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A Review Study on Pantograph Mechanism Using Ansys

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Abstract- The four-bar mechanism is crucial in the study of machine theory. The pantograph is an example of a four-bar device. In most cases, it's only the parallelogram that's utilized to duplicate the profile. A pantograph is a basic but effective instrument for expanding the realm of art and craft. With a pantograph, we may replicate pictures to a smaller or larger size depending on how the pieces are measured and constructed. The pantograph seen in the drawing would duplicate the original. We "create, develop, and study the portable pantograph for engraving letters on wood" in this subject. Our pantograph is compact and easy to transport. The major task of this pantograph is also copying with the various scales of the characters. When compared to a traditional pantograph, this machine is less expensive. It may be an ancient mechanism, but it still has a lot of potential. It has a wide range of applications nowadays.

Keywords- Pantograph, catenary system, Ansys, 3d model.

I. INTRODUCTION

The pantograph is one of the most exciting pieces of engineering equipment to have ever been produced, and it should be included in the inventory of every engineering shop in some form or another. In addition to engraving writing in two dimensions, more modern versions can function in three dimensions and can copy complicated three-dimensional patterns and engineering components, scaling them up or down depending on the situation.

A pantograph is a simple but useful tool for broadening the scope of artistic expression and craftsmanship. With a pantograph, can enlarge or decrease the size of images depending on how the elements are measured and put together. With the lengths between its pivot points serving as the "technique" for creating your final copy, the pantograph takes care of the math involved in calculating image scaling.

The pantograph would create a reproduction of the picture that was smaller than the original in the illustration. Your pantograph may be adjusted to provide a different percentage of enlargements depending on how far apart the pivot points are spaced.

High-speed rail networks are becoming more crucial in the development of global transportation policy, according to the World Economic Forum. Several reasons have contributed to this, including rising oil prices and a desire to minimise CO2 emissions. For example, trains will travel more quickly, with improved safety and comfort conditions, and with lower life cycle costs, boosting the competitiveness and attractiveness of railway networks, among other things. Furthermore, railway businesses are looking for cost-cutting options across the board, regardless of the industry in which they operate. They focussed on the costs of maintaining railway carriages, as well as the aggressiveness of rolling stock toward infrastructure, among other things. With the increasing importance placed on interoperability, there has been a surge in the need for systems that can manage the interface of different pantographs with current and future catenary systems.

While high-speed trains are not as efficient as other modes of transportation, they can compete with air travel over short and medium distances, with the additional bonus of being more environmentally friendly and having reduced pollution. Railways continue to be the most cost-effective means of long-distance freight transportation, and they are starting to establish a competitive edge in the passenger transit industry.

The collection of energy by the pantograph on the catenary is a critical component of the safe and reliable functioning of electric railway vehicles, which are currently the most cost-effective, environmentally friendly, and safe means of transportation on the market today.

Because of the limited capability of the catenary-pantograph interface to supply the required amount of energy to run the engines, high-speed trains are constrained in their ability to travel at their maximum speed [1] while utilizing the interface. It is important to note that the loss of contact not only causes an interruption in the energy supply, but it also causes arcing between the pantograph's collector bow and catenary's contact wire as depicted in Figure 1, resulting in the functional states of the two systems degrading at the same time, as illustrated in Figure 1.

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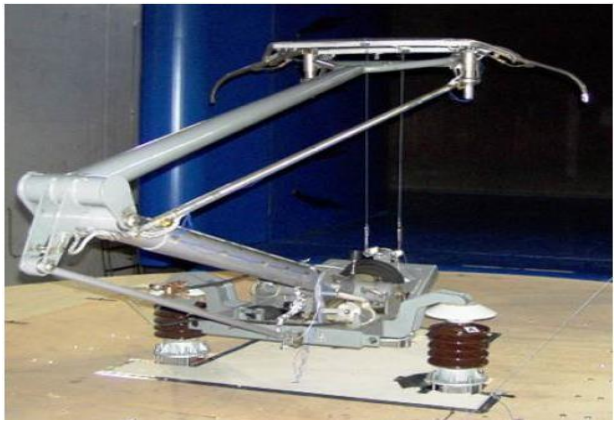

Fig 1. French CX pantograph. [2]

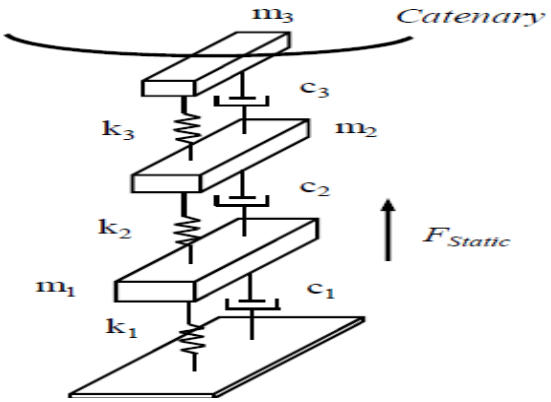

Fig 2. Pantograph Lumped mass model. [1]

Therefore, increasing the average contact force and decreasing the contact loss would result in increased wear on the catenary contact wire and pantograph collector strip, as well as increased efficiency in terms of energy collection capacity by reducing contact loss. Achieving a balance between the force characteristics of the contact and the contact wear generated by energy-collecting system components may help to enhance the quality of the contact. It is only via management of the catenary-pantograph contact force that it can sustain longer maintenance cycles and increased system dependability while simultaneously maintaining system reliability and availability.

Catenaries, pantographs, and carriages all need to be adjusted to allow greater train speeds on tracks that were originally designed to accommodate slower train speeds. The faster wave propagation speed allows for greater operating speeds to be attained on the same line due to the faster wave propagation speed. Increased tension is done by decreasing the weight of the wire per unit distance while keeping the length the same as before.

1. Pantographand Catenary system:

Pantograph-Catenary systems, as opposed to rigid catenaries and shoe collectors, are used in high-speed trains for a number of reasons, including human safety and cost, and are more cost-effective. The interaction between the pantograph collector strip and the catenary contact wire is created by the contact between these two systems, with the purpose of generating a stable electric connection between the two systems. The catenary is a metal structure with a tensioned cable that is suspended above the train at a certain height. It is responsible for giving energy to the railway's electric motor via a mechanical device known as the pantograph, which is located above the train. Currently in use, the most majority of pantographs were created specifically for the catenary in which they were meant to be used, resulting in national pantograph-catenary pairs such as CXLN2 in France or ATR95-C270 in Italy, which are the pantographs researched in this study.

When the pantograph is in operation, a pneumatic actuator oversees adjusting the height of the pantograph and, as a consequence, managing the average contact force. Increasing the contact force causes excessive wear to occur in the carbon strips at the head of the mechanism and in the catenary, while decreasing it causes contact loss, which causes interruption of the train's electric supply, discharges, and electrical erosion, resulting in damage to both the collector bow and the catenary [13]. 5

As specified by the EN 50367 [14] standard, it is acknowledged that great contact results in longer maintenance cycles. The standard also specifies a set of guidelines for maintaining high contact quality. A catenary is a metal structure in which a wire system is loaded with electricity at voltages more than 1000 volts alternating current and 1500 volts direct current (AC and DC). The contact wire, as well as the other wires in the wire system, works to lessen the vertical curvature that is generated by gravity. Masts provide structural support for the whole wire system. Under the limits of physical and economic restraints, the catenary system is tensioned by weights at the ends of each span in order to manage the axial tension of the contact and messenger wires, which is ultimately related to the maximum operating velocity of the train in the system. When the operational speed of a railway reaches 200 km/h, the railway is categorized as high speed.

The capacity of a railway vehicle to supply the requisite amount of electrical energy via the pantograph-catenary interface restricts the maximum speed that it can go at any one time. Two aspects that affect train velocity are the catenary characteristics of the rails and the interaction of many pantographs [15]. Because of the passage of the pantograph, an elastic wave is created, and the speed of the wave determines the maximum permitted train travel speed. Normally, it is defined by the tensile force applied to the contact wire, as well as the mass per unit length of the contact wire itself.

$$C = \sqrt{\frac{\pi^2 EI}{\rho L^2} + \frac{F}{\rho}} \quad \text{.....1.1}$$

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When F is the contact wire tension, EI is the beam young modulus multiplied by the bending stiffness, M is the contact wire mass per length unit, and L is the beam length, F is the contact wire tension, and L is the beam length. When a train reaches this velocity, it is difficult to maintain contact with the rails. As a result, the maximum speed of a train is determined by regulations to be 70 percent of the elastic wave travelling speed, which is calculated using equation 1. (1.1).

In general, a pantograph system must be able to perform the following movements: after rising from a seated posture, adjusting one's height to the appropriate level for the present scenario Furthermore, it deals with low frequencies of 1-2 Hz as well as high frequencies of up to 12 Hz when travelling between 250 and 300 km/h, which are created by the pantograph that runs underneath the droppers and registration arms for the catenary periodic design and is capable of handling speeds between 250 and 300 km/h. Higher frequencies may also be produced by unanticipated occurrences or the roughness of the wire itself. Although the lowest frequency is usually associated with the mechanics of the bottom frame, the pantograph head is often responsible for all other frequencies.

Improvements to the pantograph system that attempt to increase contact quality are, unsurprisingly, of considerable interest. Deterioration of contact quality may result in significant increases in maintenance expenses, which might be prohibitively expensive. Furthermore, technological advancements in railway systems have increased operational speeds throughout the world, with catenary characteristics dictating the maximum allowable running speed, making the pantograph-catenary system a critical component in meeting those criteria and ensuring that the system operates safely. On the other hand, the current crop of pantographs has a restricted future growth potential. Ambrósio et al. [19] determined that the largest possible improvement was 10-15% by changing just elements near the top of the pantograph, such as weight.

2. Interaction between pantograph and catenary:

During the journey from the power source, the pantograph-catenary system is in charge of transmitting energy from the power source to the locomotive. In order to properly transmit electric power, the contact pair must stay in motion during the transfer. It is necessary to maintain a tight and steady contact between the pantograph and the catenary in order to do this.

The effectiveness with which the pantograph and the catenary interact has a direct impact on the quality of energy transmission as well as the cost of maintenance and upkeep on a yearly basis. In part because the dynamic behaviour of a system is dictated by the designs of the system's structures, which are described in the following sections, the following sections will cover some common designs, fundamental vibration theory, and some techniques for testing and assessing the dynamic interaction of the system.

Essentially a cross between a trolley pole and a bow collector, the pantograph enables energy to be collected safely and reliably at relatively high speeds while still maintaining safety and dependability. It is mounted on the top of a locomotive or vehicle body and has the capability of being lifted and lowered automatically. Also included is a foldable main frame that is capable of vertically elevating the pantograph head a significant distance in order to collect current and avoid interfering with non-electric trains travelling underneath the overhead wires. The construction of a pantograph is seen in Figure 1.2.

The current collection is excellent due to the fact that the pantograph head is spring-loaded and pushed against the overhead cable. In order to keep the overhead line and pantograph head in touch when the system is raised or lowered, the drive, which is generally driven by compressed air from the vehicle's braking system, must generate a sufficient lifting force to guarantee that they remain in contact. Even though there are many different types of pantographs accessible today, the principles of the art remain unchanged. If your pantograph is equipped with an electric load, you may want to consider using a collector strip, which is a conductor that is linked to the pan-head and pushes against the contact wire to prevent wear on the catenary and other moving parts. The most common kind of material found in it is graphite, which is a carbon compound.

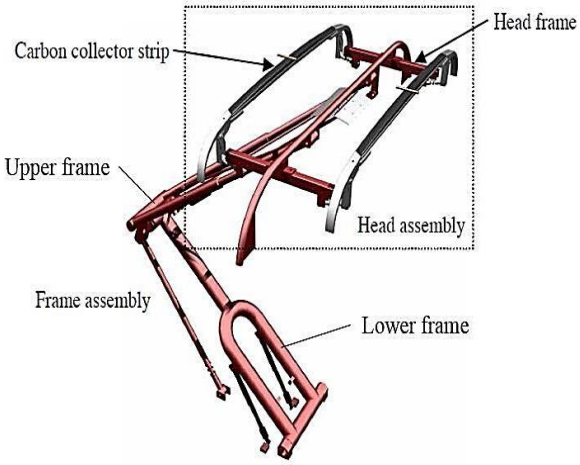

Fig 3. Schunk WBL88 pantograph [15].

In its most basic form, the catenary is made up of the contact wire, which is a continuous conductor that delivers electric current to a moving train via a pantograph or similar mechanism, and a few extra supports that support the contact wire's weight and keep it in a precise shape at specific locations. The construction of the catenary is seen in Figure 1.2. In the railway industry, catenary is commonly utilized because it enables trains to operate at greater voltages than the standard AC

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1000V and DC 1500V, allowing them to travel at faster speeds.

II. RELATED WORKS

Because of its constraints on the railway and the surrounding environment, pantograph arcing has lately sparked a great deal of attention in the scientific community. Some of the pantograph arcing research that has been conducted in the area is summarized here, along with how it pertains to the current project's goals.

Pantograph-Catenary systems, rather than rigid catenaries and shoe collectors, are utilized in high-speed trains for a variety of reasons, including human safety and cost. Because of the contact that exists between the pantograph collector strip and the catenary contact wire, it is feasible for these two systems to communicate with one another. This mechanical component, which provides energy to the train's electric motor, is driven by a tensioned cable that is connected to a catenary that is suspended above the train at a specified height above the rails. Pantographs that is special to catenaries account for the vast majority of those in use, resulting in pantograph-catenary couples being found across the nation.

As a result, a pneumatic actuator is responsible for adjusting the height of the pantograph and, as a result, for managing the average contact force. High contact pressures harm the carbon strips at the mechanism's head and the catenary, while low contact forces create contact loss, which causes the train's electric supply to be disrupted and, because of electrical erosion, causes damage to the collector bow and the catenary [3, 4]. [4]

The movement of stiff or flexible structures in relation to a fixed catenary is controlled by springs, dampers, or actuators in pantographs, which are mechanical precision systems that harvest electrical energy by harvesting the movement of stiff or flexible structures.

1. Pantograph Systems:
The catenary contact wire is mechanically connected to its contact strips, which are raised to catenary height by a pneumatically controlled mechanism on the train's top, to gather electrical energy. No matter what size or form they take, pantographs follow the same basic principles. Contact loss or excessive force in the wire must not occur during its operation. The system must be dynamically responsive to the frequencies it is triggered with in order to adapt to the catenary height change when travelling through tunnels, ducts, or other specialized areas, as well as to prevent excessive wear or lack of touch.

2. The Pantograph-Catenary interaction:
From the loaded catenary system, as seen in Figure 2.1, to the locomotive engines and other train equipment, the roof pantographs transfer the electrical energy that powers the motors of high-speed trains. When the catenary and pantograph systems are compatible, it must be possible to ensure that the contact is always maintained and that the contact force is always within a predefined range.

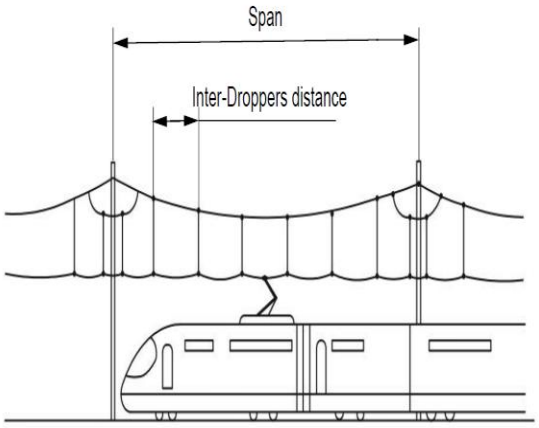

Fig 4. Catenary system overhead and passing train. [8]

As shown in figure 4, vertical droppers are used to hold a contact wire in the messenger wire, which are spaced consistently along the catenary. To maintain the contact wire in place, it is tied to masts that have articulations for the stable arms, which keep it aligned with the railroad's catenary, which is visible from above as a zig-zag form. All in all, the pantograph movement actively stimulates the catenary, which is characterized by a periodic structural pattern.

3. Mechanical Components of Pantographs:
In a standard pantograph, there are normally two four-bar-linkage systems, with one four-bar linkage system for rising and folding, as indicated in Figure 5. (a). As seen in Figure 2.2 (b), for the electrical circuit to be completed, two points on each of the two contact strips must be in contact with the catenary at the same time. The second four-bar linkage is responsible for the forward placement of the collector bow as well as the horizontal movement of the collector bow.

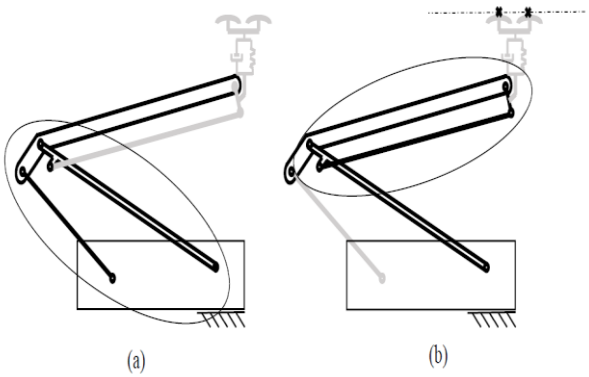

Fig 5. Lifting and repositioning the pantograph in relation to the contact wire using a double-four-bar linkage system [8]

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Jiangwen Wang, et. al.(2021) A multibody dynamics theory based on relative coordinates is utilised to explain the dynamic behaviour of the pantograph and the standard deviation (STD) of dynamic contact force is employed as an indicator to assess contact quality in the study of the two tension wires of the catenary. With a view to assisting with pantograph structural design and parameter optimization in high-speed rail systems, this research will examine how changes to a pantograph's primary structure affect contact quality.

Shimanovskyet. al. (2016) The dynamic loads at the pantograph-wire interface were investigated by the researchers using the MSC.ADAMS computer programme. To determine the time-dependent contact force between a pantograph and the wire that it is linked to, calculations were performed. It was decided to investigate the stress-strain condition of the coal insert in accordance with the simulation findings. The contact interaction between a pantograph and a catenary wire was determined by the Ansys programme, which used a finite element analysis to do so. The model was constructed from of wire, coal, and a steel liner, among other materials. According to the calculations, there is a relationship between the stress levels in corners and the graphite crumbling in rectangular cross sections.

Jenny Jerrelindet. al. (2012) It's being investigated whether or not it's possible to use a typical railway overhead power system to provide energy to long-distance road transporters in a new setting. There is evidence to suggest that the investigated disturbances have an effect on the dynamics of the truck-pantograph-catenary system, although contact force variations are well within the permitted range according to the technical standards for interoperability (TSI).

Many feel that an overhead power system is a realistic solution for trucks and buses on particular road sections that need more environmentally friendly electricity. Pantograph-catenary systems may be tailored to specific road sections, taking into account vehicle dynamics, road imperfections, and practical solutions for crossings, bridges, tunnels, and other impediments, as well as the specific road segment in question. The pace at which the pantograph and catenary will be used is also an important factor; although they were designed for high-speed trains, trucks and buses often operate at speeds of less than 100 kilometres per hour. Consequently, low-cost pantograph and catenary systems for use on electric roads are now feasible to design.

Jia Yang et. al. (2021) According to the findings of this investigation, a high-speed inspection vehicle travelling at 378 kilometres per hour on China's superhighway network is equipped with an instrumented pantograph. ANCF and multibody dynamics are used to build a pantograph-catenary numerical model. It is compared to the numerical simulation and field test by comparing contact force and dynamic lift. A multibody dynamics model is used to simulate the pantograph's motion.. On the high-speed railway between Chengdu and Chongqing, an inspection vehicle equipped with an instrumented pantograph travels at a speed of 378 kilometres per hour. According to numerical modelling and field testing, the present pantograph-catenary model can provide reliable numerical results at 378 km/h. According to computer simulations at 378 km/h, the trailing pantograph fails to fulfil the requirements for assessment. Double-pantogram interval and messenger wire tension may be adjusted to increase the performance of trailing pantographs.

Tripathi Utkarsh et. al. (2018) The Pantograph Engraving Machine (PEM) is a precision and exact cutting machine that can cut wood, plastic, and mild steel plates into any form. The pantograph engraving machine is able to work because it is supported by four bar mechanisms, one of which is fixed. The movement of the tracing link is matched by the movement of the other connections. This is an excellent purchase at an affordable price. In order to construct a model of the Pantograph engraving machine using commercially accessible components, it is intended to employ CAD tools such as AutoCAD, Pro-e, and other similar programmes. The construction of the components was careful. Performance of the machine would be adversely affected if the components produced by the machine lacked precision and accuracy, resulting in a poor surface quality.

Deshmukh et al (2012) It is possible to address and fix the joints since compliant joints have less backlash and may be used with the PZT to obtain sub micron precision. Lubrication difficulties may be rectified fast and simply due to the one-piece construction. Compliant mechanisms may be a viable alternative to standard position systems in the development of Micro factories, which need just a small number of components to function. For linear positioning systems [4, 7], the pseudo rigid body model (PRBM) must be used in conjunction with the pantograph [4, 7]. The researchers employed FEM, ANSYS, and ADAMS tools to analyse the disease's processes over the course of the study. These programmes may be used to analyse the flexure-based mechanism in both static and dynamic modes, depending on the application. The ANSYS Workbench module may also be used to determine the fatigue life of a system. Simulation may be used to acquire information on the deformation and stress assessments in critical zones. Technology such as laser machining and electro-discharge machining (EDM) should be researched for use in the manufacturing of compliant mechanisms, as opposed to conventional machining methods.

Barpate et al (2016) The portable pantograph for wood engraving was created, produced, and tested. Engraving machines are created using a pantograph mechanism. To

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ensure accurate engraving, the engraving tool on the pantograph should track the stylus's movement. An item may be traced with a stylus. A manipulator, sometimes known as a copying machine capable of mass production, may be used to manufacture a low-cost replica of the object. The model of pantograph engraving machine is light, portable, and easy to use for both beginners and experts. Compared to more difficult equipment. so that there are no manufacturing concerns, they developed a safe mechanism for the engraving machine.

John Morris et. al. (2021) Examined prior work and considered the idea of utilising a new strategy to duplicate the behaviour to improve on it. It is determined if brief neutral parts have the potential to improve their performance in the context of the United Kingdom. The interaction between the pantograph and the overhead contact line (OCL) was dynamically simulated using a proprietary finite element analysis programme. Physical characteristics and laboratory test results were utilized to create the neutral component of a proven pantograph/ OCL simulation model, which was then used to develop the active portion. Test data has been used to validate the findings of the neutral section simulation, which has been completed. Using this method, the performance of the neutral section was studied to determine its susceptibility to diverse structural elements.

The effects of parameter modifications were investigated to evaluate whether they would be beneficial in the near run. One of these modifications was the installation of a lever arm to the rear end of the neutral portion. According to the findings of this work, an unique pantograph/OCL dynamic simulation may be used to correctly analyse the characteristics of neutral sections.

Paweł Zdziebkoet. al. (2017) A co-simulation technique is used to investigate the interaction between a catenary and a pantograph. Assume that data transmission between pantograph models and catenary models is implemented in the proposed co-simulation way with the help of a multi-domain technique; the pantograph and the catenary are investigated. The contact between the pantograph's slider and dropper is taken into account in a nonlinear finite element catenary model, whilst the pantograph's multibody model takes into account friction forces as well as suspension springs. In order to account for the impacts of wind on the pantograph's aerodynamic forces during dynamic modelling, the fluid structure interaction approach was used to the pantograph. The interaction between the pantograph and the catenary was investigated in connection to the electromagnetic force operating on the pantograph, as well as vertical vibrations and tilt of the locomotive.

Zhenfeng Wu et. al. (2020) It was discovered that computational fluid dynamics software may be used to calculate the aerodynamic drag on pantograph fairings of various structures and pantographs. In this examination, three pantograph fairings are utilised as research subjects, each of which has a different function. Using air flow, surface pressure, and aerodynamic drag as metrics in a flow field, it was discovered that the ellipsoid pantograph fairing, followed closely by the guiding surface, has superior aerodynamic drag performance, but the double arch has the poorest.

The ellipsoidal pantograph fairing has the lowest total aerodynamic drag, followed by the guiding surface, and finally the double arch. With this pantograph fairing, aerodynamic drag was decreased by 56.7 percent when compared to the double arch pantograph shielding at speeds ranging from 0 to 300 kilometres per hour.

O. A. Sidorovet. al. (2016) The three most frequent forms of pantograph models are a reduced mass model, a rod model, and a computer-aided design (CAD) model. It is the goal of this research project to investigate methods of selecting a dynamic pantograph model for use in high-speed electric transportation systems. Experiments have been carried out at a catenary-contact section, and contact pressure measurements as well as estimations based on computational methodologies have been collected.

As a consequence of the inquiry, a plan was designed to accomplish the goal. It gives the option of selecting a dynamic pantograph model for use in pantograph and catenary interaction modelling applications. It is necessary and advantageous to use a model with lower mass to optimize the catenary section. A rod model or a CAD-system model must also be utilized to optimize the pantograph's parameters, in addition to the above.

Dongli Song et. al. (2016) Researchers looked to the contact surface of a pantograph–catenary system to see how well it worked. As a result of gravity and other factors, there is a periodic component to contact wire irregularity and also a random component owing to wear and other reasons. Most of the time, periodic and low-frequency random anomalies increase the contact force's amplitude at sites where the peak wavelengths are less than the tension length, span, or dropper spacing.

System dynamic performance deterioration is mostly caused by high-frequency random irregularity, which has an influence on the amplitude of all frequencies. The larger the shape parameter's absolute value, the worse the dynamic performance.

Using the contact force eigenvalues criterion, they can determine the frequency-dependent contact wire irregularity amplitude and the contact strip shape parameter A's threshold value. Information and intelligent high-speed train health management systems can inspect components and decide if maintenance is required using the threshold suggested in this research.

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Yang Song et. al. (2021) Aspects of the pantograph-catenary system of the Chengdu-Chongqing passenger special railway is the subject of this investigation. The catenary model is constructed using the ANCF software, and the correctness of the numerical findings is validated against field measurement data taken from a 378 km/h inspection vehicle during the construction phase. The pantograph-catenary system is constructed using a customised spatial grid for the stochastic wind field that is based on the empirical spectrum of the wind field. Even in the face of crosswinds up to 20 m/s, the pantograph-catenary technology used by the passenger special railway functions successfully and efficiently.

When the crosswind speed is more than 30 m/s, the turbulence severity increases by more than 17 percent. A few pieces of information about contact force are in violation of the safety requirement. As long as the crosswind speed does not exceed 30 m/s, the contact wire will always function within the safe working range of the pantograph head, which is a very important consideration. Certain safety issues arise when the pantograph head is lifted to its maximum lift with turbulence intensity higher than 21 percent, as shown by the following.

Wenping Chu et. al. (2020) A mathematical model of the pantograph head and the contact wire reattachment momentum effect is presented in this study in order to more correctly characterize the contact loss operation utilizing simulation tools in the future. The notion of momentum preservation is used during the reattachment process to ensure that momentum is retained. A range of numerical simulations are performed to study the effects of the reattachment effect on the contact wire height and the contact force on the contact wire height.

Because of the reconnection of the contact wire and pantograph head velocities, the velocities of the two components quickly increase, resulting in an increase in contact force. When the reattachment effect is taken into consideration, both the maximum contact force and the standard deviation increase considerably. The intensity of the reattachment impact increases in direct proportion to the mass and stiffness of the pantograph.

Jianpu Wang et. al. (2021) The major factors influencing the lateral offset and rotation angle of a high-speed pantograph are being investigated in this study. In order to compare and contrast outcomes before and after optimization, they compare and contrast the results after and before optimization. To complete the process of creating the pantograph from perfect data, Solidworks is required.

To determining the correctness of optimization findings, the pantograph model entered the finite element analysis tool generates a displacement cloud diagram of the bow head, which is used to validate the accuracy of the results. The ideal structural characteristics of a pantograph may be determined via optimization and comparison, and these qualities can then be used as a reference for subsequent design work.

An advanced finite element static analysis is performed on the optimized design to guarantee that the end product is as resilient as possible. Angle of the balancing arm about the bow's head must be no more than 3 degrees and no larger than 30 mm in each direction.

Yongming Yao et. al. (2020) explained in detail the construction of a sophisticated model to analyse in depth the dynamics of ice on PAC systems Pantograph simulations are carried out with the help of a lumped-mass model, while catenary simulations are carried out with the help of a fan-shaped wire. The icing problem with the PAC system may be traced back to several variables, including the adoption of more uniform loads and the application of combinatorial material icing techniques. Each of the three simulation approaches is investigated and compared with the others. However, even at the faster speeds shown by the three techniques, the current collection quality between the pantograph and the catenary is mostly unaffected by the thickness of the ice.

In this instance, it is evident that simulating ice coating is effective. Using the combinatorial approach, it is possible to get an accurate estimate of catenary icing. According to research, the speed of the train influences the quality of the current PAC collection. Because of increased train speeds and growing ice thickness, the present collection quality of the PAC system is being negatively impacted.

III. INTRODUCTION OF ANSYS

It is one of the most widely used computer-aided engineering software packages, ANSYS, which does finite element analysis (FEA) (CAE). In order to simulate structural, machine component, and system behaviour, engineers can use ANSYS software to create computer models of the structures, machine components, and systems. This allows them to apply operational loads and other design requirements to the models, as well as study physical responses such as stress levels, temperature distributions, and pressure distributions.

It lowers the requirement to construct and demolish many prototypes in order to test a concept. In addition to ordinary things such as dishwashers, kitchen utensils, and automobiles, the ANSYS design analysis tool may be used to analyse more difficult systems such as nuclear reactor containment structures and bridges, as well as X-ray equipment and orbiting satellites. It is possible to use ANSYS to portray two-dimensional situations by using nodes with six nodes, four nodes, and eight nodes, as well as polygons with six nodes.

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1. Static Analysis:
It's used to determine displacements, stresses, and other characteristics under static loading conditions. ANSYS can perform both linear and nonlinear static analyses. In the context of engineering, nonlinearities include plasticity (stress stiffening), deflection (high strain), hyper elasticity (contact surfaces), and creep.

1.1 Transient Dynamic Analysis - This approach is used to determine the response of a structure to arbitrary time-varying loads. Static Analysis allows all nonlinearities listed there.

1.2 Buckling Analysis - In this function, the buckling loads are calculated, and the buckling mode is determined. There are both linear and nonlinear forms of buckling assessment that may be used.

Two-dimensional components provide a variety of analysis choices:

- Plane Stress
- Plane Strain, andPlane Stress with Thickness.

Plane Stress is the default analysis option, and it examines a single-thickness component as the default. When the thickness of a unit thickness is unknown, the stress, strain, and deflection distributions for that unit thickness may be utilized to derive the thickness for a design challenge.

Hundreds of measurements are taken to determine the displacements of structures and materials to minimize inertia or damping. Under response conditions, it is anticipated that the loading would remain stable. Domestic inertial forces, as well as external forces and loads, imposed (nonzero) movement speed, and temperatures, may all be used, as can other parameters (for thermal stress). It is possible to do a static linear or a non-static analysis. No, linear static analysis does not go unnoticed in our current research.

IV. CONCLUSION

Although the Pantograph is an antique device, it nevertheless has many useful applications today. Pantograph is a parallelogram connection used in paper engraving on materials such as wood. Unlike other difficult engraving machines, our kind of Pantograph engraving machine is light, portable, and simple to manage for inexperienced people.

Contact wire irregularity has a periodic component due to gravity and other causes, as well as a random component due to wear and other factors. Periodic and low-frequency random anomalies, for the most part, enhance the amplitude of the contact force at points where the peak wavelengths are smaller than the tension length, span, or dropper spacing. High-frequency random irregularity, which affects the amplitude of all frequencies, is the most common cause of system dynamic performance degradation.

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