DOWNLOAD PDF MOTORCYCLE CHASSIS DESIGN

Chapter 1 : Motorcycle Frame Plans

Motochassis is for those interested in motorcycle handling and chassis. Articles and illustrations on motorcycles and racing in general. It is the prime source for the book "Motorcycle Handling and Chassis Design" by Tony Foale and software packages for motorcycle suspension setup and analysis.

It also provides a protected space for the occupant s. Chassis Types There are multiple types of chassis but all of them can be classified into one of two approaches: Use lengths of round or square tubing, or other structural metal shapes to form the chassis structure Space frame, multi-tube, ladder frame Use joined panels to form the chassis structure Monocoque, Unibody Both approaches can provide a structure capable of mounting other vehicle components, but each has its own advantages and disadvantages. Spaceframe Chassis The Spaceframe chassis uses numerous cut and shaped pieces of structural metal tubing usually steel joined together to form a strong framework. The principle of spaceframe design is to use triangulation of the tubes to create a rigid structure. Diagrams SF2 and SF3 below show how triangulation is used to rigidize a structure: An untriangulated box One missing its sides is easily warped. An un-triangulated box has very little strength. You can see this in action above. As the hand pushes against the corner of the box, the shape warps into a parallelogram. Now, if we cross-brace or triangulate the box with a tube, the strength is greatly increased: A box with a cross-member forms two triangles Shown in red and is said to be triangulated. The force applied to the box is trying to pull the cross-member apart. In diagram SF3 above, the tube is being pulled in tension as if the corners of the box to where it is attached were trying to tear it apart. However the ideal design always has the member tubes working in tension which provides far superior strength to tubes working in compression. Diagram SF4 below shows how the load being applied is now attempting to crush or compress the tube instead of tearing it apart. Because of the reduced strength in compression, buckling can become an issue. The force applied to the box compresses the cross-member, potentially buckling it if the force is sufficient.. Returning to diagram SF1, there are numerous examples in this diagram of how open box tube structures have been triangulated to create a much more rigid chassis. The diagram also shows suspension and other mounting brackets. Spaceframes usually use square or round tubing. Square tube is easier to work with because cutting it involves straight cuts at a particular angle. Round tubing does not butt up against other round tubes well, and therefore requires a special tube notcher to cut round shapes into it. The key aspect of spaceframe design is to identify and analyze the loads that are to be expected, and design the frame and triangulation to handle those loads in an optimized fashion. As tubing in tension provides higher strength than compression, a lighter gauge tubing may be used in tension loaded areas to save weight. In areas where tubing sees compression loads, a heavier gauge or larger diameter tubing may be better to use. Monocoque Chassis The monocoque chassis is technically an improvement over the spaceframe chassis. Diagram MC1 below shows a simple example of the difference between spaceframe and monocoque design. Comparing the behavior of a monocoque versus a spaceframe under tension load. When the hand pushes against it in the direction shown by the green arrow, it creates a shear force across the panel. This force is effectively handled the same way a tension load is by the spaceframe triangulated box on the right. However, if the hand were to push from the other side of the box, the spaceframe tube could potentially collapse in compression, whereas the monocoque box would behave the same way it did before. See diagram MC2 below: Comparing the behavior of a monocoque versus a spaceframe under compression load. Note the superior tension load handling of the monocoque and inferior compression load handling of the spaceframe. Both types of chassis can be made just as strong as each other. However, to make an equivalent strength spaceframe generally requires more material and therefore more weight. The materials used make a big difference as well. Rear of spaceframe not shown to keep diagram clarity. Although the monocoque can usually be made lighter and stronger than a spaceframe , it does have some downsides that make it more complicated to design, build and operate. Incomplete load handling by a monocoque will cause it to deform and buckle. Where an opening exists, the chassis must handle loads through a supporting sub-structure. A primary goal in monocoque design is to ensure that there are no unhandled load paths that can cause the monocoque structure to buckle. A buckled monocoque is no better than a buckled spaceframe tube. In the case of poorly handled load paths, the spaceframe can be more forgiving as the tubing diameter and steel material usually provide a more gradual failure than a monocoque. However, it is better to design the chassis correctly in the first place then to rely upon noticing gradual failures. This brings us to another key point about the monocoqueâ€”If it is damaged, it is difficult to repair compared to spaceframe tubes. It is also difficult to detect damage on a monocoque whereas bent or broken tubing is quite easy to spot. Torsional Rigidity Torsional rigidity is a property of every vehicle chassis that determines how much twist the chassis will experience when loads are applied through the wheels and suspension. Diagram TR1 below shows the principle. The less the chassis twists, the more torsionally rigid it is considered. If the chassis twists when a tire hits a bump, it acts like part of the suspension, meaning that tuning the suspension is difficult or impossible. Ideally, the chassis should be ultra-rigid, and the suspension compliant. One end of the chassis front or rear is held stationary and the other end is balanced on a point and twist is applied via a beam. Diagram TR2 below shows the basic idea: Method to measure torsional rigidity. Identifying the correct parts of the chassis structure to cut or modify is critical. Consider using scale models of the vehicle if plastic models were made , to mockup the changes, or 3D modeling software to do the same. If the changes involve the suspension, such as lowering the vehicle, model the new suspension first. Sometimes lowering the vehicle while using the same suspension pickup points will create poor handling. Build Chassis Models Modeling a spaceframe chassis with balsa wood sticks enables you to see firsthand the differences triangulation makes to the stiffness of a chassis. Likewise, using cardboard, paper and glue to build model monocoques can be a very rewarding and low cost learning experience as well. Load paths are defined as the forces resulting from accelerating and decelerating, in the longitudinal and lateral directions which follow the tubing from member to member. The first forces which come to mind are suspension mounts, but things like the battery and driver place stresses on the spaceframe structure. Maximize CG placement and vehicle balance Center of gravity affects the car like a pendulum. The ideal place for the CG is absolutely between the front and rear wheels and the left and right wheels. Placing the CG fore or aft or left or right of this point means that weight transfers unevenly depending on which way the car is turning, and whether it is accelerating or decelerating. The further from this ideal point, the more one end of the car acts like a pendulum, and the more difficult it is to optimize handling. The CG is also height dependant. Placing an engine higher off the ground raises the CG, and forces larger amounts of weight to transfer when cornering, accelerating, or decelerating. The goal of vehicle design is to keep all four wheels planted if possible to maximize grip, so placing all parts in the car at their lowest possible location will help lower the CG height.

Chapter 2 : Motorcycle Chassis | HowStuffWorks

"Motorcycle Chassis Design - the Theory and Practice" by Foale and Willoughby is a disappointment. The later book is much better and more complete and is titled "Motorcyle Handling and Chassis Design - The Art and Science", by Tony Foale.

Rake and Trail Rake is a term used to describe the angular relationship between the bikes steering stem and an imaginary vertical line dropped down from the centerline of the frame neck to the ground. A cycle with zero degrees of rake has a stem that is perpendicular to the ground or in other words straight up and down. If the force is coming from directly overhead the wheel simply wants to revolve around a pinpoint spot on the ground directly below the force being applied and it will just spin around about its vertical axis getting nowhere as seen in Figure 2. If the force is lessened however or the angle of attack becomes steeper the wheel will have a tendency to start revolving about its true vertical axis since the force of gravity acting downward will eventually overcome the angular forces as illustrated in Figure 2. As the motive force is reduced gravity will eventually take over and you end up trying to balance the wheel assembly on a pinpoint spot directly below the tire contact patch. The opposite also holds true and as the speed increases the angle of force also increases as it overcomes gravity regardless of the steering stem angle. At extremely high speeds, like you might see at the Salt Flats for instance, this angle can become almost parallel to the road surface and the wheel becomes very unstable. To overcome this phenomena all motorcycles, and bicycles for that matter, have built in a mechanism to keep the forces applied to the front wheel at an angle of attack that provides relatively good low speed maneuverability while providing high-speed stability. This mechanism is called the steering stem rake angle. The illustration on the left represents a fairly typical stock steering head situation while the one on the right represents a more radical design usually found on the more extreme chopper frames. Almost all stock motor driven cycles have a steering stem rake angle of somewhere between twenty-four and thirty-five degrees measured relative to an imaginary line perfectly perpendicular to the ground. Modified bikes, bobbers and choppers on the other hand can push this angle another five to ten degrees and some extreme choppers have fifty degree rake angles. Since this guidebook is about chopped bikes however we need to say right off the bat that raking the steering head beyond stock angles is done purely for the sake of appearances except for drag bikes which are intended to go in only one direction to begin with. How much you give up depends on how cool you want to look. The following illustrations depict a single frame with four different degrees of rake angle to visually show how much impact neck rake has on the overall profile of any given bike. In descending order the bitmaps show 30, 35, 40 and degree rake angles applied to the very same frame. The more or less stock bike with a rake angle of 30 degrees can turn around at low speed within a circle having a five foot radius but on the extreme opposite end of the spectrum the bike having the 45 degree rake angle needs another six feet of room to make a degree turn. Trail is expressed as the distance measured horizontally along the ground level between a point that lies directly beneath the wheels axle and an imaginary line extended through, and at the same angle as the steering stem as shown in the hypothetical geometry of Figure 2. If we leave everything else stock and simply rake the neck out to about forty degrees and add some extended forks to keep the frame level the trail distance increases to 9-inches as seen in Figure 2. Most authorities agree that the ideal situation is to keep trail somewhere between 2. There are many bikes out there with trail measurements over five inches that still handle reasonably well at all speeds and conversely there are bikes out there with little or no trail that also handle well. One noted Springer designer sets his front-ends up for nearly zero trail and they handle superbly. These trees are typically available with 3, 5 and 7 degrees of rake and are intended to be used exclusively on modified frames that have neck rake angles in the range of 37 degrees and greater. Remember we described earlier that trail was a dynamic attribute and as speed increased trail became more visibly effective and as speed was reduce trail had less effect on the behavior of the wheel and forks. As you turn the front end of a two-wheeled vehicle more and more in one direction or another the wheel and fork combination will try to reach a point where their center of gravity seeks equilibrium. The point being that you should set your fork stops at some arbitrary position that is well ahead of the bikes Flop Point.

Generally bikes with hydraulic forks have the stops set at degrees on either side and bikes with Springers or Girders have the stops set at degrees. The entire theory of rake and trail geometry when its applied to real bikes and not just mathematical calculation is complicated to say the least and the vast majority of data available to the designer and builder is largely empirical but that data does suggest that one can alter trail fairly significantly before the effects of a change are noticeable to the rider. For example an increase or decrease of up to 1. For example changing the neck rake from 30 to 35 degrees only changes trail by slightly over 1-inch on the average Big Twin. Going from 30 to 40 degrees changes trail by 3. Offset On the cheapest and simplest ways to alter trail on motorcycles is to use triple trees with different offset dimensions. Fork offset is the distance measured between the steering neck centerline axis and the axis of the fork tubes as shown in Figure 2. In the examples above we have used one way to calculate trail but there is another way as well. Use whichever method is easiest for your particular application. Reducing trail will not reduce the turning radius of a Chopper and conversely increasing trail will not increase the turning radius. The turning radius of any bike is a function of the wheelbase. Handling characteristics involve hundreds of variables as we mentioned earlier and the trail value is but one of those factors.

Chapter 3 : Custom Chopper and Motorcycle Frames

Mr. Foale's book is a hugely practical treatise on the subject of motorcycle chassis design-- and the only worthwhile one I know of other than some very technical SAE papers from the 's on modeling and simulation of motorcycle handling.

Who does what around here? Chris McCormick is our lathe operator, frame prep guy and fabricator. Michael Daugherty welds and does custom-fabbed oil tanks. Sean White is our CNC mill and lathe operator. I own the place, and I make most of the frames and manage the CNC. Everyone in the building can pretty much do everything. Where did you pick up the confidence to own and operate a full-service specialty fab shop at such a comparably young age? I have been working at many fab shops most of my life. Before I opened Chassis Design Co. I built safes, race trucks, roof racks, race cars and other stuff. I worked at Daytec for four years, then started making parts and frames for other guys with a buddy named Jeff Delise. Eventually I got into making my own parts because it seemed less stressful than making complete bikes. As we grew I started making tools to make building frames and other mass-produced parts easier. When business grew, we bought a Hass VF-3 mill and took classes to operate it properly. In school I learned master CAM X5 design and programming so we could offer a complete range of billet trees, risers, hand controls, kickstands, grips, pegs and other parts. How many frames did you make last year? Can you break the numbers into "pro" and "garage builders? When it comes to riding I try to hit Sturgis every year by motorcycle. In Chris and I rode 4, miles in nine days. Thanks again for letting us snoop around your shop. Phil Day and Terry Marino. Also, please let CC readers know where they can go to check out our stuff.

Chapter 4 : Motorcycle Chassis Design and Modification

Motorcycle Handling and Chassis Design the art and science Tony Foale. Foreword The motorcycle is a complex system that has long defied full analysis. For a very.

The frame The purpose of the frame, aside from the obvious utility considerations, is firmly to join and align these elements: Frame members that do not fulfill this essential function are ancillary and need not be overly rigid. A classic example of a more or less direct load path is the Colin Seeley frame and its variants, a Norton is shown here. Notice the straight line from the steering head to the swing-arm pivot tube; click the picture for a larger view. If not, use it. If so, add material where convenient and cost-effective until it stops. Since then, another critical benchmark has been interposed: Strength is frequently not the test, but rigidity stiffness. The forces exerted on these parts is far greater than anticipated by Turner, Page, etc. This higher standard includes frames, swing-arms, fork clamps, fork tubes, axles, cranks, head, cylinder and crankcase castings. Most of these do not have enough stiffness to prevent compliance yielding its designed shape to applied force , and benefit from added bracing, methods of applying load over a larger area, etc. There is no specific guide to detect inherent weakness in a frame design, but in general any street frame built before needs work, excluding Featherbed types used entirely for pleasure. How to determine where existing areas need improvement: Such an easy lesson, and took 50 years to learn. Also stronger if properly triangulated - any bend at all is going to bend again when stressed, whereas a triangle can only flex out of plane unless the weld breaks. Look at a Buell, Moto Guzzi, Ducati etc. Since this is not linear nor controllable, it modifies wheel motion reacting to the suspension, and causes irregular handling. A more rigid chassis has another benefit: The easiest way to add stiffness in terms of engineering is also the hardest to actually construct. The stiffness not the strength of a tube of fixed length depends on these factors, in descending order: The difficult part is leaving room for the go-bits and the pilot, have it weigh as little as possible, and cost even less. Thin wall also invites vibration fracture, and easy penetration by an intersecting tube or other component. Shape Round or elliptical tube is not the only choice. Square or rectangular tube can be used with the obvious fitting difficulties and cosmetic disadvantages. For the same nominal size round tube OD vs. This is due to its diagonal width being greater than its lateral width by about Since the relative size of this axis proportionate to the original dimension is known, the increase in stiffness can be calculated from the relationship without knowing the specific dimension. There is a weight difference: The stiffness to weight ratio of the square tube is higher. In some frames the width across the chassis is limited, but the depth height is not, and a square or better a rectangle with its long axis vertical with the same lateral width as the same size round tube will add stiffness here. A tube with an asymmetrical cross-section such as an ellipse or rectangle is stiffer through its long axis roughly proportionate to the ratio of the axes, so proper orientation is needed to align this axis with the anticipated bending force to achieve full benefit. To calculate the stiffness in this plane, use the longer side of a rectangle or the major axis of an ellipse. Click here to see compare tubes of the same wall thickness but different OD for a huge change in stiffness but almost no weight penalty: Once modified, the frame has almost no original value except for your project , and finding someone competent to do the work will not be easy. The areas that need work are highly stressed, and the fabricated parts should not only be inserted into the remaining tubes as far as the curve permits, but insertions are usually pinned with a small rod through both, or rosette welded through access holes in the tube OD. This should be done in a frame jig to reduce distortion, or heavily clamped to a big I-beam etc. Unless you KNOW that the weight saving occurred in non-critical areas and produced no additional compliance or mis-alignment under load, 5 lbs. Simple things left un-done: Many axles and fork stems can be drilled easily, and are longer than needed if safety wire is used. Big chunks of mounting plates are structurally useless and can be cut with a hole saw if you know where; after a little exposure, you can intuitively guess pretty well where a plate is going to bend or break. Many other small thermo-plastic bits such as chain guards, chain guides are available cheaply for moto-x. Really simple way to stiffen an older fork: It takes more work to re-assemble, but still can be serviced etc. The larger rigid seat increases the stiffness of the joint quite a bit with almost no weight penalty, but must be individually fitted.

This is excellent for both axles and swing-arm pivot as well. These are very nice, look at the structure around the steering head, not only the amount of tubing but the 3-dimensional effect with support for the fork stem in 3 planes. The biggest change from the more traditional British frame is that the top tubes splay off from the steering head very widely, so the steering head and fork stem are tied down in both planes. If you just want a chassis that works there are cheaper choices. The Manx enjoyed a weight saving from use of Reynolds tube instead of DOM, and the street bike was probably made to the same dimensions but cheaper material to save money, and we know now what they vastly underestimated then - that even such a small engine will stress the frame beyond acceptable limits. Click the picture for a larger view.

Chapter 5 : Why things are the way they are: Frame design - RevZilla

Motorcycle frame theory, design, function and improvement by Jeffrey Diamond Here I will make various observations and comments on how the chassis, swing-arm, forks, brakes &c. function, and in some cases how to diagnose minor faults and make improvements.

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Chapter 6 : Motorcycle Handling And Chassis Design: The Art And Science by Tony Foale

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The motorcycle chassis consists of the frame, suspension, wheels and brakes. Each of these components is described briefly below. Frame Motorcycles have a frame made of steel , aluminum or an alloy. The frame consists mostly of hollow tubes and serves as a skeleton on which components like the gearbox and engine are mounted. The frame also keeps the wheels in line to maintain the handling of the motorcycle. Suspension The frame also serves as a support for the suspension system, a collection of springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts. A swingarm design is the most common solution for the rear suspension. On one end, the swingarm holds the axle of the rear wheel. On the other end, it attaches to the frame via the swingarm pivot bolt. A shock absorber extends upward from the swingarm pivot bolt and attaches to the top of the frame, just beneath the seat. The front wheel and axle are mounted on a telescoping fork with internal shock absorbers and internal or external springs. Instead, the air is held between the rim and the tire, relying on a seal that forms between rim and tire to maintain the internal air pressure. Tubeless tires are less likely to blow out than a tube-type tire, but on rough roads, they can be a problem because even a small bend in the rim can cause a deflation. Tires come in a variety of designs to match the needs of terrain and driving conditions. Dirt bike tires, for example, have deep, knobby treads for maximum grip on dirt or gravel. Touring bike tires, made of harder rubber, usually provide less grip but last longer. The tires of sportbikes and racers generally steel-belted radials deliver astonishing gripping power, especially considering the small area that is in contact with the road surface. Parts of a disc brake HowStuffWorks Brakes The front and rear wheels on a motorcycle each have a brake. The rider activates the front brake with a hand lever on the right grip, the rear brake with the right foot pedal. Drum brakes were common until the s, but most motorcycles today rely on the superior performance of disc brakes. Disc brakes consist of a steel braking disc, which is connected to the wheel and sandwiched between brake pads. When the rider operates one of the brakes, hydraulic pressure, acting through the brake line, causes the brake pads to squeeze against the disc on both sides. Friction causes the disc and the attached wheel to slow down or stop. Brake pads must be replaced periodically because the pad surfaces wear away after repeated use. Seats and Accessories Seats on motorcycles are designed to carry one or two passengers. They are located behind the gas tank and are easily removable from the frame. Some seats have small cargo compartments underneath or behind them. For more storage, saddlebags -- either hard plastic boxes or leather pouches -- can be installed on either side of the rear wheel or over the rear fender. Large motorcycles can even tow a small trailer or pull a sidecar. The sidecar has its own wheel for support and may have an enclosed seating compartment to accommodate a passenger.

Chapter 7 : Chopper Frame | eBay

BUILDER: Jeff Palhegyi of Jeff Palhegyi Design Nothing worth doing is easy. This is true in life and in custom frame fabrication, a part of the motorcycle-building process that stems from a.

Motorcycle Chassis Design and Construction and Other Technical Topics When I started the Euro Spares website back in the mid s I had been writing and posting a series of articles on frame design and construction to some of the email lists I was on. These articles began when I asked if anyone on the lists was interested in the subject. The first article was a response to several messages I received, and things just took off from there. I had received a number of posts asking if I intend to expand the articles into a book, including drawings, photos, and other graphics. I certainly had no intention of doing this when I set out. Please keep in mind several things: I am not an engineer; these articles are based on my own experience, the experience of a friend of mine, and whatever information I have been able to glean from various books, magazines, etc. If you use the information in these articles, you do so at your own risk. These articles are meant as a general discussion, and not a detailed design procedure. These articles are, at best, in rough draft form. I generally sit down and knock one out when I have the time, give it a cursory review, and then post it. These articles do not cover all possible topics, and should not be considered a definitive treatise on the subject. Graphics and Copyright The articles could use more graphics. There are some ASCII graphics that reproduce with varying degrees of success depending on the browser being used. As I get the opportunity I will load some images on this page to help illustrate the articles. I am retaining copyright to these articles and request that they not be republished, especially as they have not been closely checked for errors at this time. I would be very happy to receive your questions about the articles. I do ask that you please read all of the articles before sending your questions, as some of the later articles include additional information on topics in earlier articles. If you find this topic of interest please consider subscribing to my mc-chassis-design email list. Details on how to do that can be found here. My original post, replies from others, my replies. What you need to design a frame. Tools, steering head, engine mounts. Rear suspension, and some messages and replies. Swing arms and related components.

Chapter 8 : Motorcycle Chassis Design: The Theory and Practice: Tony Foale: racedaydvl.com: Books

Chassis Design Co. has been in the business a long time, and they have plenty of different machines in-house to make frames and other motorcycle parts exactly how you want them. I can't wait to get my next frame from them.

Chapter 9 : Motorcycle frame - Wikipedia

Design and critically evaluate chassis concepts and use analytical methods in the investigation of the installation of drive-train components and the stresses generated.