

Prediction of Shear Stresses and Critical Speed of Composite Flywheel: A Review

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Abstract— A rotating disc often undergoes severe vibrations at high speeds because of unstable joining between the disc and the drive shaft. The analysis has presented the effect of shear Stress with different profiles of the flywheel with different layered (0.5mm, 1mm) and different Hub angle (4°, 5°, 0°). The natural frequency and modes of different materials and shear stress effects were analyzed on different profile and materials of flywheel and distribution along the flywheel was studied. The natural frequency along the flywheel profile is found to be maximum of the 4° hub angle of T300 material profile with 1mm multi rim flywheel. The shear stress distribution along the multi rim flywheel is maximum for T300-EPOXY non layer and minimum for T300-EPOXY 1mm layered of a flywheel with different profiles. The magnitude of frequency is maximum in the case of T300 material profile with 4° hub angle. The nature of the natural frequency is maximum near its end in 1st 2nd and 3rd mode. The nature of the shear stress is minimum near its hub of flywheel with 1mm multi rim of T300-EPOXY and 4° inclined hub angle.

Key words: Fly Wheel, Shear Stress, Hub Angle, Composites

I. INTRODUCTION

A Flywheel is a machine element which is used to increase a momentum of rotating element and to control fluctuations which are induced on rotating element like shafts turbines etc. It also conserves energy for continuous rotation; Flywheel also reduces vibration on rotating element. It also acts as a damper.

A Flywheel is a rotating mechanical gadget used to store kinetic energy. Flywheels were in use for pretty a variety of capabilities for the period of human historic beyond for good sized portions of years. In the start they had been used as a way to furnish balance, corresponding to a potter's wheel. During the monetary Revolution, they had been mainly incorporated in steam engines. However, it was as soon as not except the overdue Sixties/early Nineteen Seventies, with the advent of composite substances and an elevated hobby in renewable power assets, that study into the capabilities for flywheels as a possible alternative to chemical batteries was carried out. The production of magnetic bearings in the Eighties moreover exacerbated curiosity and research. Flywheels can also be separated into lessons: traditional and high-performance (wonderful flywheels). Conventional flywheels are constructed from widespread materials, maximum in all likelihood metallic, even as first-rate flywheels are composed of composite substances. The praise work includes assessment on each styles of flywheels, however with the number one middle of interest positioned on conventional flywheels. A common flywheel is tested in Fig. 1-1. Flywheels were proposed as an opportunity or complement to average chemical batteries at some stage in

diverse areas. These include mobile purposes, such because the car and aerospace company, or vigour law in electrical strength generating plants.

A. Energy Storage

With the growing demand for oil worldwide and dwindling non-renewable assets, curiosity in vigor storage has had an uptick in recent a long time. The current world vigour storage capacity is 90GW from a whole creation of 3400 GW (i.e. Handiest 2.6% of total electrical vigour in the world is in a position of being stored) [1]. Energy storage devices upload balance and reliability to electrical grids. This in turn improves efficiency and reduces consumption of property. Instabilities in electric grids are delivered on with the useful resource of load variants due to various factors, much like fluctuating input masses from renewable assets (wind and sun), frequency deviations, and discrepancies among top and average electrical electricity call for. The quite lots of methods of electricity storage include mechanical, electro-chemical, thermal, electro-magnetic, and chemical programs. Each of those wonderful techniques is used depending on efficiency, value/discharge cost, discharge time, garage capability, cycling capacity, self-discharge, environmental erects, and charges. Depending on their software program, the programs may be divided into 4 classes [2]:

- Low-power application in isolated areas, essentially to feed transducers and emergency terminals.
- Medium-power application in isolated areas (individual electrical systems, town supply).
- Network connection application with peak leveling.
- Power-quality control applications.

II. FLYWHEEL FUNCTIONS

The flywheel provides the engine side face for the clutch to bite into, but its main job is to store kinetic energy. It's kind of like when you spin a bicycle wheel in mid-air and it free wheels for a while. That's the wheel storing the energy you put into it and releasing it as it slows down due to things like friction.

It helps keep the engine running by way of preserving crankshaft momentum between combustion strokes however most significantly, it performs a main component in how a vehicle drives.

A heavier flywheel will dull engine reaction, but will help a car maintain momentum up hills or even as towing. It also makes it less difficult to take off from a stand nevertheless and it has the mass to get the car rolling smoothly whilst the snatch is disengaged.

Lighter flywheels can enhance engine reaction and acceleration because of their decrease rotating inertia. For years they had been visible as liberating free horsepower and

have been suited for the whole thing from rather strung 4 cylinders to huge cube eights.

III. TYPES OF FLYWHEEL

A. Single Mass Flywheels

Most factory standard flywheels are usually made from cast steel, Heavy however difficult wearing and durable. The maximum not unusual type of mild weight flywheels are made from chrome moly or aluminium with bolt in friction plates. Chrome moly is right, the aluminium ones can motive a few troubles in the event that they aren't effectively geared up, but they still have their place in certain applications.

B. Dual Mass Flywheels

They were designed purely for reducing noise, vibration and harshness. They paintings further to the sprung centre clutch disc in that they use springs to hose down driveline surprise and harmonics. They are not honestly appropriate for performance applications as they may be a whole lot heavier than a conventional flywheel and are prone to failure under heavy use or extreme heat

IV. COMPOSITES

Composite is a fabric which is combo from exclusive factor. There unit lots of blended object around you. Cement possibly a mixture. It can be great from concrete, rock, and sand, and generally has steel poles inside to enhance it. These sparkly inflatable you get throughout the medication middle as soon as you are worn out square measure stunning from a combo, which includes of a polyester sheet an Al thwart sheet, made right into a sandwich. The compound combination fabricated from polymers, or from polymers next to fully unexpected form of substances. In any case, specifically the fiber-strengthened mixture rectangular measure materials within that a fiber extremely good from one material is inserted in a further fabric.

A Composite material (T300, T1000G, EPOXY, POM) is a material made from two or more constituent materials with different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites.

Composites are made up of individual materials referred to as constituent materials. There are two most important categories of constituent substances: matrix (binder) and reinforcement. At least one component of every kind is required. The matrix cloth surrounds and supports the reinforcement substances by way of maintaining their relative positions. The reinforcements impart their special mechanical and bodily houses to decorate the matrix residences. A synergism produces cloth residences unavailable from the person constituent substances, even as the extensive style of matrix and strengthening materials lets in the fashion designer of the product or shape to select an superior mixture. Composite substances must be fashioned to shape. The matrix

fabric can be added to the reinforcement earlier than or after the reinforcement cloth is located into the mildew hollow space or onto the mold surface. The matrix material experiences a melding event, after which the part shape is essentially set. Depending upon the nature of the matrix material, this melding event can occur in various ways such as chemical polymerization for a thermoset polymer matrix, or solidification from the melted state for a thermoplastic polymer matrix composite.

A variety of moulding methods can be used according to the end-item design requirements. The predominant factors impacting the methodology are the natures of the chosen matrix and reinforcement substances. Another essential component is the gross amount of fabric to be produced. Large portions may be used to justify high capital expenses for speedy and automated manufacturing era. Small production portions are accommodated with decrease capital costs however higher labour and tooling expenses at a correspondingly slower charge. Many commercially produced composites use a polymer matrix cloth regularly known as a resin answer. There are many one-of-a-kind polymers to be had relying upon the starting raw components. There are several large categories, each with numerous variations. The most commonplace are called polyester, vinyl ester, epoxy, phenolic, polyimide, polyamide, polypropylene, PEEK, and others. The reinforcement materials are regularly fibres however additionally usually floor minerals. The numerous techniques defined under had been advanced to lessen the resin content of the very last product, or the fibre content material is extended. As a rule of thumb, lay up outcomes in a product containing 60% resin and 40% fibre, whereas vacuum infusion gives a final product with 40% resin and 60% fiber content material. The strength of the product is greatly dependent on this ratio.

V. NON-ROTATING DYNAMICS

Expect that our computing tool should not be turning, that the headings have really no damping, that the orientations have degree with spiral firmness in the course of the vertical and flat headings. Empower U.S. Besides assume that there square degree 3 renditions of this computing device, one every with gentle, center of the street and agency direction. Through both research and a modular test, we might see a gaggle of ordinary frequencies/modes. At each recurrence, the motion is two-dimensional. This conduct is the element that we would count on from a static charter

VI. LITERATURE REVIEW

Jung et.al (2016) [1] - the investigation flywheel manufacturing blunders outcome in car-to-automobile variations within the measurements and have a terrible impact on the misfire detection efficiency. A misfire detection algorithm need to be in a position to make amends for this form of automobile-to-car variants if it is for use in creation cars to assure that legislations are fulfilled. It's shown that flywheel angular editions between autos within the magnitude of zero.05° have a colossal influence on the measured angular speed and ought to be compensated for to make the misfire detection algorithm effective. A misfire detection algorithm is proposed with flywheel error

adaptation as a way to increase robustness and shrink the number of mis-classifications.

Lyu et.al (2016) [2]-this investigation to give a economic and powerful stage for the investigation of AMB bolstered vitality stockpiling flywheels, including research on the define of their criticism controllers, we propose in this paper to repeat the operation of such flywheels on a rotor-AMB scan fix we as of late developed. In detailed, the two AMBs founded at the two finishes of the rotor are utilized as aiding course, while the opposite two established on the rotor mid traverse and quarter traverse are utilized to copy the generator terrible firmness and gyroscopic impacts on the rotor flow brought on with the aid of the flywheel circle. Copy and scan outcome are introduced to illustrate the adequacy of the proposed copying approach.

Rupp et.al. (2016) [3] - the investigation demonstrates the introduction of flywheel energy storage systems in a gentle rail transit teach is analyzed. Mathematical items of the teach, driving cycle and flywheel vigor storage procedure are developed. These models are used to be trained the vigor consumption and the operating rate of a mild rail transit coach with and without flywheel vigor storage.

Caprioli et.al (2016) [4] - the investigation demonstrates Thermal cracking of railway wheel treads is investigated making use of a combined experimental and numerical strategy. Results from managed brake rig tests of repeated discontinue braking cycles for a railway wheel in rolling contact with also called rail wheel are presented. Scan conditions are then numerically analyzed using finite aspect (FE) simulations that account for the thermo-mechanical loading of the wheel tread. For the studied discontinue braking case, thermal cracks are observed in the wheel tread after few brake cycles. Results from thermal imaging expose a frictionally excited thermo-elastic instability phenomenon referred to as "banding" the place the contact between brake block and wheel happens only over a fraction of the block width.

Ryabov et.al. (2015) [5] - this investigation demonstrates the article is getting to know the vibration isolation properties of a flywheel dynamical absorber of the automobile body oscillations. It's noted that the authors have beforehand proposed further flywheel dynamical absorbers with mechanical drives and it's proved that they have accelerated the vibration isolation houses of the suspension approach. However, such dynamical absorbers are heavy. For this reason there may be being developed a flywheel dynamical absorber with hydraulic force containing a hydraulic cylinder and a hydraulic laptop with a flywheel.

Kirilov et.al. (2015) [6] - this investigation disturb relate measure pivot symmetric bendy rotor worked up by dissipative, moderate and non-preservationist factor powers began on the contact with the aeolotropic stator loop. The Campbell graph of the unruffled framework would be a work like structure inside the frequency-pace aircraft with twofold physicist frequencies at the hubs.

Wei et.al. (2015) [7] -This investigation demonstrates the micro vibrations generated by means of flywheels walking at full pace onboard excessive precision spacecrafts will have an impact on stability of the spacecraft bus and further degrade pointing accuracy of the payload. A passive vibration isolation platform created from multi-phase

zigzag beams is proposed to isolate disturbances of the flywheel. With the aid of for the reason that the flywheel and the platform as an indispensable process with gyroscopic effects, an an identical dynamic mannequin is developed and validated via eigenvalue and frequency response evaluation. The imperative speeds of the method are deduced and expressed as services of process parameters.

Ramli et.al. (2015) [8] -this investigation demonstrates The analysis inquisitive about the have an effect on of making use of flywheel on vigour generation, vigor price, and internet reward price for distinct configurations of hybrid method. Analyses on gasoline consumption and carbon emission mark downs for the procedure configurations had been additionally offered on this paper.

Hiroshima et.al. (2015) [9] - this investigation suggests A rotating disk almost always undergoes extreme vibration at excessive rotation speeds considering of unstable joining between the disk and a pressure shaft. As described herein, three connection approaches between a using shaft and an annular rotation disk fabricated from three-dimensionally carbon-fiber reinforced composite were discussed to attain steady rotation at high rotation speeds by using changing the hub material and becoming a member of geometry: the connecting device. In two of the three methods, the vibration amplitude elevated at a tip speed better than 500 m/s. Key reasons that brought on the vibration had been analyzed.

Nagabhushan et.al. (2014) [10] - the investigation shows the dynamics of the three-flywheel method are developed and elaborate simulations are carried out to affirm the validity of the process. The performances of the proposed three-flywheel procedure and an equivalent single flywheel system are in comparison. The influence of single/multiple flywheel failure in the three flywheel method is investigated. An indicative design of the three-flywheel system and different implementation features are discussed to proof its practicality. The advantage develops in the mass, and energy consumption of the three-flywheel process is mentioned utilizing a power and mass evaluation centered on the indicative design.

Quan track et.al. (2014) [11] -The investigation exhibit that this new DMF can decrease the idle velocity of the engine, realize excessive counter torque at a enormous torsional angle, and preclude the impact because of the abrupt changes of stiffness. An inertia steadiness mechanism is proposed to get rid of the inertia forces produced by relocating materials of the compensation device, which will successfully put the torque compensation concept into engineering follow.

LI et.al. (2013)[12] -it used to be investigated that to strengthen the radial force of power storage flywheel, this paper design and analyses the multi-ring flywheel rotor in one-of-a-kind conditions with the aid of finite element method. From the results, we can verify that interference is critical have an effect on the stress gradient of the rim. The results can furnish a guide for prime vigor density multi-ring composite flywheel rotor design.

Punde et.al. (2013) - In present research, to counter the requirement of smoothing out the big oscillations in speed all through a cycle of a I.C. Engine, a flywheel is designed, and analyzed. By means of the use of Finite detail analysis are used to calculate the stresses within the flywheel, we will

evaluate the layout and evaluation end result with present flywheel.

Choudhary et.al. (2013) - This examine totally specializes in exploring the consequences of flywheel geometry on its energy storage/supply capability according to unit mass, in addition defined as unique strength. On this paper we have studied numerous profiles of flywheel and the saved kinetic power is calculated for the respective flywheel. Various profiles designed are solid disk, disk rim, webbed/section cut, arm/spoke flywheel. It indicates that smart layout of flywheel geometry could both have a big impact at the precise power overall performance and decrease the operational hundreds exerted at the shaft/bearings due to decreased mass at high rotational speeds. Green flywheel design used to maximize the inertia of moment for minimal material used and assure high reliability and long life. FE evaluation is accomplished for distinctive cases of loading on the flywheel and maximum vonmises stresses and total deformation are decided.

Handa.et.al. [2012][13] - the investigation on this paper was once a sequence of full-scale experiments had been implemented to clarify the influence of residual stress and tangential drive on tread thermal cracking. The wheel/rail tangential force and the localized tensile residual stress caused by localized heating, alternatively than wheel weight, mostly have an impact on the thermal cracking.

VII. STRESS CONCENTRATION

Whenever a machine component changes the shape of its cross-section, the simple stress distribution no longer holds good and the neighborhood of the discontinuity is different. This irregularity in the stress distribution caused by abrupt changes of form is called stress concentration. It occurs for all kinds of stress in the presence of fillets, notches, holes, keyways, splines, surface roughness or scratches etc. Consider a member with different cross-section under a tensile load, A little consideration will show that the nominal stress in the right and left hand sides will be uniform but in the region where the cross-section is changing, a re-distribution of the force within the member must take place. The material near the edges is stressed considerably higher than the average value. The maximum stress occurs at some point on the fillet and is directed parallel to the boundary at that point. The theoretical or form stress concentration factor is defined as the ratio of the maximum stress in a member (at a notch or a fillet) to the nominal stress at the same section based upon net area. Mathematically, theoretical or form stress concentration factor,

$$K_t = \frac{\text{Maximum stress}}{\text{Nominal stress}}$$

The value of K_t depends upon the material and geometry of the part.

In static loading, strain concentration in ductile materials isn't always so severe as in brittle substances, because in ductile materials neighborhood deformation or yielding takes location which reduces the concentration. In brittle materials, cracks may also appear at those neighborhood concentrations of strain to be able to growth the pressure over the rest of the phase. It is, consequently, necessary that the designing part of brittle material inclusive of castings, care ought to be taken. In order to keep away from failure because of strain concentration, fillets on the change of segment must be supplied. In cyclic loading, strain

awareness in ductile materials is always serious due to the fact the ductility of the cloth isn't powerful in relieving the awareness of pressure as a result of cracks, flaws, surface roughness, or any sharp discontinuity within the geometrical form of the member. If the stress at any point in a member is above the endurance restriction of the material, a crack may develop beneath the action of repeated load and the crack will lead to failure of the member.

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