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TESTING EQUIPMENT FOR THE IMPROVEMENT OF MECHANICAL DEVICES TO MINIMIZE DAMAGE TO FRUIT IN COMMERCIAL PACKING LINES

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SUMMARY

Damages produced in fruit packing lines is a major cause of grade reduction and quality loss in fresh market fruit. Fruit must be treated gently during their handling to improve their quality in order to get a good price in a competitive market. The correct post-harvest handling in fruit packing lines is a prerequisite to cut down the heavy post-harvest losses. Fruit packing lines must be evaluated, studying their design, the impacts applied to the fruits, the characteristics of the materials, etc. This study establishes the possibility of carrying out modifications and tests in a packing line during a long period of time. For this purpose, an experimental fruit packing line has been designed and located in the Agricultural Engineering Department of the Polythecnic University of Madrid with the aim of improving mechanical devices and fruit handling conditions to minimize damage to fruit. The experimental line consists of several transporting belts, one rollers transporter, one sizer, one elevator, one singularizer, and three trays to receive the calibrated fruit. The line has a length of 6.15 m and a width of 1.9 m. Movement of the different components is regulated by electric motors with variable velocity electronically controlled. The height of the transfer points is variable and can be easily modified. The experimental line has been calibrated using two instrumented spheres IS 100 (8.8 cm ∅ and 6.2 cm ∅). Average acceleration values obtained in all the transfers of the experimental line lay under 80 g's, although there is big variation for some of them being some values above 100 g's.

Key words: fruit handling, instrumented sphere, impact damage, transfer points, fruit quality, packing lines

INTRODUCTION

Quality of fruits is one major factor to consumer acceptance in the European Union. The fresh produce industry is a prime example where handling and process quality control coupled with fruit quality are essential (Brown et al., 1987).

The role of the packer is to maintain and, in some cases, enhance fruit quality. Therefore, damage in handling, should be minimized in packing lines (Miller and Wagner, 1991).

The main objective of this work has been the design and to put in operation an experimental packing line with the aim of improving mechanical devices and fruit handling conditions to minimize damage to fruit. This is posible to do sistematically in an experimental unit and very difficult to achieve in a commercial packing line where stops for modifications and trials are not accepted.

Instrumented spheres have been used for identifying and eliminating sources of bruise damage. Instrumented spheres and normal fruit are used for the tests, although in this paper only the results with an instrumented sphere are given. For most fruits accelerations above 50 g" are cause of damage that produces bruises above 1 cm^2 which represents the lost of EU-Grade I (in the case of apples and pears).

EXPERIMENTAL METHODS

The experimental packing line (Fig. 2) has a length of 6.15 m and a width of 1.9 m and is composed of several transporting belts, one singularizer, one sizer, one elevator, one roller transporter and three trays to receive the calibrated fruit. All the components can be modified in relation to the height of transfer and the velocity of operation, regulated by electric motors (with a power between 0.25 and 0.5 CV) with variable velocity, electronically controlled.

The elements of the experimental line are disposed forming a circuit, in a way that a fruit can be led to the receiver trays or be recycled obtaining different characteristics of work, number of transfers and total distance covered, similar to those existing on a real packing line.

In transfers T1 and T2 it is possible to install decelerators like a curtain or a rotating brush made of plastic filaments. The speed of the elements of the packing line has been calibrated by means of a digital tachometer ONO SOKKI HT-5200.

The main instrumentation used in this study were two commercial instrumented spheres IS (Zapp. et al., 1990): the first one 300.6 g of mass and 8.8 cm Ø (IS 100 G) and the second 114.7 g and 6.2 cm Ø (IS 100 P).

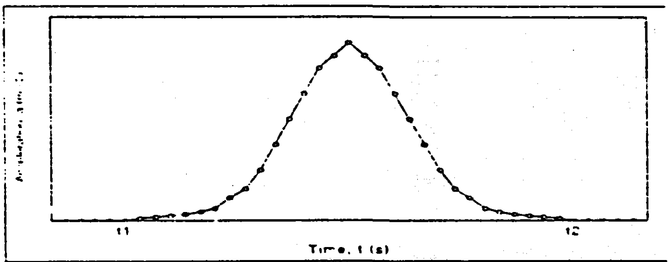
The instrumented sphere IS holds a triaxial accelerometer, a timer, a battery and a memory. To study the operation of a packing line the IS is initialized (put the internal timer at zero), and placed in the line at the point where the measurement is needed. The

IS travels alone or together with the rest of the fruit through the different elements of the packing line (García et al., 1996). A manual time log of the IS location is kept to later identify sections of the line that cause damaging impacts. Upon retrieval of the IS from the packing line, the data is uploaded from the IS to a personal computer (PC) for the analysis.

A computer program that comes with the IS, provides information of the peak acceleration and velocity change for each impact in relation to time.

Peak acceleration is defined as the maximum acceleration value for each impact. Each impact data is registered as acceleration of gravity units (g's) where 1g = 9.8 m/s^2.

Velocity change is the area under the acceleration vs. time curve during the impact (Fig. 1).



$$\Delta v = \int_{t_1}^{t_2} a \cdot dt \quad \text{(m/s)}$$

Δv = velocity change

a = acceleration (m/s^2)

t = time (s)

Figure 1. *Graphical definition of peak acceleration and velocity change for an impact*

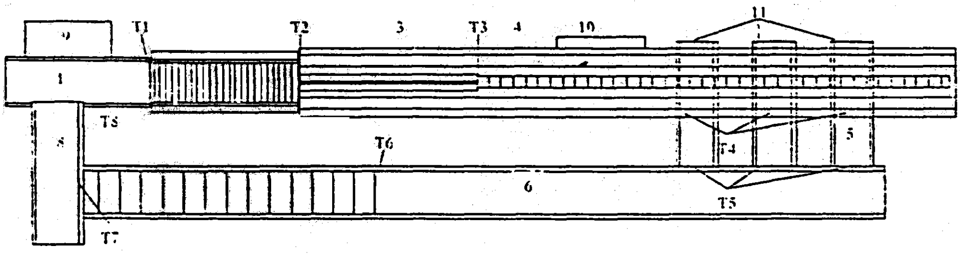
Peak acceleration and velocity change are parameters used to predict the degree of bruising. The higher the acceleration (big force of impact) and the lower the velocity change (quick rebound) the larger the bruise in the fruit as has been demonstrated by several authors (Zapp et al. 1989).

Figs. 3.3 and 3.4 show the curves of change of velocity vs. peak acceleration of the IS impacting into steel, foam 3.2 mm (P20125) and foam 6.4 mm (P15250) of thickness.

Schulte (et al., 1992) concluded that most packing line impacts ranged from 20 to 130 g for peak acceleration and from 0.1 to 3 m/s for velocity change.

The results given in this paper correspond to the values obtained with the larger instrumented sphere IS 100 G traveling through the experimental packing line.

Table 1 gives the values of the height for each transfer point and the speed of each element of the packing line.



Elements

1. Transporting belt	2. Roller transporter	3. Singularizer	4. Sizer
5. Three transporting belts	6. Transporting belt	7. Elevator	8. Transporting belt
9. Supporter for fruit boxes	10. Control electric box	11. Three collecting trays	

Transfer points

T1: from 1 to 2	T2: from 2 to 3	T3: from 3 to 4	T4: from 4 to 5 or to 11
T5: from 5 to 6	T6: from 6 to 7	T7: from 7 to 8	T8: from 8 to 1

Figure 2. *Experimental fruit packing line*

Table 1. *Heights of transfer points and speeds of elements of the packing line.*

Transfer points	T1	T2	T3	T4	T5	T6	T7	T8
Height (cm)	13.5	21	6	24	8	9	15	14
Elements	1	2	3	4	5	6	7	8
Speed (m/min)	32.7	20	39	37.8	14.6	39	44.7	32.1

RESULTS AND DISCUSSION

Graphs obtained

The results obtained with the instrumented sphere IS 100 G are presented in three different types of graphs (Fig. 3):

- Impact acceleration (Fig. 3.1): the range of impact acceleration (g's) in each transfer point of the packing line is shown.
- Impact probability (Fig. 3.2): the histogram represents the probability that a fruit suffers a impact with an acceleration higher than 50 g's, 100 g's or 150 g's.
- Impact distribution (Figs. 3.3 and 3.4): the values of change of velocity (m/s) vs. peak acceleration (g's) for each transfer point are represented, taking as reference the curves for steel, foam 3.2 mm and foam 6.4 mm as impact surface materials.

Results analysis

The mean values of the impact accelerations of the instrumented sphere IS 100 G in all transfer points are under 80 g's, although there is a large variation for some of them

(T2, T4, and T7). In the case of points T2 and T4 the variation is increased by the presence of two extreme points above 135 g's (Fig. 3.3). However, instead these extreme points, the variation of the impact acceleratios registered by the IS in T2, T4 and T7 is really representative.

Transfer point T2 (roller transporter – singularizer) shows the highest mean impact acceleration (76.2 g's) and also the largest variation (highest value 140 g's). On the other side, in transfer point T6 (transporting belt-elevator) all impact accelerations are below 30 g's.

In transfer points T2, T4, T5, and T7 the instrumented sphere registered the highest values of acceleration impacts. The impact probability above 50 g's is 66.6 % for T2 and 75 % for T7, and values above 100 g's are 16.6 % for T2 and 4.16 % for T4 (Fig. 3.2).

The kind of material against the fruits impacts varies for the different transfers points. In transfer points T1, T4, T5, T6, T7 and T8 the IS impacted against soft surfaces (padding materials and transporting belts) being quite high the values for the change of velocity, but in transfer points T2 and T3 the IS impacted against hard surfaces (support of the singularizer and cups of the sizer), being small the values for the change of velocity.

CONCLUSIONS

The IS has been employed at specific conditions in the experimental packing line, providing an excellent tool for estimating the critical points that may cause damage to fruits.

The overall distribution of peak acceleration and velocity change in the transfer points of the packing line are excellent parameters to predict bruises in fruits. All authors agree that the higher acceleration peak and the lower the velocity change, the larger the bruises in the fruits.

As all components of the experimental packing line can be easily modified in relation to the height of transfer and speed of operation, it can be used to test different mechanical devices to minimize damage to fruits in packing lines.

In the particular case of this study, transfer points T2, T4, and T7 showed the highest values and the biggest variation for the impact accelerations, although the mean values registered by the IS are under 80 g's. The lowest values for the velocity change are for transfer points T2 and T3. Therefore the most critical transfer point of the experimental packing line is T2 (roller transporter – singularizer) and a rotating plastic brush is mounted to guide the fruits softly from one element to the other to minimize damages to the fruits (Fig. 4).

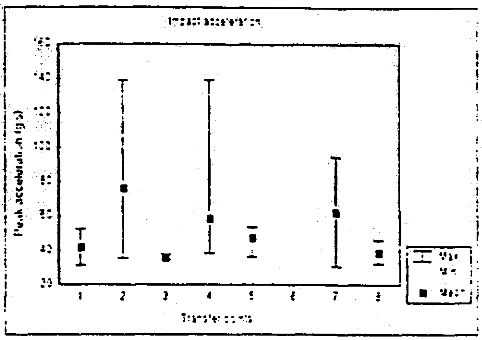


Figure 3.1. *Graph of impact acceleration*

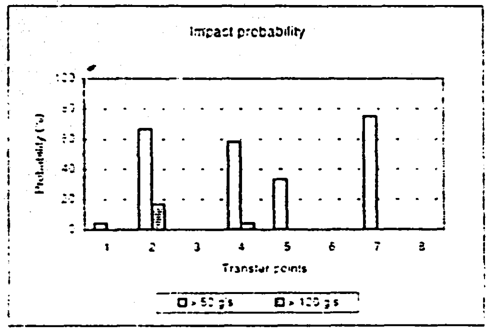


Figure 3.2. *Graph of impact probability*

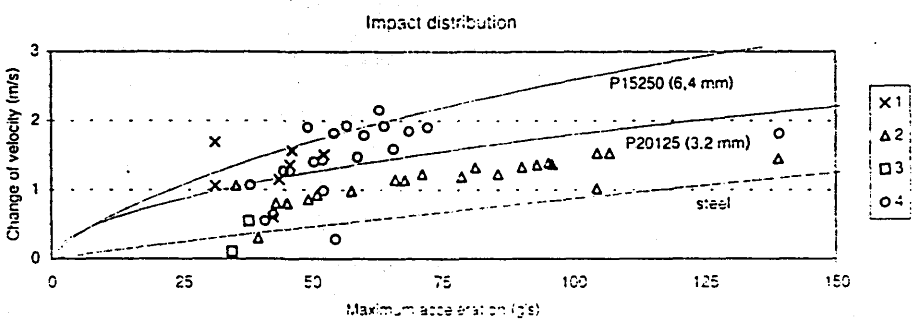


Figure 3.3. *Graph of impact distribution (transfers 1, 2, 3 y 4)*

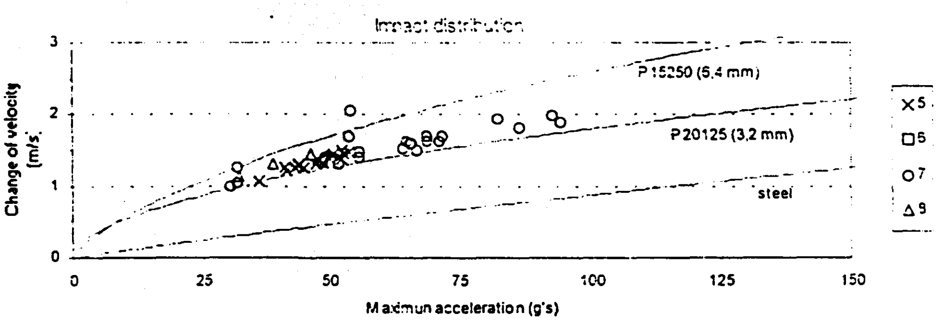


Figure 3.4. *Graph of impact distribution (transfers 5, 6, 7 y 8)*

Figure 3. *Graphs of results obtained with the instrumented sphere*

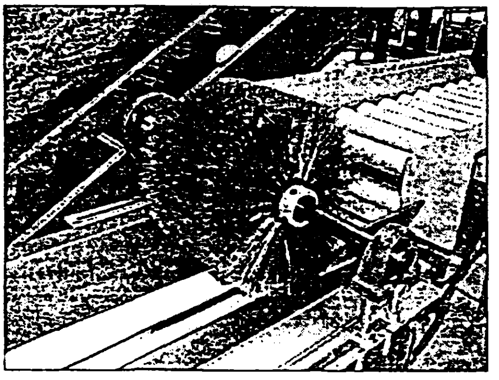


Figure 4. Rotating plastic brush to transfer fruit

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REFERENCES

1. BROWN, G.K., et al., (1987) Apple packing line damage assesment. ASAE paper 87-6515.
2. GARCÍA, F., et al., (1996) Study of packing lines for stone fruits and citrus using two instrumented spheres in some cooperatives in the region of Murcia (Spain). AgEng Madrid 96. Paper 96F-038.
3. MILLER, W.M., WAGNER, C., (1991) Florida citrus packing line studies with an instrumented sphere. Applied Engineering in Agriculture. 7(5): 577-581.
4. SCHULTE, N.L., BROWN, G.K., TIMM, E.J., (1992) Apple impact damage threshold. Applied Engineering in Agriculture. 8(1): 55-60.
5. ZAPP, H.R., et al., (1989) Instrumented sphere performance: dynamic measurements and demostration. ASAE paper 89-0008.
6. ZAPP, H.R., et al., (1990) Advanced instrumented sphere (IS) for impact measurements. Transactions of the ASAE. 33(3): 955-960.