Scientific Journal of Impact Factor(SJIF): 3.134

e-ISSN(O): 2348-4470
p-ISSN(P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 2,Issue 7, July -2015

Energy based Analysis to avoid Box Tipping

Umama Shaikh[1], Abdullah Khan[2], Murtuza Chasmawala[3], Balaji Subramaniam[4], Aun Siddiqui[5]

[1]Department of Mechanical Engineering, MH Saboo Siddik College of Engineering
[2]Department of Mechanical Engineering, MH Saboo Siddik College of Engineering
[3]Department of Mechanical Engineering, MH Saboo Siddik College of Engineering
[3]Department of Mechanical Engineering, Bharathidasan Institute of Technology
[3]Department of Mechanical Engineering, MH Saboo Siddik College of Engineering

Abstract — *The shipping of goods are on high since the advent of shipping goods for e-commerce. Such manufacturers usually ship goods in packing crates that are eventually strapped down on pallets for handling purposes. During shifting of such goods, the manufacturers may face a problem of the box getting tipped over due to mishandling and thus the goods therein may get damaged which increases the overall cost of handling. This paper proposes an energy analysis to avoid the box getting tipped, thus saving the experimental and handling costs while transportation of such goods.*

Keywords-*energy analysis; pallets; box tipping; potential; impact; packing; centre of gravity*

I. INTRODUCTION

It is a common practice for manufacturers to ship their products in packing crates that are strapped down on pallets for handling. There is often concern about the stability of this package as it is handled in transit to the purchaser. For this problem, we understand that the manufacturer wants to perform a simple test on each package shipped to assure that it will not tip over in transit. The test will consist of tipping the package slightly to the left and placing a block under the right edge of the pallet. The block is then quickly pulled out and the question is whether or not the package will fall over to the right. The answer depends upon the amount of the initial tip to the left and the location of the center of mass of the combined packing crate and pallet. It is clear that the falling box impacts the floor, causing an impulsive distributed load to act on the bottom of the package. This will apply both an impulsive upward force and an impulsive moment to act on the box. Since the actual distribution of the force is unknown (and unknowable), an impulse.momentum approach to this problem is not likely to get very far. There is, however, a much simpler energy analysis available.

II. ENERGY BASED ANALYSIS OF TIPPING POTENTIAL

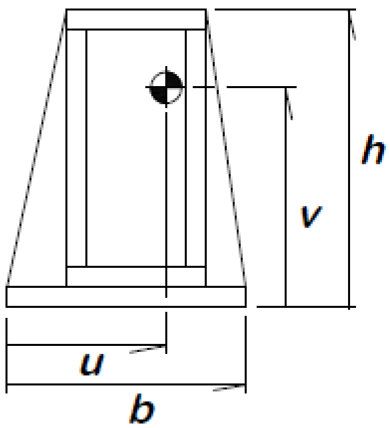
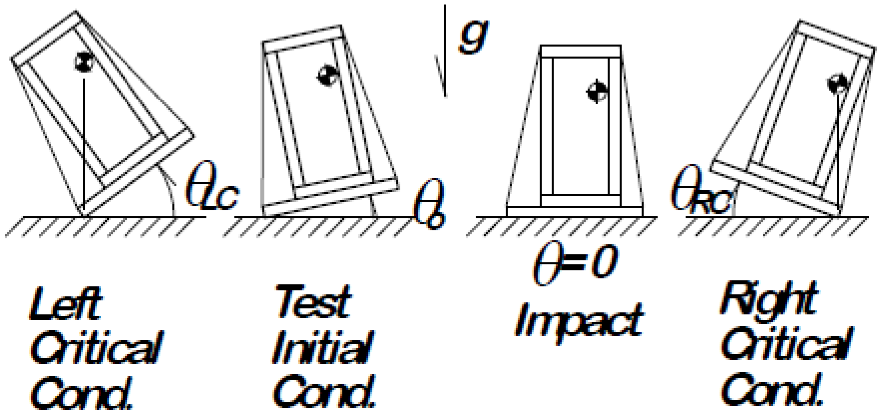


Fig1. System

Consider a box, strapped to a pallet, as shown in the figure below. The assembly overall dimensions are b x h, and the composite center of mass is located at (u; v) as indicated. Four states are considered as shown in Fig. 2 below. The initial condition of the test is the second state shown in this sequence.



A. Left Critical Condition

The left critical condition is the limiting position to avoid tipping the box to the left. It is apparent that the initial test condition, $\theta = \theta o$ must be such that $\theta o \leq \theta LC$. In the left critical condition, the center of mass is directly over the left edge. Thus

$$\theta LC + \arctan(v/u) = \pi/2$$

or

$$\theta LC = \pi/2 - \arctan(v/u)$$

The initial test condition must not raise the box any more than this; if it does, the whole assembly will fall to the left.

B. Test Initial Condition

In the test initial condition, the box is at rest but the center of mass is elevated. The potential energy of the box is

$$VTIC = Mg\ (u \sin \theta o + v \cos \theta o - v)$$

with respect to the position $\theta = 0$. The initial kinetic energy of the box is

$$TTIC = 0$$

because the box is at rest. This is where the test begins.

C. Impact

When the box is released from rest in the initial condition, it falls to the floor where impact occurs. The impact is a complicated process, involving a distributed impulsive loading on the base of the pallet and acting for a very short, but indeterminate, time interval.

From the initial release down to the instant of impact, energy is conserved. Therefore,

$$TTIC + VTIC = TImpact\ Initial + VImpact\ Initial$$

Because this position is the reference state for potential energy
VImpact Initial = VImpact Final = 0.

Thus
$$TImpact\ Initial = VTIC = Mg\ (u \sin \theta o + v \cos \theta o - v)$$

Real impacts always involve the loss of some energy, but the amount is difficult to quantify.

In the limiting case, energy is conserved in an impact, so that

$$TImpact\ Final \leq TImpact\ Initial = Mg\ (u \sin \theta o + v \cos \theta o - v)$$

D. Right Critical Condition

The right critical condition is reached when the box is on the verge of tipping to the right. At this condition, the center of mass is directly over the right edge of the pallet as shown in the fourth image of Fig. 2. At this position, the angle θRC is such that

$\theta RC + \arctan(v/b\text{-}u) = \pi/2$

or

$\theta RC = \pi/2 \arctan(v/b\text{-}u)$

In the right critical condition, the potential energy of the box is

$VRC = Mg\,[(b - u)\sin\theta RC + v\cos\theta RC - v]$

and the kinetic energy is

$TRC \geq 0$

where the equality represents the limiting condition.

E. Resolution

If the total energy at the end of impact sufficient to reach the right critical condition, then the box will tip over; if it is not, the box cannot tip. Thus, to assure that the box does not tip,

$TImpact\ Final < VRC$

$Mg\,(u\sin\theta o + v\cos\theta o - v) < Mg\,[(b - u)\sin\theta RC + v\cos\theta RC - v]$
$u\sin\theta o + v\cos\theta o - v < (b - u)\sin\theta RC + v\cos\theta RC - v$
$u\sin\theta o + v\cos\theta o < (b - u)\sin\theta RC + v\cos\theta RC$

As long as this relation is satisfied, the box will not tip, even with energy conserved in the impact process. For specified values of b; u; v it is possible to solve this relation for the maximum value of θo; the most extreme test condition that will not tip the box. Conversely, for given dimensions and θo, it is possible to test whether or not the box tips.

The important variables here are
θo = initial tilt angle to the left
b = width of the pallet base
u = horizontal position of the combined center of mass
v = vertical position of the combined center of mass.

With these four parameters specified, the non-tipping of the package can be assured, provided that the last inequality above is satisfied. This removes the need for the actual test to be performed at the risk of damage to the package.

III. REFERENCES

[1] W. F. Riley and L. D. Sturges, *Engineering Mechanics: Dynamics*, 2nd ed., New York: John Wiley and Sons, 1995
[2] S.Graham Kelly, Mechanical Vibrations, Tata McGraw Hill, 2007, pp.68–73.
[3] Anti-tipping storage box for eyeglasses and the like, US 6626287 B1, Grant, US 10/131,341
[4] S.B.Junnarkor," Mechanics of Structures Vol.I", 17th Edition,
[5] V.Natarajan ," Elements of Applied Mechanics", Oxford & IBH Publishers
[6] Vazirani & Ratwani,"Analysis of Structures Volume I",Khanna publishers,17th ,2003
[7] Dr.N.V.Arunachalam, Textbook of graphics Statics
[8] S.Ramamirtham ,"Strength of materials", Dhanpat Rai, 14th Edition,2003.
[9] Timoshenko and Young," Elements of strength of materials", CBS Publications
[10] R.S.Khurmi," Strength of materials", S.Chand & company, 2nd Edition,1979.
[11] S.A.Urry," Solution of problems in strength of materials", Sir. Isaac Pitman & sons Ltd.
[12] R.L.Jindal," Elements of Theory of structures", S.Chand & company, 2nd Edition,1970.
[13] Dr.A.Elangovan ," Engineering mechanics Tamil version", - Anna University

