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DESIGN AND ANALYSIS OF HEAT STACKING MECHANISM USED IN PACKAGING MACHINERY

K.Nagendhar
M.Tech (Machine Design),
Department Of Mechanical Engineering,
Anurag Engineering College,
Kodad, Nalgonda, T.S, India.

B. Shankar
Assistant Professor
Department Of Mechanical Engineering,
Anurag Engineering College,
Kodad, Nalgonda, T.S, India

Veeranjaneyulu
Assistant Professor
Department of Mechanical Engineering,
Anurag Engineering College,
Kodad, Nalgonda, T.S, India

ABSTRACT:

Heat stacking can be performed at low rates using a single heated tool (flat tip attached to a hand-held soldering iron) or high rates using a pneumatic press and 4 point tool (to stake all 4 legs simultaneously). These instructions apply to both cases. This process is proven for heat staking the lens holder assembly to a heat sink or metal-core printed circuit board 1.5 to 2.0 mm thick. Using Heat Stacking can be a repeatable, economical and safe method to form a stud joining two pieces of plastic or plastic and other materials.

In heat stacking Mechanism for sealing the bottle opening by aluminum foil at continuous without interrupting the flow. we use high rate press that is pneumatic press the pneumatic press operates on the air which use to movie the piston up and down position to seal the bottles.

In this project we want to seal the bottle top with Aluminium foil by use of heat stacking in this process we want to consider some of parameters for the heating and conveyor systems we take speed of conveyor as 135mm/s and, rate of sealing of the bottle as 80 bottles per minute and rate of sealing is 3 sec.Heat Stacking is connected with pneumatic systems which stacks and cuts the foil under certain pressure. This concept is modeled in CREO-2 software and Structural Analysis should be done in ANSYS Software and its functionality is tested by Appling mechanisms. A Prototype is made by using detailed drawings and cost optimization is done..

Key Words: ***Heat Stacking, Hot Air, Design, Wire Frame, surface modeling, 3D CAD, Structural analysis, Vibrational analysis, Element Analysis.***

INTRODUCTION

Heat stacking is all about the process of connecting different components into a cohesive functioning unit. The application is very common with the assembly of products that involve plastic and resin parts. The plastic joining strategy that is part of heat staking helps to strengthen the overall structure of the manufactured item and provide the product with a higher degree of stability.

The basic concept behind heat staking involves joining the components at pre molded interfaces. As an example, a plastic stud that is attached to one component would be inserted into a hole found on the accompanying part. Once the two components are joined, the end of the stud is softened and heated to allow the formation of a larger head that will hold the stud firmly in the hole.

It is important to note that heat staking can be utilized in more than just joining two plastic components together at a joint. Because of the heat induction qualities employed in heat staking, the process also makes it possible to join a plastic component to a metal part as well. With so many products manufactured with a mix of metal and plastic components, the use of heat staking can also eliminate the need for screws and rivets in some cases.

Heat staking apparatus

The heat staking apparatus, and more particularly relates to an apparatus for heat staking parts together by heating and then forming plastic protrusions extending from one part into the other.

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For this reason, usually a second heat staking apparatus is purchased. However, the additional machinery is expensive and also consumes precious floor space, and further requires additional maintenance. Additionally, plastic components may vary dimensionally from the designed shape, such that fine tuning of the relative locations of the heat staking tools is necessary, particularly during start-up.

HEAT STAKING METHODS

A comparison between three methods

Ultrasonic staking: the advances in materials and electronic controls, which have had a major impact on injection molding equipment in recent years, have also greatly improved the performance of heat staking equipment.

Hot air/cold stake equipment: which is the most common method used for staking large components with any number of posts, provides a cost effective solution for many staking applications? The addition of more sophisticated controls to hot air/clod stake equipment provides a higher level of confidence in the system for users.

Direct contact staking another change in heat staking processes, which can be attributed to technology, is the reintroduction of the process called direct contact staking, or staking with a constant temperature probe.

Advantages of heat staking.

Not only are heat staking, swaging, and sealing the preferred methods for consumer electronic devices, but they also are the assembly method of choice for the following applications: multi-level staking or insertion projects; staking multiple threaded inserts at one time; applying heat seal connectors to an LCD/PCB; and swaging around the perimeter of a part for retention purposes.

INDUCTION SEALING:

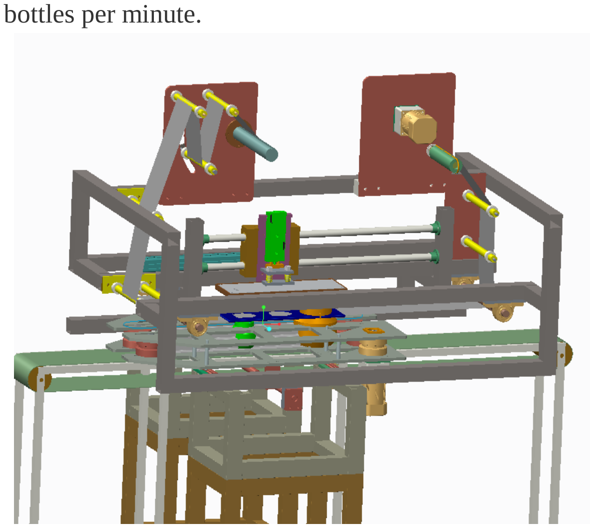
This project is based on the heat stacking sealing which will be same as induction sealing. The induction sealing is process of sealing bottles opening by Aluminum foil; the process of sealing an aluminum foil on the bottle mouth by use of an electromagnetic field is called induction sealing. This is a non-contact process; hence there is no direct heat transfer.

Working of induction sealing

The closure is supplied to the bottler with foil liner already inserted. Although there are various liners to choose from, a typical induction liner is multi-layered. The top layer is a paper pulp that is generally spot-glued to the cap. The next layer is wax that is used to bond a layer of aluminum foil to the pulp.. As the container passes under the induction coil (sealing head) the conductive aluminum foil liner begins to heat. The heat melts the wax, which is absorbed into the pulp backing and releases the foil from the cap.

HEAT STACKING UNIT

Variable bottle cup sealing unit design is specifically used for food packaging industries .To meet the requirements of such a wide range demanding velocity of the production lines, the research & development department of our project makes research and improvement with great care to design this product, the highest velocity of which can be up to more than 80 bottles per minute.



Heat stacking unit

Heat Staking Design Considerations

Very simple design guidelines are required: post diameter, height, and geometry are the essential factors in obtaining good heat-staking results. Working height above the mating piece should be approximately 1.5 to 2.0 times the post diameter, as shown in Figure 1. That height will result in stud-head diameters having approximately a three-to-one head-to-post diameter ratio.

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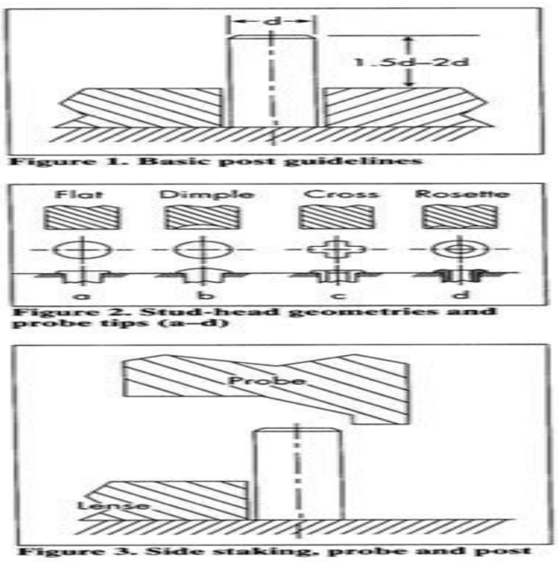

Side staking probe and post

Design post features

A variety of post designs are show in figure 2. A radiused post root adds strength to the post and minimizes molded-in stress (figure 3). A common cause of rejects for heat staked components is damage to the post prior to staking. During staking, especially ultrasonic staking, considerable forces are applied that can damage weak posts. The radius at the post root will strengthen the post to minimize rejects.

INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provides the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software (construction, manufacturing, etc.) typically uses vector-based (linear) environments

Types of CAD Software

2D CAD

Two-dimensional, or 2D, CAD is used to create flat drawings of products and structures. Objects created in 2D CAD are made up of lines, circles, ovals, slots and curves. 2D CAD programs usually include a library of geometric images; the ability to create Bezier curves, splines and polylines; the ability to define hatching patterns; and the ability to provide a bill of materials generation.

3D CAD

Three-dimensional (3D) CAD programs come in a wide variety of types, intended for different applications and levels of detail. Overall, 3D CAD programs create a realistic model of what the design object will look like, allowing designers to solve potential problems earlier and with lower production costs

3D Wireframe and Surface Modeling

CAD programs that feature 3D wireframe and surface modeling create a skeleton-like inner structure of the object being modeled. A surface is added on later.

Solid Modeling

Solid modeling in general is useful because the program is often able to calculate the dimensions of the object it is creating. Many sub-types of this exist. Constructive Solid Geometry (CSG) CAD uses the same basic logic as 2D CAD, that is, it uses prepared solid geometric objects to create an object.

INTRODUCTION TO CREO-2

Creo is a family or suite of design software supporting product design for discrete manufacturers and is developed by PTC. PTC Creo is a scalable, interoperable suite of product design software that delivers fast time to value. It helps teams create, analyze, view and leverage product designs downstream utilizing 2D CAD, 3D CAD, parametric & direct modeling.

HEAT STAKING UNIT MODELING

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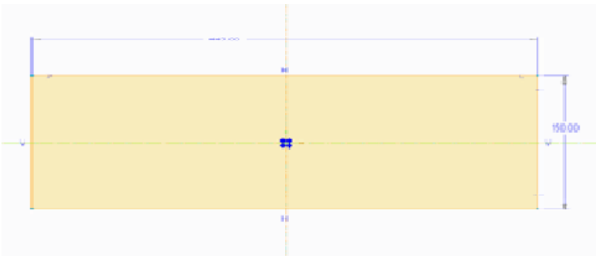
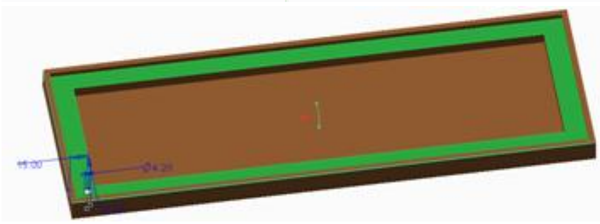




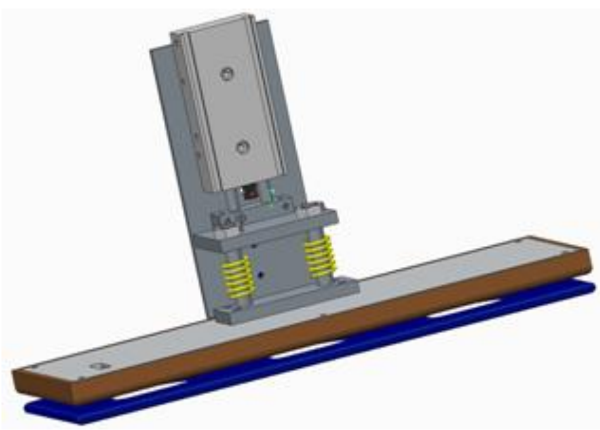
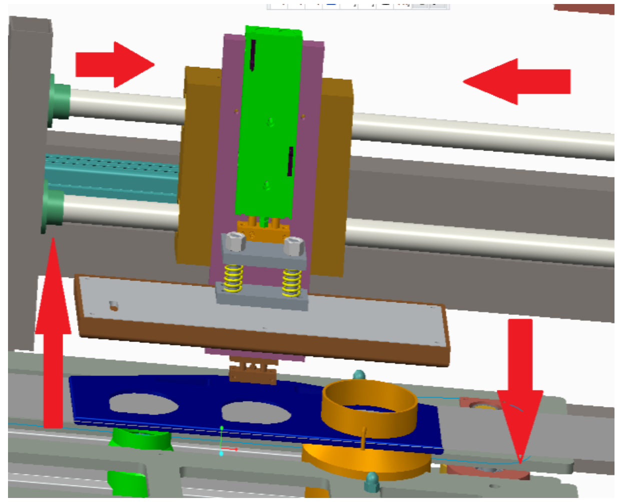


Plate with high pressure stacks the bottle therefore structural analysis has to be done before building the equipment.

Analysis on heat stacking equipment:

Heat stacking equipment as a plate heated by coil and the total equipment is fixed at two ends. This unit can be moved two and fro, forward and background directions. Analysis as to be done as high sudden impact loads falls on outer diameter of the bottle. In some cases it may deform the bottle. Springs are assembled in order to overcome the compressive loads. Certain predefined load as to be applied as shown in the figure in ANSYS Software and results has to be studied.



Types of sealing machines:

1. Linear Sealing Machines
2. Rotary Sealing Machines

INTRODUCTION TO FEA

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 client's 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.

Types of Engineering Analysis

Structural analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in.

Vibrational analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may

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act on the natural vibration frequency of the material which, in turn, may cause resonance and subsequent failure

Heat Transfer analysis models the conductivity or thermal fluid dynamics of the material or structure. This may consist of a steady-state or transient transfer. Steady-state transfer refers to constant thermo properties in the material that yield linear heat diffusion.

Results of Finite Element Analysis

FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem areas in a material and allowing designers to see all of the theoretical stresses within. This method of product design and testing is far superior to the manufacturing costs which would In practice, a finite element analysis usually consists of three principal steps:

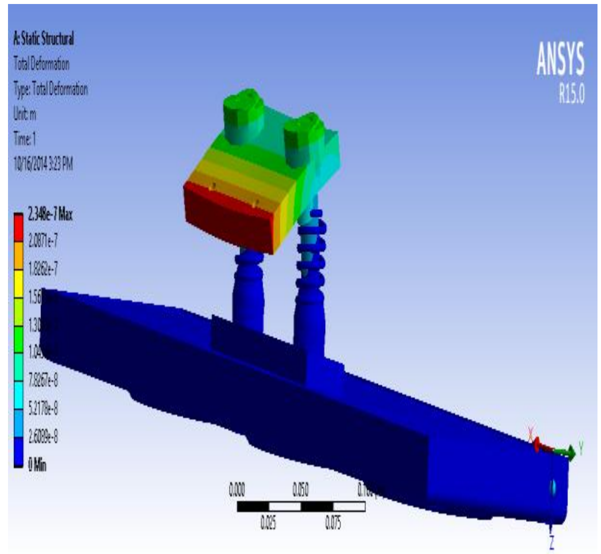
- **Preprocessing**
- **Analysis**
- **Post processing**

INTRODUCTION TO ANSYS

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

Generic Steps to Solving any Problem in ANSYS

Like solving any problem analytically, you need to define (1) your solution domain, (2) the physical model, (3) boundary conditions and (4) the physical properties. You then solve the problem and present the results. In numerical methods, the main difference is an extra step called mesh generation. This is the step that divides the complex model into small elements that become solvable in an otherwise too complex situation. Below describes the processes in terminology slightly more attune to the software.



Analysis Results

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4) > Geometry > Parts

Object Name	*Part 1*	*Part 2*	*Part 3*	*Part 4*	*Part 5*
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Stiffness Behavior	Flexible				
Coordinate System	Default Coordinate System				
Reference Temperature	By Environment				
Thickness	2. mm				
Thickness Mode	Manual				

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Offset Type	Middle				
Material					
Assignment	Structural Steel				
Nonlinear Effects	Yes				
Thermal Strain Effects	Yes				
Bounding Box					
Length X	5. mm				
Length Y	5. mm				
Length Z	15. mm				
Properties					
Volume	471.22 mm³				
Mass	3.6991e-003 kg				
Centroid X	207.5 mm		-2.4275e-016 mm	3.4829e-016 mm	-207.5 mm
Centroid Y	-60. mm	60. mm	-60. mm	60. mm	-60. mm
Centroid Z	2.5 mm				
Moment of Inertia Ip1	8.0647e-002 kg·mm²				
Moment of Inertia Ip2	8.0657e-002 kg·mm²				
Moment of Inertia Ip3	2.2877e-002 kg·mm²				
Surface Area(approx.)	235.61 mm²				
Statistics					
Nodes	156				
Elements	144				
Mesh Metric	None				

Model (A4) > Geometry > Parts

Object Name	*Part 11*	*Part 12*	*Part 13*	*Part 14*	*Part 15*
State	Meshed				
Graphics Properties					
Visible	Yes				
Transparency	1				
Definition					
Suppressed	No				
Stiffness Behavior	Flexible				
Coordinate System	Default Coordinate System				
Reference Temperature	By Environment				
Thickness	2. mm				
Thickness Mode	Manual				
Offset Type	Middle				
Material					
Assignment	Structural Steel				
Nonlinear Effects	Yes				
Thermal Strain Effects	Yes				
Bounding Box					
Length X	5. mm	12. mm	5. mm	12. mm	24.249 mm
Length Y	5. mm	12. mm	5. mm	12. mm	21. mm
Length Z	10. mm	16. mm	10. mm	16. mm	12.8 mm
Properties					
Volume	325.71 mm³	1212.5 mm³	325.71 mm³	1212.5 mm³	3414.2 mm³
Mass	2.5568e-003 kg	9.5182e-003 kg	2.5568e-003 kg	9.5182e-003 kg	2.6801e-002 kg
Centroid X	-35. mm		35. mm		-35. mm
Centroid Y	-31. mm				
Centroid Z	-25.178 mm	-86.964 mm	-25.178 mm	-86.964 mm	-84.401 mm
Moment of Inertia Ip1	3.0591e-002 kg·mm²	0.37413 kg·mm²	3.0591e-002 kg·mm²	0.37413 kg·mm²	1.4174 kg·mm²
Moment of Inertia Ip2	3.0595e-002 kg·mm²	0.37422 kg·mm²	3.0595e-002 kg·mm²	0.37422 kg·mm²	1.4175 kg·mm²
Moment of	1.5777e	0.33958	1.5777e	0.33958	2.1252

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Inertia Ip3	-002 kg·mm²	kg·mm²	-002 kg·mm²	kg·mm²	kg·mm²
Surface Area(approx.)	162.85 mm²	606.25 mm²	162.85 mm²	606.25 mm²	
Statistics					
Nodes	130	78	130	78	1650
Elements	118	66	118	66	900
Mesh Metric	None				

Coordinate Systems

Model (A4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. mm
Origin Y	0. mm
Origin Z	0. mm
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Connections

Object Name	*Connections*
State	Fully Defined
Auto Detection	
Generate Automatic Connection On Refresh	Yes
Transparency	
Enabled	Yes

Model (A4) > Connections

Model (A4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region 11*	*Contact Region 12*	*Contact Region 13*	*Contact Region 14*	*Contact Region 15*
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Contact	2 Faces				
Target	2 Faces				
Contact Bodies	Part 11	Part 12		Part 13	Part 14
Target Bodies	Part 20	Part 15	Part 20	Part 21	Part 16
Contact Shell Face	Program Controlled				
Definition					
Type	Bonded				
Scope Mode	Automatic				
Behavior	Program Controlled				
Suppressed	No				
Advanced					
Formulation	Program Controlled				

Mesh

Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	On: Curvature
Relevance Center	Coarse
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Curvature Normal Angle	Default (30.0 °)
Min Size	Default (0.934560 mm)
Max Face Size	Default (4.67280 mm)
Max Size	Default (4.67280 mm)
Growth Rate	Default

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Minimum Edge Length	1.53090 mm
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Advanced	
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Default (0.84110 mm)
Generate Pinch on Refresh	No
Sheet Loop Removal	No
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default (0.700920 mm)

Static Structural (A5)
Model (A4) > Analysis

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

Model (A4) > Static Structural (A5) > Loads

Object Name	*Fixed Support*	*Force*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Face	
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Magnitude		-25. N (ramped)
Direction		Defined

Model (A4) > Static Structural (A5) > Force
Solution (A6)
Model (A4) > Static Structural (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done

Model (A4) > Static Structural (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes

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Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

Material Data

Structural Steel

Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

Structural Steel > Compressive Ultimate Strength

Compressive Ultimate Strength MPa
0

Structural Steel > Compressive Yield Strength

Compressive Yield Strength MPa
250

Structural Steel > Tensile Yield Strength

Tensile Yield Strength MPa
250

Structural Steel > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
460

Structural Steel > Isotropic Secant Coefficient of Thermal Expansion

Reference Temperature C
22

Structural Steel > Alternating Stress Mean Stress

Alternating Stress MPa	Cycles	Mean Stress MPa
3999	10	0
2827	20	0
1896	50	0
1413	100	0
1069	200	0
441	2000	0
262	10000	0
214	20000	0
138	1.e+005	0
114	2.e+005	0
86.2	1.e+006	0

Structural Steel > Strain-Life Parameters

Strength Coefficient MPa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient MPa	Cyclic Strain Hardening Exponent
920	-0.106	0.213	-0.47	1000	0.2

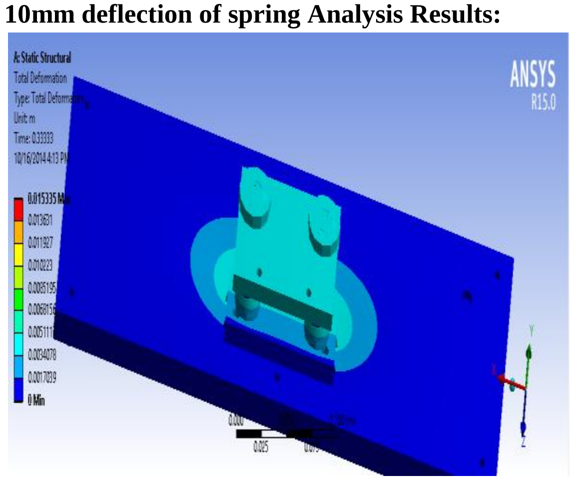
Structural Steel > Isotropic Elasticity

Temperature C	Young's Modulus MPa	Poisson's Ratio		Shear Modulus MPa
	2.e+005	0.3	1.6667e+005	76923

Structural Steel > Isotropic Relative Permeability

Relative Permeability
10000

10mm deflection of spring Analysis Results:



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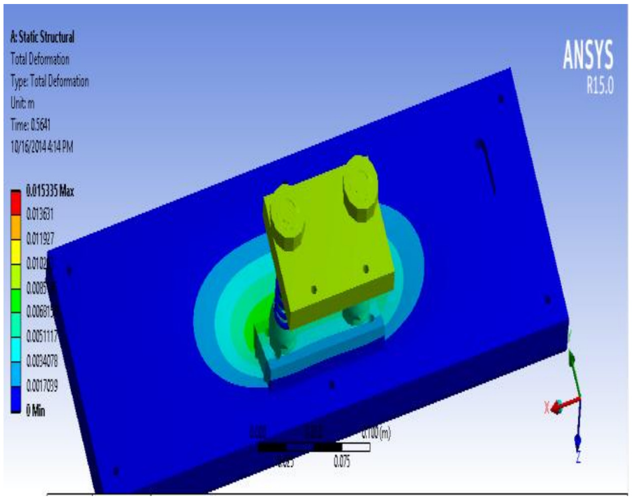

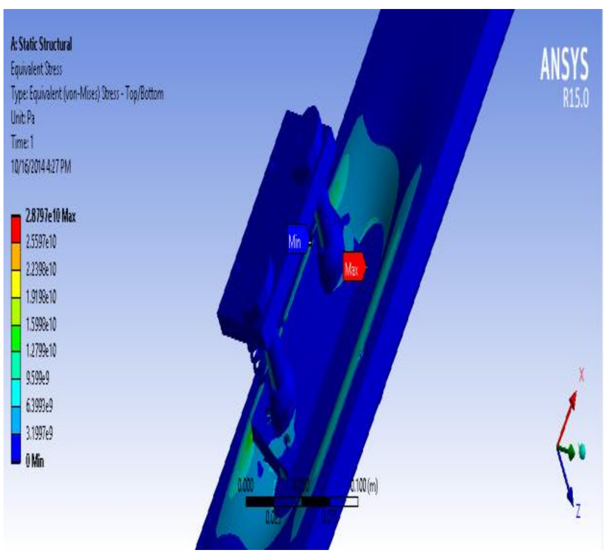

CONCLUSION

Existing food packing machinery's are giving less production, labour oriented, machinery cost is very high , manufacturing cost, material aspects, complex in structure, less efficiency, more time taking process. So, we design and built machines to the highest quality machine standards to meet the demands of high volume mass production.

- Works on pneumatic systems
    - Able to stack at any size and shape of container.
    - quick change over facility from container to other
    - Easy and accurate adjustments to stack the container.
    - Available in linear format.
    - compatible with other stacking equipments.
    - Infinite variable speed drive for output control can be provided if required
    - Maximum output in minimum possible time.
    - Adjustable and spacing saving
    - Low power consumption
    - Flaw less performance
    - Accuracy better than ±1%
    - Adustable sealing height for varible neck diameter and varible bottle height
    - Temperature controller for heat stack plates
    - Leak prevention.