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Three Structural Component Linkage Front Suspension and Directly Connected Suspension for Motorcycles

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Abstract

Directly connected suspension was first tried and tested on a motocrosser to combat the menace of ‘square-edged’ bumps, which react to throw the rider over the handlebars. The mathematical calculations prior to testing this new design gave a 25-30% reduction in chassis pitch. Only, these calculations did not take into account the fact directly connected suspension upon reducing chassis pitch puts greater emphasis on the shock absorbers to perform more efficiently for any given settings and any given dynamic condition thereby further reducing chassis rotation. A superior linkage front suspension, other than the one first tried on the motocrosser, then had to be devised and developed if directly connected suspension was to become successful. In recent times, a three structural component one-sided design was tried and tested where around 40 advantages over conventional telescopic fork and (unconnected) single shock absorber rear suspension design were achieved. Only, the single-sided nature of such a design was not appropriate for strength and stiffness in relation to component weight nor was it appropriate to achieve equal degrees of lateral flex from either side of the bicycle/motorcycle. There was also restricted steering lock. Given all this, the lower ball joint was repositioned from inside the front hub to above the front tire where the same basic design was retained. This is the most successful design tested to date. It was imperative rider feel was retained at a level comparative to, or above, that of telescopic forks where both these three structural component linkage front suspension designs have the handlebars move slightly with suspension travel amplifying feel for the rider. Simplicity was the final consideration – three structural components, two ball joints and two sets of rotational bearings is all that these front suspension designs utilize, which could be considered as basic as telescopic forks are.

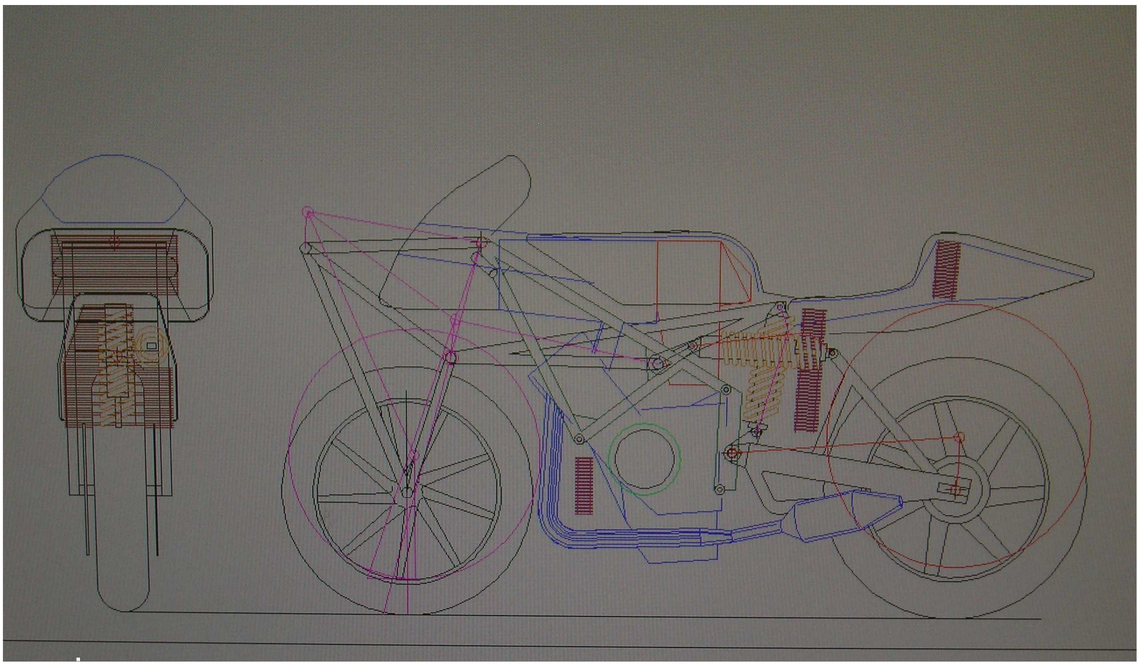
Directly connected suspension works by transferring a limited amount of motion load and weight onto the opposing suspension system, front to rear, and, rear to front, when suspension motion is encountered with either suspension system. This gives a self-leveling effect in all dynamic conditions and also provides superior suspension action over all other suspension designs. When one suspension system encounters a bump (and is only partially absorbed; where no conventional motorcycle suspension system fully absorbs bumps encountered) the opposing suspension system extends slightly to ensure the body of the motorcycle remains close to level. Directly connected suspension has been found to work too well as it has a natural anti-wheelie aspect to it, but this can be utilized by way of shorter wheel-bases to the benefit of increased cornering potential, handling and weight saving (both sprung and un-sprung).

Electronic active suspension is currently being developed for both telescopic forks and rear shock absorbers, but given the fact the telescopic fork is now at the end of its development cycle due to excessive cornering lean from improved tire grip, and the resulting cornering ‘chatter’, the fundamental design flaws cannot be overcome, therefore such a development is only a temporary solution. Race chassis technicians can only give a compromise but cannot address the problems relating to cornering chatter and retain high speed stability. A realistic alternative design has to be found soon to take motorcycle development to the next level. At best, electronic active suspension systems on motorcycles only have the potential to change the compression and rebound dampening where the most advanced versions will alter the spring preload. But it is the spring rate and the rising rate, and/or leverage ratio, of the suspension system which need to alter with the motorcycle from being upright to leant over during cornering to give a much

needed breakthrough in chassis technology. Directly connected suspension automatically does this. When cornering forces compress both front and rear suspension the outer ends of the respective shock absorbers are then displaced further away from perpendicular thereby increasing leverage ratios to give lighter suspension action, plus giving the side benefit of less compression of the motorcycle (compression of one suspension system acts to extend the other) to assist ground clearance, which has the secondary benefit of improved aerodynamics where reduced frontal area can be achieved when motorcycle designs are produced lower to the ground.

Directly connected suspension also has the benefit of altering suspension ratios during braking to more ideal. When braking forces compress the front suspension the rear extends to become lighter in action with the front, upon compression, becoming stiffer. Again, by means of displacement of the outer ends of the shock absorbers. With the final design of three structural component linkage front suspension shown below, the front control arm pivot point and the rear swinging arm pivot point can be positioned near vertical, one above the other, where compression of the front suspension will place load onto the rear suspension system (the outer end of the front control arm with ball joint attached remains above the front tire therefore it is the opposite inward end of the control arm which has to go downwards) to the benefit of superior braking and shorter stopping distances. Further, rear wheel braking places more load on the front suspension system than can be achieved with telescopic fork designs. When the swinging arm pivot point goes downward upon braking (with the higher swinging arm pivot point than the rear wheel axle where both want to become horizontal due to rear wheel braking dragging the rear axle backwards) taking the vertically above front control arm pivot point with it thereby loading up the front suspension, again to the benefit of braking performance.

This new linkage front suspension benefits from longitudinal chassis stiffness for superior braking performance and has greater control over lateral flex making it easier to achieve a higher natural frequency to avoid cornering chatter yet provide stability for straight-line travelling.



Endorsement

[1] A letter of praise from Massimo Tamburini (designer of the *Ducati 916* and *MV Agusta F4*) dated 10/06/08.