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Design & Analysis & Optimization of Heat Stacking Mechanism for Packing Machinery

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Abstract

Heat Stacking Mechanism is mostly used in packaging industry. Heat stacking process involves the use of heat to join two similar of dissimilar materials. Also high rate of operations such as 2 to 3 components per second are required. Thus it is necessary to optimize any heat stacking mechanism so that energy consumption is minimal. In the current work, an attempt is made to optimize the heat stacking mechanism by using FEA.

Key Words: *Heat stacking mechanism, Static Analysis, FEA*

1. Introduction

Finite Element Analysis is playing an important role in the design of structures of machines. Many time tested commercial software are currently available in market. Using FEA non-linearity in geometry, material and assemblies can be taken care of. Design of large and complex parts can be verified easily. Different kinds of analysis help in simulating various situations that not only help in understanding the process but also in optimizing the design of the body's structural parameters.

Gaurav PradipSonawane, et al [1] designed a Hydro Pneumatic Press for pressing sleeve bearing into the circular casting part. The design is verified using FEA analysis. Static structural analysis is performed for this purpose. Bapat&Yousafali [2] designed a 30 ton press using numerical calculations and verified the results by performing static structural analysis for finding the stresses.Chauhan&Bambhania [3] used design calculations as well as Static FEA techniques to design the body for a press tool. The analysis is performed in Ansys. A G Naik and N K Mandaygade [4] implemented FEA concepts for optimization of top and bottom frame for hydraulic cotton lint bailing press. Static structural analyses are executed for this purpose. The simulation results are verified through calculations.Malleswara Swami, et al [5] used FEA to optimize the machine structure. Static& modal analyses are performed during this process.Watanabe, et al [6] used Static FEA analysis to study the stresses and deformation in punches and dies in deep drawing metal forming process. They verified the results experimentally. Mohamad Majed Saleh [7]discusses the theoretical and experimental model of the machine to establish the accurately optimal design analysis and further development of the present machine at minimum time and

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lower cost. FE techniques are applied so as to validate the result. LUCAS software is used for this purpose and static analyses are executed. In all these cases, static structural analysis helped in verifying and (or) optimizing the design.

The current work aims at studying the stress generated in the press of the heat stacking mechanism in electronic packaging industry using FE techniques so as to optimize it. For this purpose parts are modeled in Creo software while structural analysis in carried out using Ansys. Static structural analysis is executed for studying the stresses.

1. Heat Stacking Process

Heat staking process is well illustrated in [8]. The process involves heat staking involves joining the components at pre molded interfaces. Figure 1 illustrates the heat stacking process. The process involves the use of pressure load along with so as to join two components. In other words a press is to be used for this purpose. In the current work, optimization of heat staking mechanism for sealing bottles with aluminum foils is executed. For this purpose a high rate press is used. The current work is aimed at optimizing the press design and thus increasing the tool life of the press. For this purpose, static analysis is carried out using existing and modified designs. The description of assemblies is given in next section.

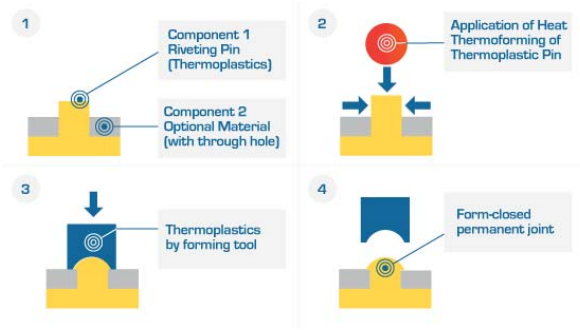

Figure 1: Heat Stacking Process

2. Heat Stacking Assembly.

The Heat Stacking Assembly is modeled in creo. Figure 2 shows the existing heat stacker model. Figure 3 shows the heat stacker model idealized for analysis. Table 1 gives the bill of materials for a conceptual model (as in Figure 2).

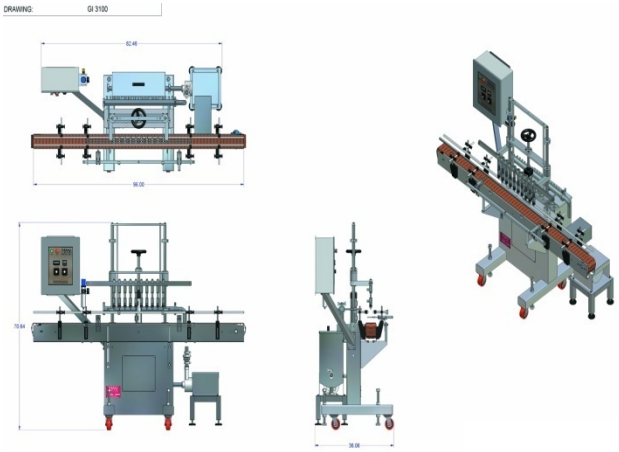

Figure 2: Drawings of existing heat stacker

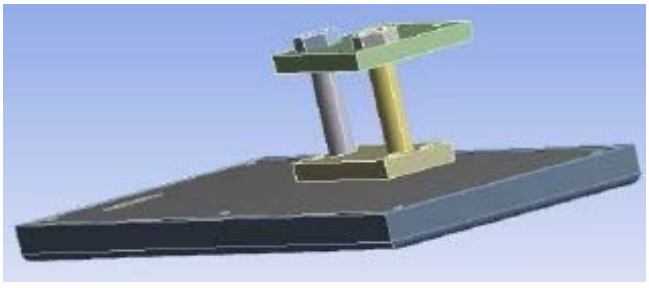

Figure 3. Model idealized for FE Analysis

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#	Part Name	Type	Qty	Material	Weight **(KG)**
HEAT_STACKING_ASEMBLY_N					
1	ball screw	b/o	1		6
2	stepper motor_	b/o	1		8.6
3	motor_mtg_plate_1	mnf	1	steel	2
4	bearing_blocl-mtg_plate	mnf	2	steel	4
5	motor_mtg_plate	mnf	1	steel	2
6	guide_mtg_plate	mnf	1	steel	10
7	height_adjustment_assly	b/o	1	steel	-
8	linear guide	b/o	1		-
9	stacking unit	-	1	steel	-
ball screw					
1	Ball screw	b/o	1	steel	-
2	Ball screw nut	b/o	1	steel	-
3	linear_guide_brg_block	b/o	1	steel	-
stacking unit					
1	stacking_support_plate	mnf	1	steel	8
2	cxsl20-60	b/o	1		-
3	cxsm15-25	b/o	1		-
4	cutting_support_1	mnf	1	steel	8
5	heat_stacking_plate_asm	mnf	1	steel	8
6	block_ballscrew	mnf	1	steel	6
7	sliding_guide_mtg_plate	mnf	1	steel	5
heat_stacking_plate_asm					
1	heat_staking_part	mnf	1	steel	8
2	staking_top_plate	mnf	1	steel	8
3	spring_base_block	mnf	1	steel	1
4	spring_guide_rod	mnf	2	steel	2
6	plate_1	mnf	1	steel	3
7	nut_93414	mnf	2	steel	-
8	spring	b/o	2	steel	
4	spring_guide_rod	mnf	2	steel	2
6	plate_1	mnf	1	steel	3
7	nut_93414	b/o	2	steel	-
8	spring	b/o	2	steel	-
Total load of heat stacking					96.6 kg

Table 1: BOM of Heat Stacker

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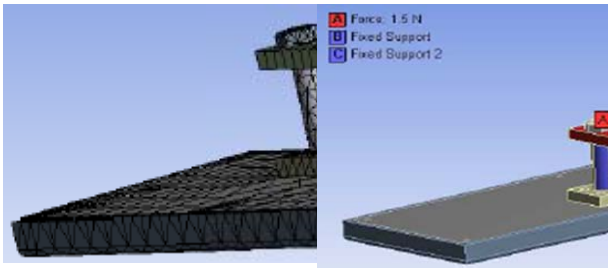
The heat stacking Mechanism for sealing the bottle opening by aluminum foil should be continuous without interrupting the flow.For this purpose high rate press that is pneumatic press the pneumatic press which use to move the mechanism up and down position to seal the bottles is used.The present conveyor in heat staking machine stops for a while for stacking the bottle opening and it takes 2 to 3 seconds to complete the stacking process. There is considerable deformation observed in the press of the tool. FE analysis is used to find the deformation due to sudden pressure. This process is simulated in static analysis for simplifying the problem as many authors, listed in introduction, have done.

3. FE Analysis of Heat Stacking Assembly

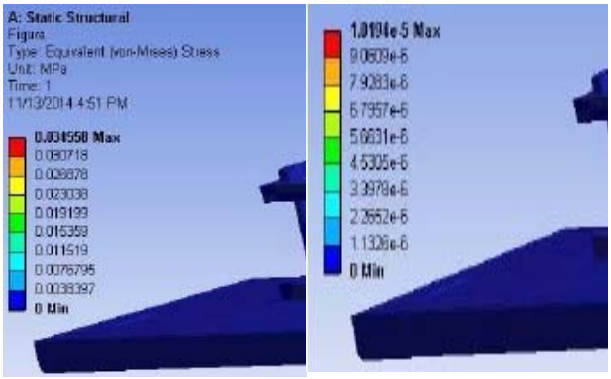
When pressure is being applied on the loading block for heat stacking, it behaves like a cantilever. The loading block is supported on a two busing which are in turn supported on the heating member. The meshed model of the exiting assembly is shown in figure 4(a). Figure 4(b) shows the loads and boundary conditions used for analysis. Figure 5 shows the equivalent stress plot and resultant deformation. Max deflection is observed to be 1.05e-5mm. In order to reduce this deflection a spring is placed instead of busing. Figure 6 shows the modified assembly. Static analysis is executed on the assembly. Figure 7 shows the deflection in the assembly. It can be observed that the total force is completely transferred to the spring which in turn transfers it to press making the machine more efficient.



(a) Meshed model of existing Model

(b) Loading and Boundary conditions of existing model

Figure 4: Existing model preprocessed for FE Analysis



(a) Equivalent stress

(b) Deflection plot

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Figure 5: Result Plots for Existing Model

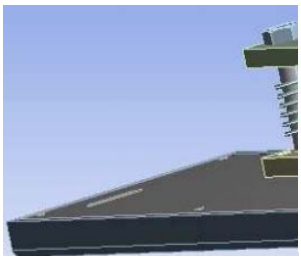

Figure 6: Modified Model

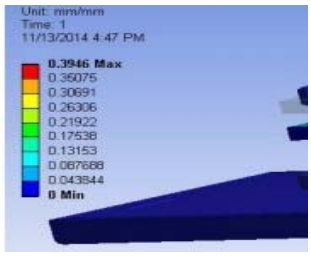

Figure 7: Deformation

CONCLUSIONS

Heat stacking mechanisms are commonly used in food industries to seal bottles with aluminum foils. The packaging rates are so high and thus the components in such a way that there is minimal wear and tear as well as minimal loss of energy. In the current work, a Heat Stacking Mechanism is taken and optimized by adding springs. Initially the deformation in the loading member are 1.105e-5mm indicating that there is some loss of energy. These busing are now replaced with springs which store energy when pressing and release it when the press is releasing and thus recovering some waste energy.

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