A STUDY OF THE CAUSES OF BOUNCING PROBLEMS OF SHOCK ABSORBER

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A thesis submitted in partial fulfillment of the requirement
for the award of the degree of
Bachelor of Manufacturing Engineering

Faculty of Manufacturing Engineering
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JUNE 2012

ABSTRACT

The purpose of the project is to investigate the problems of shock absorber in the market. The shock absorber is commonly use at all vehicle today. There are some problem happen at the vehicle when ride at the bumping road condition. One of the problems is that the vehicle bounce continuously more than one times and it is called as bouncing problems. The objective of this project is to study the causes of the bouncing problem at the vehicle and to compare the failure parts performance in terms of its yield strength between steel and beryllium copper. The scope of study for this project includes, experimental of suspension systems and bouncing problem in vehicle, apply structural analysis and model analysis on the shock absorber and application of Finite Element Analysis (FEA). In this project, after make an experiment and analysis, the problem of bouncing problem of shock absorber is come from the spring. Overall, this project acquires the skills of using software and skills to investigate the problem.

ABSTRAK

Tujuan utama projek adalah untuk menyiasat masalah penyerap hentakan di pasaran sekarang. Penyerap hentakan banyak digunakan di semua kenderaan pada hari ini. Terdapat beberapa masalah yang berlaku pada kenderaan apabila memandu di jalan yang tidak rata. Masalah utama ialah lantunan. Objektif projek ini adalah untuk mengkaji punca-punca masalah lantunan pada kenderaan dan membandingkan bahan pada bahagian yang paling cepat mengalami kegagalan menggunakan CATIA bagi mengurangkan masalah tersebut. Skop kajian bagi projek ini termasuklah eksperimen sistem hentakan dan masalah lantunan pada kenderaan, menggunakan analisis struktur dan analisis model pada penyerap hentakan dan menggunakan "Finite Element Analysis" (FEA). Di dalam projek ini, setelah menjalankan ekperimen dan analisis, masalah lantunan pada penyerap hentakan berpunca dari spring. Secara keseluruhannya, projek ini memberikan saya kemahiran menggunakan perisian dan kemahiran untuk mengkaji masalah.

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INTRODUCTION

1.1 Introduction

A suspension system or shock absorber is a mechanical device designed to smooth out and dissipate kinetic energy. The shock absorbers function is to absorb or dissipate energy. In a vehicle, it reduces the effect of traveling over rough ground, leading to improve ride quality, and increase in comfort due to substantially reduced amplitude of disturbances.

Basic safety and also traveling ease and comfort to get a car’s motorist are usually equally influenced by the particular vehicle’s suspension method. Safety refers to the vehicle’s handling and braking capabilities. Shock absorbers are a critical part of a suspension system, connecting the vehicle to its wheels. Basically shock absorbers tend to be products which lessen a good behavioral instinct skilled with an automobile, as well as properly absorb the actual kinetic power. Almost all suspension systems consist of springs and dampers, which tend to limit the performance of a system due to their physical constraints. Suspension systems, comprising of springs and dampers are usually designed for passenger’s safety and do little to improve passenger comfort.

One particular strategy to this can be the application of productive suspension devices, wherever highway circumstances are generally found employing detectors, plus the technique in a flash adapts on the placing. A shock absorber is a device which is designed to smooth out sudden impulse responses, and dissipate kinetic energy. Any moving object possesses kinetic energy, and if the object changes direction or is brought to rest, it may dissipate kinetic energy in the form of destructive forces within the object. The purpose of a shock absorber, within any moving object, is to dissolve the kinetic energy evenly while eliminating any decelerating force that may be destructive to the object.

Shock absorbers are an important part of automobile and motorcycle suspensions, aircraft landing gear, and the supports for many industrial machines. Large shock absorbers have also been used in structural engineering to reduce the susceptibility of structures to earthquake damage. A transverse mounted shock absorber, helps keep railcars from swaying excessively from side to side and are important in passenger railroads systems because they prevent railcars from damaging station platforms. In a vehicle, it reduces the effect of traveling over rough ground, and leading to improved ride quality. Without shock absorbers, the vehicle would have a bouncing ride, as energy is stored in the spring and then released to the vehicle, possibly exceeding the allowed range of suspension movement.

A typical shock absorber may simply comprise of a compression spring that is capable of absorbing energy. Commonly shock absorbers are known as dashpots, which is simply a fluid filled cylinder with an aperture through which fluid could escape under controlled conditions. The dashpot is the building block for pneumatic and hydraulic shock absorbers. These shock absorbers essentially consist of a cylinder, filled with air or fluid, with a sliding piston that moves to dissipate or absorb energy, and in these cases the energy is usually dissipated as heat.

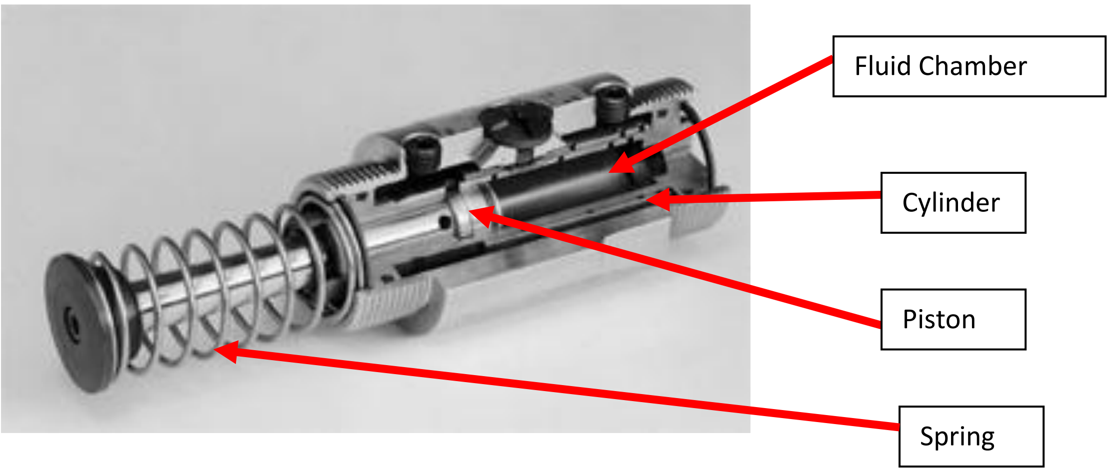

Figure 1.1: Cutaway View of Hydraulic Shock Absorber.

1.2 Problem Statement.

When a vehicle is travelling on a level road and the wheels strike a bump, the spring is compressed quickly. The compressed spring will attempt to return to its normal loaded length. It will rebound past its normal height, causing the body to be lift. The weight of the vehicle will then push the spring down below its normal load height. This causes the spring to rebound again. This bouncing process is repeated over and over, a little less each time, until the up and down movement finally stops. If bouncing is allowed to go uncontrolled, it will not only cause an uncomfortable ride but will make handling of the vehicle very difficult.

1.3 Objectives of the Project.

The objectives of the project are to:

- Study the causes of the bouncing problem at the vehicle.
- Compare the failure parts performance in terms of its yield strength between steel and beryllium copper.

1.4 Scope of Study

The scope of study for this project includes:-

- Experimental of suspension systems and bouncing problem in vehicle.
- Applying structural analysis and model analysis on the shock absorber.
- Application of Finite Element Analysis (FEA).

CHAPTER 2

LITERATURE REVIEW

2.1 Shock Absorber.

The shock absorber is really a mechanized gadget made to lessen or even moist surprise behavioral instinct, as well as dissolve kinetic power. It's a kind of dashpot. The shock absorber function is to absorb or dissipate energy. One design consideration, when designing or choosing a shock absorber, is where that energy will go. In many dashpots, power is actually transformed into warmth within the viscous liquid. Within hydraulic cylinders, the actual hydraulic liquid gets hotter, during atmosphere cylinders, the actual heat is generally worn out towards the environment. In other types of dashpots, such as electromagnetic types, the dissipated energy can be stored and used later. In general terms, shock absorbers help cushion vehicles on uneven roads.

Shock absorbers tend to be an essential a part of car as well as motorbike suspensions, plane getting equipment, and also the facilities for a lot of commercial devices. Big shock absorbers are also utilized in structural architectural to lessen the actual susceptibility associated with buildings in order to earthquake harm as well as resonance. The transverse installed shock absorber, known as the yaw damper, helps maintain railcars through swaying too much laterally and therefore are essential within traveler railroads, commuter train as well as quick transit techniques simply because they avoid railcars through harmful train station systems.

Inside a vehicle, shock absorbers slow up the effect associated with traveling more than rough floor, leading in order to improve trip quality as well as increase within comfort. While surprise absorbers serve the objective of limiting extreme suspension motion, their meant sole purpose would be to dampen springtime oscillations. Shock absorbers make use of valve associated with oil as well as gasses to soak up excess energy in the springs. Spring prices are chosen through the manufacturer in line with the weight from the vehicle, packed and unloaded. Some individuals use shocks to change spring prices but this isn't the proper use. Together with hysteresis within the tire by itself, they dampen the power stored within the motion from the unsparing weight down and up. Effective steering wheel bounce damping may need tuning shocks for an optimal opposition.

Spring-based surprise absorbers generally use coils springs or even leaf comes, though torsion bars are utilized in torsion shocks too. Ideal comes alone, nevertheless, are not really shock absorbers, as come only store and don't dissipate or even absorb power. Vehicles usually employ each hydraulic surprise absorbers as well as springs or even torsion pubs. In this particular combination, "shock absorber" pertains specifically towards the hydraulic piston which absorbs as well as dissipates vibration.

Figure 2.1: Shock Absorber in Market

2.2 Types of Shock Absorbers

There are several shock absorber designs in use today like Twin Tube Designs, Gas Charged, PSD (position sensitive damping), ASD (Acceleration Sensitive Damping) and Mono-Tube.

2.2.1 Twin Tube – Gas Charged Design

The prime function of gas charging is to minimize aeration of the hydraulic fluid. The pressure of the nitrogen gas compresses air bubbles in the hydraulic fluid. This prevents the oil and air from mixing and creating foam. Foam affects performance because it can be compressed fluid. With aeration reduced, the shock is able to react faster and more predictably, allowing for quicker response time and helping keep the tire firmly planted on the road surface.

The advantages of this shock absorber are improves handling by reducing roll, sway and dive. Also can reduces aeration offering a greater range of control over a wider variety of road conditions as compared to non-gas units. This shock absorber reduced fade shocks can lose damping capability as they heat up during use. Gas charged shocks could cut this loss of performance.

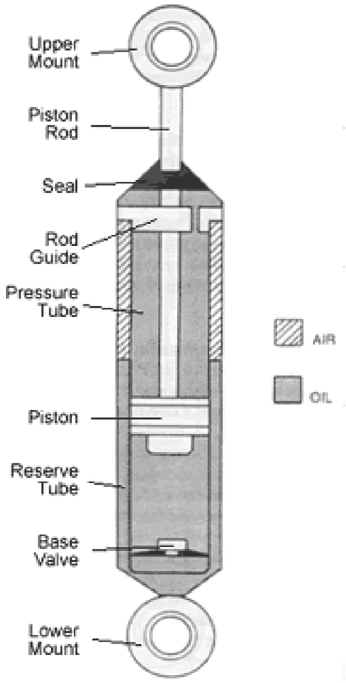

Figure 2.2: Gas Charged Design

2.2.2 Twin Tube – PSD Design

Ride engineers had to compromise between soft valve and firm valve. With soft valve, the fluid flows more easily. The result is a smoother ride, but with poor handling and a lot of roll/sway. When valve is firm, fluid flows less easily. Handling is improved, but the ride can become harsh. With the advent of gas charging, ride engineers were able to open up the orifice controls of these valves and improve the balance between comfort and control capabilities available in traditional velocity sensitive dampers. A leap beyond fluid velocity control is an advanced technology that takes into account the position of the valve within the pressure tube. This is called Position Sensitive Damping (PSD).

The key to this innovation is precision tapered grooves in the pressure tube. Every application is individually tuned, tailoring the length, depth, and taper of these grooves to ensure optimal ride comfort and added control. This in essence creates two zones within the pressure tube. The first zone, the comfort zone, is where normal driving takes place. The second zone, the control zone, is utilized during demanding driving situations.

The advantages is allows ride engineers to move beyond simple velocity sensitive valve and use the position of the piston to fine tune the ride characteristic. Adjusts more rapidly to changing road and weight conditions than standard shock absorbers.

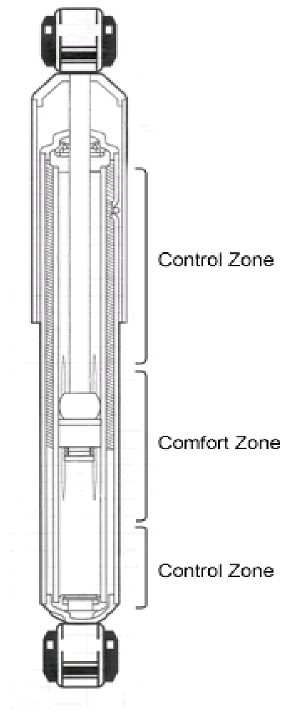

Figure 2.3: Twin Tube – PSD Design

2.2.3 Twin Tube -ASD Design (Reflex)

A new twist on the comfort control compromise is an innovative technology which provides greater control for handling while improving ride comfort called Acceleration Sensitive Damping (ASD). This technology moves beyond traditional velocity sensitive damping to focus and address impact. This focus on impact is achieved by utilizing a new compression valve design. This compression valve is a mechanical closed loop system, which opens a bypass to fluid flow around the compression valve.

The advantage of this absorber is it can control the damping without reducing driver comfort. Valve automatically adjusts to changes in the road condition and reduces ride harshness.

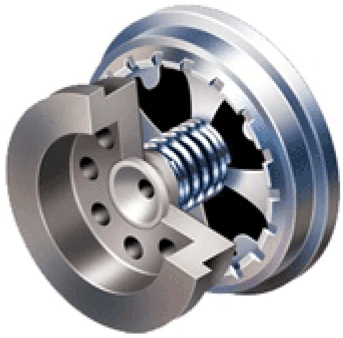

Figure 2.4: Twin Tube -ASD Design (Reflex)

2.2.4 Mono-tube design (Standard Types)

These are high-pressure gas shocks with only one tube, the pressure tube. Inside the pressure tube there are two pistons: a dividing piston and a working piston. The working piston and rod are very similar to the twin tube shock design. The difference in actual application is that a mono-tube shock absorber can be mounted upside down or right side up and will work either way. In addition to its mounting flexibility, mono-tube shocks are a significant component, along with the spring, in supporting vehicle weight. Another difference you may notice is that the mono-tube shock absorber does not have a base valve. Instead, all of the control during compression and extension takes place at the piston. During operation, the dividing piston moves up and down as the piston rod moves in and out of the shock absorber, keeping the pressure tube full all times.

The advantages for this absorber is that it can be mounted upside down, reducing the unsparing weight. May run cooler since the working tube is exposed to the air and can use original equipment many import and performance domestic passenger cars, SUV and light truck applications

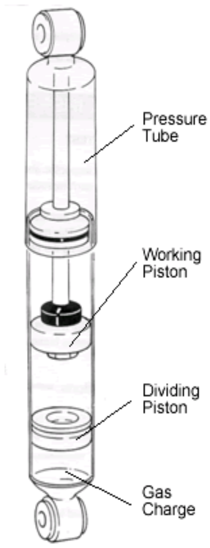

Figure 2.5: Mono-tube design (Standard Types)

2.3 Main Component of Shock Absorber.

Shock absorber has three main components to make it function well. There are damper, spring and bushing. These all three part is playing an important rule to work together and absorb the impact or bouncing.

2.3.1 Damper.

Damper shock absorber or simply damper is device that is designed for providing absorption of shock and smooth deceleration in linear motion applications. The dampers can be either mechanical or rely on a fluid. Dampers like other shock absorber absorb shock by controlling the flow of the fluid from outer to inner chamber of a cylinder during piston actuation. The damper shock absorbers can be adjusted to different road conditions and provides good balance to the vehicles.

2.3.2 Spring.

Spring shock absorber as the name suggests is used to absorb the jerks or bumps by using coil spring. The spring shock absorber is given stiffer character by tightening the spring. The center of the spring shock absorber usually contains rebound dampening unit. As the shock absorber changes the length the flow fluid inside the shock absorber starts.

Springs length is usually controlled by turning the disc at the bottom of the spring on the threads. The shorter spring length increases the preload, making the rear wheel more resistant to upward motion. The dampening is both controlled and adjusted in the spring shock absorber by controlling the fluid reservoir. If the dampening is increased the motion of the shock is slowed down.

The spring type of shock absorbers are usually utilized for protecting the delicate mechanisms, like instruments, from direct impact or or loads that are applied instantaneously. These types of springs are often made of rubber or similar elastic material.

The springs that are used in different spring based shock absorbers are coil springs or leaf springs. In tensional shocks, torsion bars can be used. In most of the vehicles, springs or torsion bars as well as hydraulic shock absorbers are used.

2.3.3 Bushing.

A bushing or rubber bushing is a type of vibration isolator. It provides an interface between two parts, damping the energy transmitted through the bushing. A common application is in vehicle suspension systems, where a bushing made of rubber (or, more often, synthetic rubber or polyurethane) separates the faces of two metal objects while allowing a certain amount of movement. This movement allows the suspension parts to move freely, for example, when traveling over a large bump, while minimizing transmission of noise and small vibrations through to the chassis of the vehicle. A rubber bushing may also be described as a flexible mounting or anti vibration mounting.

2.4 Design Calculations for Helical springs for Shock absorbers

Material: phosphorous bronze

G = 41000 = modulus of rigidity

Mean diameter of a coil = D=62mm

Diameter of wire d = 8mm

Total no of coils n_1 = 18

Height h = 220mm

Outer diameter of spring coil D_0 = D +d =70mm

No of active turns n = 14

Weight of bike = 125kgs

Let weight of 1 person = 75 Kgs

Weight of 2 persons = $75\times 2 = 150Kgs$

Weight of bike + persons = 275Kgs

Rear suspension = 65%

65% of 275 = 165Kgs

Considering dynamic loads it will be double

W = 330Kgs = 3234N

For single shock absorber weight = w/2= 1617N = W

We Know that, compression of spring (δ) = $\frac{8W\times C^3\times n}{G\times d}$

$$\text{C = spring index} = \frac{D}{d} = \frac{62}{8} = 7.75 = 8$$

$$(\delta) = \frac{8\times 1617\times 8^3\times 14}{41000\times 8} = 282.698m$$

Solid length = $L_s = n^1 \times d = 18 \times 8 = 144$

Free length of the spring $L_F = solid\ length + maximum\ compression + clearences\ between\ adjustible\ coils$

$$= n^1 d + \delta_{max} + 0.15\delta_{max} = 144 + 282.698 + 0.15 \times 282.698 = 469.102$$

Spring rate K = $\frac{W}{\delta} = \frac{1617}{282.698} = 5.719$

Pitch of coil P = $\frac{L_F + L_S}{n^1} = \frac{469.102 - 144}{18} = 26$

Stresses in helical springs: maximum shear stress induced in the wire

$$\tau = K \times \frac{8WC}{\pi d^2}$$

$$K = \frac{4_C - 1}{4_c - 4} + \frac{0.615}{C} = \frac{4 \times 8 - 1}{4 \times 8 - 4} + \frac{0.615}{8} = 0.97$$

$\tau = K \times \frac{8WC}{\pi d^2} = 0.97 \times \frac{8 \times 1617 \times 8}{\pi \times 8^2} = 499.519 Mpa$

Buckling of compression springs:

$W_{cr} = k \times K_B \times L_F$

K = spring rate or stiffness of spring $= \frac{W}{\delta}$

$L_F = free\ length\ of\ the\ springs$

$K_B = buckling\ factor\ depending\ upon\ the\ ratio = \frac{L_F}{D}$

Values of buckling factor K_B

$\frac{L_F}{D} = \frac{469.102}{62} = 7.5$

K = 0.05 (for hinged and spring)

The buckling factor for the hinged end and built-in end springs

$W_{cr} = 5.719 \times 0.05 \times 469.102 = 134.139N$

[Reference from the Simulation Tools, Modeling and Identification, for an Automotive Shock Absorber in the Context of Vehicle Dynamics.]

2.5 CATIA V5

CATIA-V5 is the industry standard 3D mechanical design software. It is the world's leading CAD/CAM/CAE software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customers to more quickly and consistently innovate a new robust, parametric feature based model. Because of that CATIA V5 is unmatched in this field, in all processes, in all countries, and in all kind of companies along the supply chains. CATIA V5 is also the perfect solution for the manufacturing enterprise with associative applications robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations.

CATIA V5 provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries consumer goods, fabrications and assembly. Electrical and electronics goods, automotive, aerospace, shipbuilding and plant design. It is user friendly solid and surface modeling can be done easily.

Advantages of CATIA-V5 are it is much faster and more accurate. Once a design is completed 2D and 3D views are readily obtainable. The ability to changes in late design process is possible. It provides a very accurate representation of model specifying all other dimensions hidden geometry. It is user friendly both solid and surface modeling can be done. It provides a greater flexibility for change. For example if we like to change the dimensions of our model, all the related dimensions in design assembly manufacturing will automatically change. It provides clear 3D models, which are easy to visualize and understand. CATIA provides easy assembly of the individual parts or models created it also decreases the time required for the assembly to a large extent.

A solid model of an object is a completed representation of the object. This model is capable of complex geometry data representation that is the art completely defined solid modeling techniques based on information all complete, valid and unambiguous of object solid modelers store more information (geometry and topology) than wire frame modelers of surface (geometry only). Both wire frame and surface modelers are incapable of handling special address ability as well as verifying that the model is well framed or not. Solid models can be quickly created without having to define individual locations as with wire frames. Solid modeling produces accurate designs, provides complete three-dimensional improves the quality of the design improves and has potential for functional automation and integration.

2.6 Finite Element Analysis (FEA).

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variation calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters.

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the clients specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry. That is 2D modeling and 3D modeling. While 2D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3D modeling however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object creating many elements.

A wide range of objective functions (variables within the system) are available for minimization or maximization:

- Mass, volume, temperature.
- Strain energy, stress strain.
- Force, displacement, velocity, acceleration.
- Synthetic.

There are multiple loading conditions which may be applied to a system. Some examples are shown:

- Point, pressure, thermal, gravity, and centrifugal static loads.
- Thermal loads from solution of heat transfer analysis.
- Enforced displacements.
- Heat flux and convection.
- Point, pressure and gravity dynamic loads.