VEHICLE SAFETY

Design of vehicle body for safety

The safety of a vehicle and its passengers can be improved by properly designing andselecting the material for vehicle bodies. The vehicle body structure is subjected to static and dynamic service loads during the life cycle. It also has to maintain its integrity and provide adequate protection in survivable crashes. At present there are two designs of vehicle body constructions: 1. Body over frame structure and 2. Uni body structure.

Necessary features of a safe vehicle body:

1. Deformable yet stiff front structure with crumple zones to absorb the crash kinetic energyfrom frontal collisions
2. Deformable rear structure to safeguard rear passenger compartment and protect the fueltank
3. Properly designed side structures and doors to minimize intrusion in side impact andprevent doors from opening due to crash loads
4. Strong roof structure for rollover protection
5. Properly designed restraint systems with working in harmony with the vehicle structure
6. Accommodate various chassis designs for different power train locations and drive train configurations.

The following design techniques/strategies are to be followed while designing a car body (especially front structure) to reduce the impact of crash and increase the safety of the car andpassengers.

Desired dummy performance:

Dummy is a physical model representing humans inside a car. To model a car for safety, it should be modeled for proper crash energy management. As the human beings are to be safeguarded, the interaction of the human beings with the restraint system during a crash has to be studied first. This branch of study is widely known as bio-mechanics. The reaction of a humanbeing for a crash pulse has to defined and studied in depth. The following steps are involved in this procedure

Stiff cage structural concept:

Stiff cage is the passenger compartment structure which provides protection for the passengers inall modes of survivable collisions.

The necessary features of a good stiff cage structure are:

1. Sufficient peak load capacity to support the energy absorbing members in front of it,
2. High crash energy absorption.

The stiff cage structure should withstand all the extreme loads and the severe deformation.

Controlled progressive crush and deformation with limited intrusion:

To make the impact of crash less, the crush event has to be controlled and the deformation should be made such that the intrusion of other components into the passenger compartment is less. Axial mode of crush is preferred to bending mode of crush as bending mode has lower energy content. To achieve this objective three different crush zones are identified:

1. Soft frontzone: Reduces the aggressively of crash in pedestrian / vehicle and vehicle / vehicle collisions

2. Primary crush zone: It consists of the main energy absorbing structure before the power train. It is characterized by a relatively uniform progressive structural collapse.

3. Secondary crush zone:
Lies between the primary zone and passenger compartment and sometimes extends into the passenger compartment up to firewall. It provides a stable platform for the primary zone and transfers the load to the occupant compartment as efficiently as possible.
4. Weight efficient energy absorbing structures:
The architecture of the structural frame (structural topology) design depends on the ability to design the primary crush zone for bending, folding, mixed folding and bending. For a given vehicle package different topologies have to be studied for the same crush energy absorption.
The steps followed are:
1. Create a simple model of vehicle front end system
2. Determine the design loads of structural members

Energy equation

The application of the conservation of energy principle provides a powerful tool for problem solving. Newton's laws are used for the solution of many standard problems, but often there are methods using energy which are more straightforward. For example, the solution for theimpact velocity of a falling object is much easier by energy methods. The basic reason for the advantage of the energy approach is that just the beginning and ending energies need be considered; intermediate processes do not need to be examined in detail since conservation of energy guarantees that the final energy of the system is the same as the initial energy. The work- energy principle is also a useful approach to the use of conservation of energy in mechanics problem solving. It is particularly useful in cases where an object is brought to rest as in a car crash or the normal stopping of an automobile.

Kinetic energy is energy of motion. Objects that are moving, such as a roller coaster, have kinetic energy (KE). If a car crashes into a wall at 5 mph, it shouldn't do much damage tothe car. But if it hits the wall at 40 mph, the car will most likely be totaled. Kinetic energy is similar to potential energy. The more the object weighs, and the faster it is moving, the more kinetic energy it has. The formula for KE is: $KE = 1/2*m*v^2$ where m is the mass and v is thevelocity.

One of the interesting things about kinetic energy is that it increases with the velocity squared. This means that if a car is going twice as fast, it has four times the energy. You may have noticed that your car accelerates much faster from 0 mph to 20 mph than it does from 40 mph to 60 mph. Let's compare how much kinetic energy is required at each of these speeds. At first glance, you might say that in each case, the car is increasing its speed by 20 mph, and so theenergy required for each increase must be the same. But this is not so. We can calculate the kinetic energy required to go from 0 mph to 20 mph by calculating the KE at 20 mph and then subtracting the KE at 0 mph from that number. In this case, it would be $1/2*m*20^2 - 1/2*m*0^2$. Because the second part of the equation is 0, the $KE = 1/2*m*20^2$, or 200 m. For the car going from 40 mph to 60 mph, the $KE = 1/2*m*60^2 - 1/2*m*40^2$; so KE = 1,800 m - 800 m, or 1000 m. Comparing the two results, we can see that it takes a KE of 1,000 m to go from 40 mph to 60 mph, whereas it only takes 200 m to go from 0 mph to 20 mph.

There are a lot of other factors involved in determining a car's acceleration, such as aerodynamic drag, which also increases with the velocity squared. Gear ratios determine how