is made possible by control valves that guide the hydraulic fluid, therefore adjusting the speed and direction of the hydraulic motor. Excellent Torque: Hydrostatic transmissions excel in providing high torque at low speeds. This is particularly useful in applications that require the moving of heavy loads at slow speeds, such as in bulldozers or forklifts. Minimal Wear and Tear: Owing to the fluid-based operation, hydrostatic transmissions endure less mechanical wear and tear, reducing the frequency and expense of maintenance. Also, the absence of mechanical gears minimises the chance of breakdowns, enhancing operational reliability. Despite the numerous benefits hydrostatic transmissions provide, their application is not without potential drawbacks and challenges which may influence their suitability for varying contexts. Potential Drawbacks and Limitations of Hydrostatic Transmission Some of the primary limitations of hydrostatic transmissions include: High Initial Costs: Hydrostatic transmissions generally command higher initial costs than comparable mechanical systems. This is due to the precision engineering and high quality components essential for the production of reliable hydrostatic systems. Sensitivity to contamination: The hydraulic fluid used in hydrostatic transmissions is quite sensitive to contamination. The presence of impurities in the fluid can impede the smooth flow and operation of the system, leading to efficiency degradation and mechanical complications. Therefore, regular fluid monitoring and filtration are necessary to maintain system performance and longevity. Limited Efficiency at High Speeds: While hydrostatic transmissions exhibit superior efficiency and torque at low speeds, their performance tends to wane at higher speeds. This is largely because the hydraulic fluid generates more heat at high speeds, leading to energy loss and decreasing transmission efficiency. Complex Maintenance: The maintenance of hydrostatic transmissions can be comparatively complex as they require specialised knowledge of hydraulic systems. This, combined with the need for regular fluid checks and changes, can escalate the overall upkeep costs. Hydrostatic transmissions play crucial roles across numerous real-world applications, from agriculture and construction to mining and manufacturing. Their extraordinary combination of precision, power, and controllability make them a preferred choice, especially for heavy-duty machinery. The applications of hydrostatic transmission are as diverse as they are abundant. They are integral in industries that demand exact control over speed and direction while lifting or moving substantial loads. Hydrostatic transmission systems bring on board extraordinary capabilities which can be harnessed to enhance efficiency in various operations. In the realms of agriculture, hydrostatic transmissions are installed in farming machinery like tractors and combine harvesters. For instance, a tractor employing hydrostatic transmission allows the operator to control the speed precisely while simultaneously managing the tractor's implements. This need for multitasking is particularly pronounced during seeding, where consistent speed is paramount to optimal planting. Equally, in the construction industry, hydrostatic transmissions are essential for ensuring the smooth and efficient operation of heavy machinery like excavators, bulldozers, and backhoe loaders. Here, the advantage of unlimited torque conversion, along with the ability to change direction swiftly, is priceless. This allows these machines to manoeuvre effortlessly around construction sites, even while shouldering hefty loads. Hydrostatic transmissions also find useful applications in lifting devices such as forklifts and cranes. They give these machines the ability to manage incredibly heavy loads while maintaining precise control over speed and movement. Moreover, the variable speed control capability is invaluable during delicate lifting operations, where precision must be matched with safety. Not to forget the paving industry, hydrostatic transmission systems are integral in road equipment like pavers and rollers. Given that a consistent speed is necessary for quality paving, the precision offered by hydrostatic transmissions contributes significantly to the end product's quality. Hydrostatic Transmission Examples in Everyday Engineering You come across applications of hydrostatic transmission in everyday life, often without realising it. From lawnmowers to snowblowers, the examples are abound. Let's examine a few familiar instances where hydrostatic transmissions make a significant difference. Riding lawnmowers are one of the familiar examples of hydrostatic transmissions at work. Here, the hydrostatic transmission system provides smooth maneuverability, allowing the mower to turn in tight circles and easily navigate around obstacles in the lawn. What gives these mowers an edge is the simple control, which lets the operator change direction and speed without needing to shift gears, thereby making mowing an effortless task. Hydrostatic transmissions are also essential in the function of snowblowers. With a hydrostatic transmission in place, it becomes possible to control the speed of the snowblower without having to stop or change gears. Given the heft and intensity of the task at hand, such smoothness of operation and control radically enhances the efficiency of the snow removal process. Another common application is found in smaller construction equipment like mini-diggers and mini-loaders. The smooth operation and simple speed control attributes of hydrostatic transmissions make them well-suited for these machines. Additionally, their robustness, coupled with their ability to provide high torque at low speeds, ensures optimum equipment performance, contributing to the successful completion of construction projects. Thus, from landscape maintenance to construction work and to snow removal, hydrostatic transmissions demonstrate a significant promise through their remarkable operational versatility and controlling precision. By continuing to deliver such consistent performance across applications, these transmission systems undeniably contribute to achieving operational efficiency and productivity enhancement. Hydrostatic Transmission: A type of transmission system that utilises pressurised hydraulic fluid to transmit power between the source and the load, eliminating the need for mechanical gears and clutches. Operating principle of Hydrostatic Transmission: The system works by the engine transmitting power to a hydraulic pump, which pressurises the hydraulic fluid. Control valves then regulate both the direction and speed of fluid flow, determining the trajectory and pace of the output device. Hydrostatic Transmission Principles: The mechanism hinges on Pascal's Law, which states that any change in pressure exerted at any point in a confined fluid will be equally transmitted to all other points in the fluid. Hydrostatic Transmission Advantages: They offer smooth operation, excellent flexibility and torque, and minimal wear and tear due to the absence of mechanical gears and clutches. Hydrostatic Transmission Disadvantages: Despite numerous benefits, they present challenges including higher initial costs, sensitivity to hydraulic fluid contamination, limited efficiency at high speeds, and complex maintenance requirements. Hydrostatic Transmission Examples: Hydrostatic transmissions are widely used in heavy-duty machinery in various industries such as agriculture, construction, lifting devices, and paving industry, as well as in everyday machines like lawnmowers and snowblowers. What is the mechanism behind a hydrostatic transmission in engineering? A hydrostatic transmission operates using the principles of fluid dynamics. Pressure created by a pump forces hydraulic fluid against pistons, generating energy or force. This energy is then used to drive gears, belts, or shafts, delivering variable speed control and direction. How does a hydrostatic transmission contribute to the efficiency of engineering machinery? Hydrostatic transmission enhances the efficiency of engineering machinery by allowing smooth, precise control of speed and torque. It eliminates the need for clutches and reduces mechanical wear. Furthermore, their capability to transmit power in both directions contributes to overall operational efficiency. What are the main components of a hydrostatic transmission in engineering? The main components of a hydrostatic transmission in engineering are the hydraulic pump, hydraulic motor, and the fluid reservoir. Other parts include valves, filters, and hydraulic fluid pipelines. What are the potential issues related to a hydrostatic transmission in engineering machinery? Potential issues with hydrostatic transmissions in engineering machinery include overheating, leaks causing low fluid levels, cavitation from rapid changes in fluid pressure, and mechanical wear and tear from long-term use. What are the steps involved in the maintenance of a hydrostatic transmission in engineering equipment? The maintenance of a hydrostatic transmission involves regular inspection for leaks, checking and maintaining fluid levels, replacing old or degraded transmission fluid, and replacing or repairing any worn or damaged components such as seals and valves. Save Article Access over 700 million learning materials Study more efficiently with flashcards Get better grades with AI Sign up for free Already have an account? Log in   Good job! Keep learning, you are doing great. Don't give up! Next Open in our app At StudySmarter, we have created a learning platform that serves millions of students. Meet the people who work hard to deliver fact based content as well as making sure it is verified. Lily Hulatt is a Digital Content Specialist with over three years of experience in content strategy and curriculum design. She gained her PhD in English Literature from Durham University in 2022, taught in Durham University's English Studies Department, and has contributed to a number of publications. Lily specialises in English Literature, English Language, History, and Philosophy. Get to know Lily Gabriel Freitas is an AI Engineer with a solid experience in software development, machine learning algorithms, and generative AI, including large language models' (LLMs) applications. Graduated in Electrical Engineering at the University of São Paulo, he is currently pursuing an MSc in Computer Engineering at the University of Campinas, specializing in machine learning topics. Gabriel has a strong background in software engineering and has worked on projects involving computer vision, embedded AI, and LLM applications. Get to know Gabriel Vaia is a globally recognized educational technology company, offering a holistic learning platform designed for students of all ages and educational levels. Our platform provides learning support for a wide range of subjects, including STEM, Social Sciences, and Languages and also helps students to successfully master various tests and exams worldwide, such as GCSE, A Level, SAT, ACT, Abitur, and more. We offer an extensive library of learning materials, including interactive flashcards, comprehensive textbook solutions, and detailed explanations. The cutting-edge technology and tools we provide help students create their own learning materials. StudySmarter's content is not only expert-verified but also regularly updated to ensure accuracy and relevance. Learn more Download this article in .PDF formatThe operating principle of hydrostatic transmissions (HSTs) is simple: A pump, connected to the prime mover, generates flow to drive a hydraulic motor, which is connected to the load. If the displacement of the pump and motor are fixed, the HST simply acts as a gearbox to transmit power from the prime mover to the load. Most HSTs, however, use a variable-displacement pump, motor, or both so that speed, torque, or power can be regulated (Fig. 1).Depending on its configuration, the HST can drive a load from full speed in one direction to full speed in the opposite direction, with infinite variation of speed between the two maximums—all with the prime mover operating at its optimum speed.1. Hydrostatic drives pack a lot of power into a small package and allow versatile machine control. The walk-behind compactor shown here uses a dual hydrostatic drive: one to rotate the drum, and one to rotate an eccentric weight, which increases compacting force by nearly 22 kN in addition to the machineâ€™s weight. HSTs offer many important advantages over other forms of power transmission. Depending on its configuration, an HST: transmits high power in a compact size exhibits low inertia operates efficiently over a wide range of torque-to-speed ratios maintains controlled speed (even in reverse) regardless of load, within design limits maintains a preset speed accurately against driving or braking loads can transmit power from a single prime mover to multiple locations, even if position and orientation of the locations changes can remain stalled and undamaged under full load at low power loss does not creep at zero speed provides faster response than mechanical or electromechanical transmissions of comparable rating, and can provide dynamic braking. Either of two types of construction is used for HSTs: integral and non-integral. Non-integral construction is by far the most common, because power can be transmitted to one or more loads in areas that would otherwise be difficult to access. In this technique, the pump is coupled to the prime mover, the motor is coupled to the load, and they the pump and motor are connected through hose and tubing assemblies, Fig. 2.2. This closed hydrostatic transmission consists of a variable-displacement pump and fixed-displacement motor connected through metal tubing and hose. Providing a reservoir between the pump and motor would make this an open-circuit system. Whatever its task, the HST must be designed for an optimum match between the engine and the load. This allows the engine to operate at its most efficient speed and the HST to make adjustments to operating conditions. The better the match is between input and output characteristics, the more efficient the entire power system will be.Ultimately the power system should be designed for a balance between efficiency and productivity. A machine designed for maximum efficiency usually has sluggish response, which robs productivity. Conversely, a machine designed for quick response usually exhibits low efficiency because a high degree of energy must be available at all times to perform work—even when there is no immediate need for work.Four Functional Types of HSTsThe configuration of an HST—whether it has a fixed- or variable displacement pump, motor, or both—determines its performance characteristics. Figure 3 summarizes these configurations and the performance characteristics of each.The simplest form of hydrostatic transmission uses a fixed-displacement pump driving a fixed-displacement motor (Fig. 3a). Although this transmission is inexpensive, its applications are limited, primarily because alternative forms of power transmission are much more energy efficient. Because pump displacement is fixed, the pump must be sized to drive the motor at a fixed speed under full load. When full speed is not required, fluid from the pump outlet passes over the relief valve. This wastes energy in the form of heat.Using a variable-displacement pump instead of one with a fixed displacement creates a constant torque transmission (Fig. 3b). Torque output is constant at any speed because torque depends only on fluid pressure and motor displacement. Increasing or decreasing pump displacement increases or decreases motor speed, respectively, while torque remains fairly constant. Power, therefore, increases with pump displacement.3. Functional hydrostatic transmissions summarized according to types of pumps and motors involved: Fig. a shows HST with fixed-displacement pump and motor; Fig. b has fixed motor and variable-displacement pump; Fig. c has fixed pump and variable-displacement motor, and Fig. d has a variable-displacement pump and motor. Using a variable-displacement motor with a fixed-displacement pump produces a transmission that delivers constant power (Fig. 3c). If flow to the motor is constant, and motor displacement is varied to maintain the product of speed and torque constant, then power delivered is constant. Decreasing motor displacement increases motor speed, but decreases torque—a combination that maintains constant power.The most versatile HST configuration teams a variable-displacement pump with a variable-displacement motor (Fig. 3d). Theoretically, this arrangement provides infinite ratios of torque and speed to power. With the motor at maximum displacement, varying pump output directly varies speed and power output while torque remains constant. Decreasing motor displacement at full pump displacement increases motor speed to its maximum; torque varies inversely with speed, and horsepower remains constant.The curves in Fig. 3d illustrate two ranges of adjustment. In Range 1, motor displacement is fixed at maximum; pump displacement increases from zero to maximum. Torque remains constant as pump displacement increases, but power and speed increase.Range 2 begins when the pump reaches maximum displacement, which is maintained while the motor's displacement decreases. Throughout this range, torque decreases as speed increases, but power remains constant. (Theoretically, motor speed could be increased infinitely, but from a practical standpoint, it is limited by dynamics.)An Application ExampleAssume that a 3,116-lb-in. torque load must be driven at 1,000 rpm with a fixed-displacement HST. Power required is determined from:P = T × N / 63,024Where:P is power in hpT is torque in lb-in., andN is speed in rpm.Therefore,P = 3,116 × 1,000 / 63,024 = 50If we choose a 2,000-psi pump (based on experience for providing a good combination of size, weight, performance, and cost) rated at 50 hp, we then calculate the flow it must deliver:q = 1,714 × P / pWhere:q is flow in gpm, andp is pressure in psi.Therefore,q = 1,714 × 50 / 2,000 = 43 gpmWe then select a hydraulic motor with a displacement of 10 in.3 /rev to deliver 3,116 lb-in. of torque at 2,000 psi—approximately 43 gpm at 1,000 rpm. Figure 3a shows the power/torque/speed characteristics for the pump and motor, assuming the pump operates at constant speed.Pump flow is maximum at this operating speed, and the pump attempts to deliver this quantity of oil to the fixed-displacement hydraulic motor. Load inertia makes it impossible to accelerate instantaneously to full speed, so part of the pump output flows over the relief valve. (Figure 3a also illustrates the power loss during acceleration.) As the motor increases speed, it transmits more of the pump's output, and less oil flows over the relief valve. At rated speed, all oil flows through the motor.Torque is constant because system pressure builds to the relief valve setting immediately after the control valve shifts. Power lost over the relief valve is the difference between the constant power delivered by the pump and the variable power delivered by the motor.4. Critical speed (indicated by point A) in a constant-power HST is the lowest speed at which maximum constant power can be transmitted.The area under this curve represents the power wasted when the transmission starts or stops. It also shows the low efficiency for any operating speed below maximum. A fixed-displacement transmission is not recommended for applications requiring frequent starts and stops, or when less than full load torque occurs frequently.Torque-Speed RatioTheoretically, the maximum power a hydrostatic transmission can transmit is a function of flow and pressure. However, in constant power transmissions with variable output speeds, theoretical power divided by the torque/speed ratio determines actual power output. The greatest constant power that can be transmitted is determined by the lowest output speed at which this constant power must be transmitted.For example, if the minimum speed represented by point A on the power curve in Fig. 4 is half the maximum speed, the torque-to-speed ratio is 2:1. The maximum power that can be transmitted is half the theoretical maximum. At point B, corresponding to output speed A, the torque curve decreases as speed increases. At maximum output speed, it has dropped to point C.At output speeds less than half the maximum, torque remains constant at its maximum value, but power decreases in proportion to speed. The speed at point A is the critical speed and is determined by the dynamics of the HST's components. Below critical speed, power decreases linearly (with constant torque) to zero at zero rpm. Above critical speed, torque decreases as speed increases, which provides constant power.Building a Closed-circuit HSTThe descriptions of closed-circuit hydrostatic transmissions in Fig. 3 concentrate on parametric considerations only. Additional functions must be provided to achieve a practical HST.Pump-end components. Consider, for example, a constant-torque HST—the type used most commonly—with a servo-controlled, variable-displacement pump driving a fixed-displacement motor (Fig. 5a). Because this is a closed-circuit HST, slip flow accumulates in the pump and motor cases and is removed through a case drain line (Fig. 5b). The combined case drains flow to the reservoir through a heat exchanger.One of the most important components in a closed-circuit HST is a charge pump. The charge pump is usually an integral part of the main pump package, but can also be an independent pump gang-mounted with the drive pumps it serves. Whatever the arrangement, the charge pump performs two functions. First, it prevents cavitation of the main pump by replenishing the fluid lost by the closed system through pump and motor slip. It also provides pressurized fluid required by the variable-displacement control mechanism.Referring now to Fig. 5c, low-pressure relief valve A on the discharge side of the charge pump sets control pressure. Although charge pressures vary from one pump manufacturer to another, they typically range between 250 and 300 psi. Back-to-back replenishing check valves B and C supply make-up fluid to the appropriate low-pressure line.Motor-end components. A typical, closed-circuit HST also requires crossover relief valves D and E (Fig. 5d). These usually are integrated into the motor package. Two crossover relief valves are installed to prevent excessive pressure from developing in either supply line due to shock-load feedback through the motor, an overrunning load, or similar conditions. These valves limit pressure in either pressure supply line by routing high-pressure fluid to the low-pressure line. These relief valves perform the same function as a system relief valve in an open circuit. However, they are located at the fluid motor end because this is where overpressures originate in closed-circuit HSTs.In addition to crossover relief valves, shuttle valve F is included. The shuttle valve is always shifted by high-pressure fluid, which connects the low-pressure line to low-pressure relief valve G. Valve G routes excess charge pump flow to the motor case, then through the drain line to the pump case. Fluid then returns to the charge pump reservoir through the heat exchanger.Cavitation ControlThe stiffness of an HST depends on the compressibility of the fluid and the compliance of system components—namely, tubing and hoses. The influence of these components can be compared to the effect a spring-loaded accumulator would have if connected to the supply line through a tee fitting. Under light loads, the effective accumulator spring compresses slightly; under heavy loads, the accumulator undergoes substantial compression, and there is more fluid in the accumulator. This additional fluid volume must be supplied by the charge pump.5. Displayed is the progression of constant-power HST circuits, from a bare pump and motor to an assembly with basic accessories. The critical factor is the rate of pressure rise in the system. If pressure rises too rapidly, the rate of volume increase on the supply side (compressibility flow) may exceed the flow capacity of the charge pump, and the main pump may cavitate. Perhaps circuits powered by variable-displacement pumps with automatic controls pose the most serious threat of danger. When such a system cavitates, pressure drops or disappears altogether. The automatic controls can attempt to respond, resulting in an unstable system.Mathematically, the rate of pressure rise can be expressed as:dp/dt = Be Qcp/ VWhere:Be is effective bulk modulus of the system, psiV is volume of fluid on pressure side in in.3, andQcp is charge pump output in in.3/sec.Another Application ExampleAssume that the HST of Fig. 5 is connected with 2 ft of 1½-in. ID steel tubing. Neglecting the volumes of pump and motor, V is about 30 in.3 For oil in steel tubing, effective bulk modulus is roughly 200,000 psi. Assuming the charge pump delivers 6 gpm (28 in.3 /sec), then the rate of pressure rise is:dp/dt = 200,000 × 28 / 30   = 187,000 psi/sec.Now consider the effect of plumbing the system with 20 ft of 1½-in. ID, three-wire braided hose. The hose manufacturer would have to provide the volumetric expansion coefficient in in.3/1,000-psi to enable calculating the effective bulk modulus. Assume, for this example, that Be is about 84,000 psi.Then:dp/dt = 84,000 × 28 / 294.5 = 7,986 psi/secIncreasing the output of the charge pump would be the most effective way to prevent the tendency of such a system to cavitate. Alternately, if changes in the external load are not continuous, an accumulator can be added to the charge circuit. In fact, some HST manufacturers provide a port for connecting an accumulator to the charge circuit.If the stiffness of the HST is low, and it is equipped with automatic controls, the HST should be started with pump displacement at zero. In addition, acceleration of the displacement mechanism should be limited to prevent jerky starts, which, in turn, could generate excessive pressure surges. Some HST manufacturers provide damping orifices in the stroking circuit for this very purpose.This discussion demonstrates the multi-faceted role of the charge pump system in a closed-circuit HST. Therefore, system stiffness and control of the rate of pressure rise may be the primary considerations for determining charge pump delivery, rather than simply internal leakage of the pump and motors.Looking for parts? Go to SourceESB.Download this article in .PDF format A hydrostatic transmission is desirable because it causes no disruption in engine power. For all those who are wondering what is a hydrostatic transmission and how does it work, WheelZine has the answers for you. We tell you about you the benefits and drawbacks of a hydrostatic transmission, along with several other related aspects. Did You Know? The Honda DN-01 motorcycle is the first consumer road vehicle that used a hydrostatic transmission. Most modern vehicles work using an internal combustion engine. These engines produce rotational motion, but the vehicle has to move in a linear fashion. This is made possible by the vehicle's transmission, which 'transmits' the power generated by the engine to the axle of the vehicle, making the wheels turn. IC engines have the limitation that they cannot operate below a specific rate, so this creates a problem while stopping or slowing down the vehicle. The transmission also performs this task of modifying the engine speed, by engaging and disengaging gears of different levels. Transmission can be either manual, where the driver himself has to change gears, or automatic, when the vehicle itself does this task. The changing of gears, either manually or automatically, creates disruptions in the power transmission of the vehicle. This means that the engine power reduces momentarily when gears are being changed. This problem can be solved by using a continuous variable transmission (CVT), also called a gearless transmission. The most famous type of CVT is the hydrostatic transmission, which finds application not only in heavy equipment, like forklifts, agricultural tractors, and industrial machinery, but also in vehicles, riding mowers, and even tanks. What is Hydrostatic Transmission? When the power generated by an engine is transferred to the wheels by using pressurized fluid rather than with a drive belt or gears, then such a transmission system is called a hydrostatic transmission. In this, an IC engine drives a hydraulic pump which delivers pressurized fluid to a motor that is responsible for movement of the wheels. How Does Hydrostatic Transmission Work? A hydrostatic transmission uses the power from a prime mover, such as the crankshaft of an internal combustion engine, to operate a hydrostatic pump motor. So, the rotary motion from the engine is used to pressurize fluid, which is then directed towards a hydrostatic drive motor. To accommodate the pressurized fluid, the pistons of the drive motor have to start moving, thus creating a rotational motion which turns the wheels. The fluid used is generally oil. The pressure and amount of fluid sent to the drive motor dictates the speed at which the wheels move. This is controlled by a swashplate, which is operated by a hand lever on the equipment. When the swashplate is vertical, no fluid is sent to the motor, and it is not operated. When the swashplate is rotated forwards by 15º, the vehicle begins moving in the forward direction. When the swashplate is rotated backwards when the vehicle is in motion, it has a slowing effect. When rotated backward by 7º on a stationary vehicle, it is put into reverse transmission, by directing the fluid in the backward direction. The hydrostatic transmission is a closed-loop circuit, where the fluid exiting from the drive motor outlet is returned to the hydrostatic pump without being sent to the tank. In this circuit, the input drive is the hydrostatic pump connected to the prime mover, and the output drive is the drive motor which is connected to the load. Types Based on Design Close-coupled The hydraulic pump, drive motor, and other components are all enclosed in a common housing, with the motor and the pump sharing a common valve. This enclosed assembly is then bolted to an axle. This type is compact and ideal for applications with space constraints, besides being economical. Split In this type, the hydraulic pump and motor are placed in separate locations, but are interconnected by high-pressure hoses or pipes. Being more powerful, it is used in industrial applications where the required space is available. Based on Performance Fixed-displacement Pump with Fixed-displacement Motor This type involves either a variable prime mover or flow-control valves, which help control the speed. Since the pump has a fixed displacement, it has to be of the appropriate size to be able to turn the motor. The output torque (turning force) or speed may differ from that of the prime mover, depending on what the individual displacements of the motor and pump are. Reversibility is possible only if the prime mover can be reversed. Variable-displacement Pump with Fixed-displacement Motor This arrangement helps deliver a constant torque, because torque depends solely on motor displacement. Increasing the capacity of the pump will increase the speed and power. It is highly popular as a general-purpose drive, which offers a wide variety of speeds, along with an ease of control. Fixed-displacement Pump with Variable-displacement Motor A fixed-displacement pump helps maintain constant power, while the speed and torque can be changed by varying the motor displacement. Lowering the motor displacement will increase the speed, and increasing it will produce more torque. Variable-displacement Pump with Variable-displacement Motor This is the most versatile arrangement, which allows for a variety of torque and speed to power ratios. While the power and speed can be modified by altering the pump displacement, torque depends on the motor displacement. Despite being efficient and flexible, it has a higher cost. Advantages ● There is no need to apply the clutch and gears, and hence, no disruption in transmission. ● A preset, controlled speed is possible in both directions, independent from the load being carried. ● There are many number of speeds, in both, the forward and reverse directions. ● A single lever can be used to control the speed and direction. ● Very little maintenance is required, other than regular oil and filter replacements. ● Hydrostatic transmission can be used to operate power steering or dynamic brakes. ● A single prime mover can be used to transfer power to various locations. ● This transmission has a lower response time when compared to gear transmissions. ● Since it does not involve an engaging gear system, power loss due to friction is minimized. ● A variety of torque or power to speed ratios are possible. ● Since the speed and power depends on the pressurized fluid, the IC engine can be left operating at its most efficient RPM, greatly reducing fuel costs. Disadvantages ● This system is more expensive than the traditional transmission system, with the fluid being especially costly. ● The efficiency of a hydrostatic transmission is slightly lower, at around 80 – 85%, as compared to the 93 – 95% of a mechanical transmission. ● The high torque generated may cause the problem of wheel-spinning on soft surfaces. ● It cannot be towed, like conventional vehicles, as this may damage the seals in the pump by creating a back pressure. This is because the drive motor turns with the wheels, but the pump does not. It's obvious that the advantages of a hydrostatic transmission far outnumber its problems. This is why it is regarded as an excellent means of power transmission, especially when a variable output speed is required.