International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 3 Issue: 2
ISSN: 2321-8169
109– 112

A Review on Optimization and Design of Corrugated Sheet Box Size for an Industrial Part

Nilesh V. Kalyankar
Dept. of Mechanical Engg.
YCCE, Nagpur,(India)
kalyankarnilesh1143@gmail.com

Sachin G. Mahakalkar
Asst.Prof. Dept. of Mechanical Engg.
YCCE, Nagpur,(India)
sachu_gm@yahoo.com

Abstract— Corrugated paper produced in large volume for packaging purpose an application which place high demand on it's strength and structural stability of the corrugated sheet box. while studying the various industrial boxes it observe that the deformation of the boxes and strength are weak in load bearing capacity.so in this paper all the deformation and strength will be calculate by Reduce the clearance and change in dimension of actual corrugated sheet box. This is find out by using optimization procedure for reducing the area and specific weight of corrugated board by using FEA. The present study focused on the optimization of the corrugated sheet box.

Keywords- *corrugated sheet box, finite element analysis, packaging, strength, craft paper.*

*****

I. INTRODUCTION

Corrugated containers are the most important structural application of paperboard. Corrugated cardboard is a paper based material consisting of a fluted corrugated sheet and one or two flat linerboards. It is widely used in the manufacture of corrugated cardboard boxes and shipping containers. We all know corrugated board as used in boxes, but its origin is something different. In the 19th century, hand-cranked corrugated roller presses were used to generate corrugated paper. Corrugated paper replaced the plain paper which was used to keep the shape of the tall, stiff hats worn by gentlemen. It is a machine which is used to crease the corrugated sheet and along that creased edges, the sheet is folded to make the box. Corrugated cardboard pertaining to papers family is one of the most used packing currently. This success is due to the various virtues of this material: good protection of the product, low cost and can be recycled as well as biodegradable. Biodegradable product are more and more demanding as being a major concern again the protection of the environment and hence respect a durable development. A transport package is required to be strong and light weight in order to be effective cost.
Furthermore, it should be recycled because of environmental and economical. In its most common form single-wall board, two face sheets, called liners, are bonded to a wave shaped web called fluting or medium. The resulting pipes make the board extremely stiff in bending and stable against buckling in relation to its weight. Consequently, the strength of the wood fibers in the board is also utilized in an efficient way.

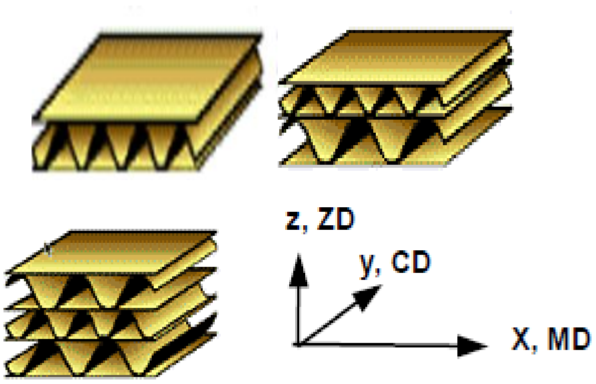

Fig. 1 Types of corrugated board a) Single wall b) Double wall c) Triple wall.

The fluting lines are oriented in the cross-direction (y, CD) of board production. The orientation of the board in-line with production is called machine-direction (x, MD). Orientation through the thickness of the board is denoted Z-direction (z, ZD). FE-based simulation has been increasingly used in the last decades as the main structural analysis tool in many different industrial sectors and, in combination with other numerical techniques and tools. In general terms, compression strength can be considered as the most important requirement of a package, or at least the one that is common to all package types, as during transport and storage, any box has to support without damage the weight of the rest of the supported boxes; thus, initially, corrugated board industry has considered FEM as a possible tool for replacing the traditional application of semi-empirical expressions.

II. LITERATURE REVIEW

M.A. Jimenez-Caballero and I. Conde explained through a set of application examples, shows how different Abaqus modeling capabilities can be applied for solving the different problems that arise when modeling corrugated board. The integration of these capabilities has led to the development of virtual prototypes for the two most common corrugated board packages boxes and agricultural trays. From the experience in these box types and taking advantage from the inherent modeling simple of the composite layered models together to the flexibility offered by the available modeling techniques in Abaqus, these virtual prototypes have been extended as a design tool for very different types of corrugated board packages. Abaqus provides the required framework for the development of a virtual prototyping framework for the corrugated board industry. Presented results shows that this application offers possibilities ranging from selection of flute geometry, to detailed design of package geometry for a set of given requirements [1].

Daxner, Flatscher An application which places high demands on the structural stability of the employed corrugated board containers. This is taken into account in the optimization procedure for reducing the area-specific weight of corrugated board which is presented in this paper. For predicting effective properties of corrugated board designs, the geometry of the board is discretized by finite shell elements, and a minimum wall is used for this purpose. By application of appropriate periodicity boundary conditions, the effective mechanical behavior of a theoretically infinite board can be predicted within the limits of linear shell theory. Furthermore, local loss of stability can also be calculated. Numerical optimization schemes were then used to produce improved corrugated board designs by iteratively changing the principal geometrical parameters of the corrugated board in the sense of a sizing optimization. Compared to reference geometries a 15.5% weight reduction was achieved for the board made from isotropic material and a 18.2% weight reduction was achieved for the board made from orthotropic material [2].

Arsalan Jamialahmadi studied vibrations and shocks acting on pallets during transportation are transferred to the corrugated boxes and considerably reduce the integrity and life time of the boxes. In this present a technique used for investigation these stress based on a pressure sensitive film, which gives many data point. Study on the forces existing between the boxes shows Rayleigh force system. In this use I-scan system for load distribution analysis. Hysteresis and drift effects in the I-scan be accounted for in static condition but in dynamic testing, statistical measures should be used to estimate the error [3].

Tomas Nordstrand A panel compression test (PCT-) rig, The PCT-rig furnishes simply supported boundary conditions, i.e. the edges of the panel are prevented from moving out-of-plane without any rotational restraint. The first part of the expression is similar to ordinary Euler buckling of a column, where the maximum compressive load is limited by the critical buckling load. In the second part of the expression the membrane forces produce a parabolic relationship between the compressive load and out-of-plane displacement. The results show an 18 % difference between experimentally estimated critical buckling load and the analytically predicted critical buckling load for orthotropic plates [4].

P. Patel, Nordstrand, and Carlsson, L.A. in this paper an experimental study of failure corrugated boxes under combined stress has been performed. The effective collapse stresses of the board in the absence of local buckling were predicted from stress analysis of the cylinder in combination with the Tsai-Wu failure criterion [5].

T. Nordstrand, Blackenfeldt, M. and Renman, M. A method for prediction of the top-to-bottom compression strength of corrugated board containers using finite element analysis was developed. Up to triple-wall corrugated board is accommodated in the finite element model. In order to keep computational time down, the corrugated main layer is considered to be homogeneous with effective material properties, and the complete corrugated board is represented by a multi-ply eight node isoparametric shell element. Buckling and large displacements are considered in the analysis, and container collapse loads are predicted using the Tsai-Wu failure criterion [6].

Zhiguo Zhang, Tao Qiu, Riheng Song and Yaoyu Sun the study based on nonlinear finite element analysis of the fluted corrugated sheet in the corrugated cardboard based on software SolidWorks2008. The model of corrugated board with three or more flutes is reliable for stress and displacement measurement to eliminate the influence of the number of flutes in models. According to the static pressure test, with the flute height H and radius increased, the maximum stress in the models decreased and the maximum displacement increased. the maximum stress and maximum displacement in the models increase nonlinearly. The optimal flute angle θ could be 60∘ for corrugated board [7].

Adeeb A. Rahman This study focused on the glue material in a finite element model that represents the actual geometry and material properties of a corrugated fiberboard. The model is a detailed representation of the different components of the structure (adhesive, linerboard, medium) to perform buckling analysis of corrugated structures under compressive loads. An increase in the modulus of elasticity of the adhesive increases the buckling strength of the fiberboard up to 50% when adhesive modulus is 20 times greater than linerboard modulus. A decrease in adhesive properties relative to the linerboard stiffness does not change the fiberboard strength in a dramatic way, provided that a perfect bond is still present between components. This behavior can be explained by the load sharing principle [8].

R. C. McKee, J. W. Gander, and J. R. Wachuta The top-load compression strength of vertical flute, corrugated boxes which are not extremely short depends on the edgewise compression strength of the combined board, the flexural stiffness of the combined board in both principal directions, And the box perimeter. A common method of determining flexural stiffness is by testing a specimen of material as a centrally-loaded (three-point) beam. The test results from this type of beam test reflect both the flexural stiffness and the shear rigidity of the material [9].

III. DESIGN OF CORRUGATED BOX

All the corrugated sheet box design in three parameters

LENGTH X WIDTH X HEIGHT (MM)

A) Design of first box

the product dimension is

630 x 600 x 880 outer size of box is 670 x 640 x 920

And inner dimension of box is 660 x 630 x 910.All the dimension are in mm.

Weight of the product present in the box is 30kg and the maximum load on the bottom side of the box and the box is 7ply.Paper used for the upper layer of box is 200gsm and inner layer is 120gsm and B type of flute is used is also called narrow flute.

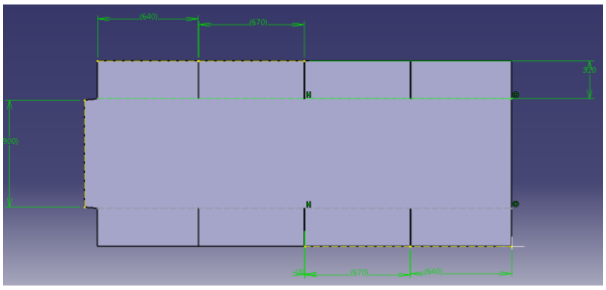

Fig.2. Sheet of box

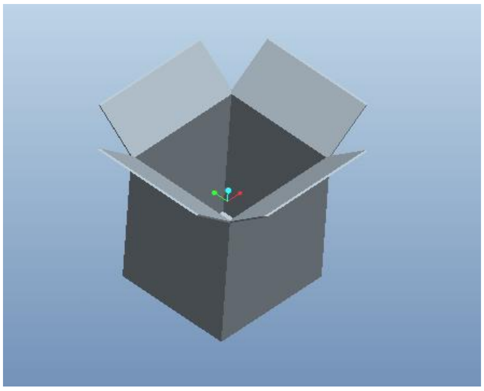

Fig.3. model of first box

AREA OF THE BOX

L+W+50-----(1)

W+H+25-----(2)

A= (1)x(2)mm^2

670+640+50=1360

640+920+25=1585

A=1360 x 1585

=2155600mm^2

Area=2.2 m^2

WEIGHT OF THE BOX

W=Area x Used paper

Used paper for outer layer is 200gsm and for inner layer is 120gsm and for flute paper it is 40% more than that of plane paper.as the box is 7ply so there are 4 plane layer and 3 flute present.

For upper layer 200x1=200gsm

Inner layer 120x3=360gsm

For flute layer 168x3=504gsm

Since the total paper is 1064gsm

Weight = 2.2 x 1064

=2340

Weight of box is 2.3 kg

B) Design of second box

the product dimension

400 x 400 x 250 outer size of box is 440 x 440 x 290

And inner dimension of box is 430 x 430 x 280. All the dimension are in mm. this box is also 7ply and weight of product is 20kg.flute type is narrow flute also called B-flute.

AREA OF THE BOX

L+W+50-----(1)

W+H+25-----(2)

A= (1)x(2)mm^2

440+440+50=930

440+290+25=755

A=930 x 755

=702150mm^2

Area=0.7 m^2

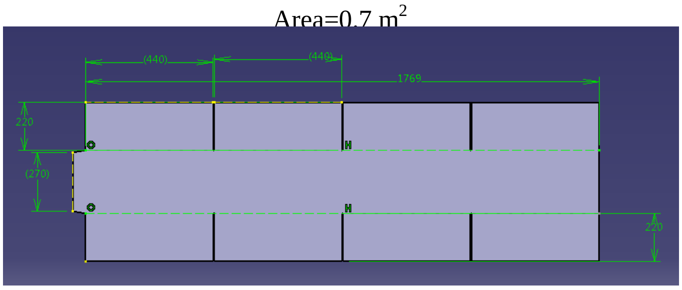

Fig. 4. Sheet of box

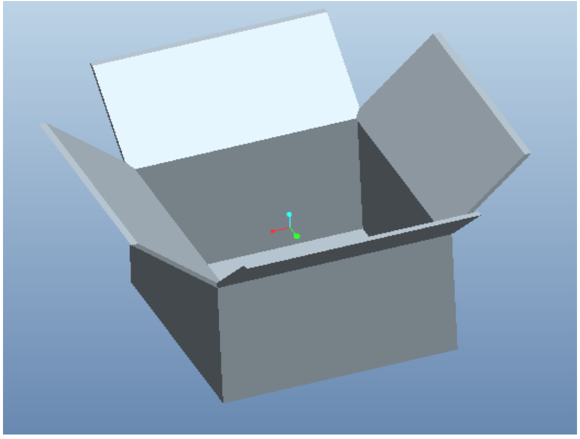

Fig. 5.model of second box

WEIGHT OF THE BOX

W=Area x Used paper

Used paper for outer layer is 200gsm and for inner layer is 120gsm and for flute paper it is 40% more than that of plane paper.as the box is 7ply so there are 4 plane layer and 3 flute present.

For upper layer 200x1=200gsm

Inner layer 120x3=360gsm

For flute layer 168x3=504gsm

Since the total paper is 1064gsm

Weight = 0.7 x 1064

=744.8

Weight of box is 0.744 kg

IV. CONCLUSION

From above papers it concludes that there are various methods for calculating failure in the corrugated sheet box under compression and tensile load and the buckling constraints gives set of parameters which describe a new design, But this paper is focuses on the minimizing the box size and optimization of box clearance. So, by using FEA we will be carrying out the further calculation on the basis of strength and dimensions. The calculated FEA dimensions are compared with actual dimensions on the basis of strength.

REFERENCES

[1] M. A. Jiménez-Caballero, I. Conde, B. García, E. Liarte *"Design of Different Types of Corrugated Board Packages Using Finite Element Tools"C/ María de Luna 7-8, 50007 Zaragoza. SPAIN*

[2] Daxner, Flatscher, and Rammerstorfer, F.G. *"Optimum Design of Corrugated Board under Buckling Constraints" COEX Seoul, 21 May - 25 May 2007, Korea*

[3] Arsalan Jamialahmadi "*Experimental and numerical analysis of the dynamic load distribution in a corrugated packaging system" mechanical engineering at blekinge institute of techonology jan 2008-aug 2008*

[4] Tomas Nordstrand *"Analysis and Testing of Corrugated Board Panels into the Post-buckling Regime" SCA Research, Box 716, 851 21 Sundsvall, Sweden*

[5] P. Patel, Nordstrand, T. and Carlsson, L.A. "*Local Buckling and Collapse of Corrugated Board under Biaxial Stress" Composite Structures, Vol. 39, No. 1-2, pp. 93-110, 1997*.

[6] T. Nordstrand, Blackenfeldt, M. and Renman, M. "*A Strength Prediction Method for Corrugated Board Containers" Report TVSM-3065, Div. of Structural Mechanics, Sweden, 2003.*

[7] Zhiguo Zhang, Tao Qiu, Riheng Song and Yaoyu Sun "*Nonlinear Finite Element Analysis of the Fluted Corrugated Sheet in the Corrugated Cardboard" Hindawi Publishing Corporation Advances in Materials Science and Engineering Published 23 July 2014*

[8] Adeeb A. Rahman *"adhesive in the buckling failure of corrugated fiberboard: a finite element investigation" Department of Civil Engineering Eastern Mediterranean University Vol. 1: 533-539*

[9] R. C. McKee, J. W. Gander, and J. R. Wachuta *"Flexural stiffness of corrugated board" The Institute of Paper Chemistry, Appleton, Wisconsin*