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Research Paper :

Testing and performance evaluation of tractor mounted hydraulic elevator

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ABSTRACT

A Tractor mounted hydraulic elevator (TMHE) powered by tractor PTO was tested for the mechanical harvesting of mango orchards by using digital load cell for stability study. The field performance of the above machine was carried out on plane land on horticultural mango plot, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. - Ratnagiri (Maharashtra, India). This machine was tested for the better stability at maximum reach position during mango harvesting of various mango varities like Alphanso, Totapuri etc. This stability study was carried out by using strain gauge load cell (S-beam) having capacity of 2000 kg. The load cell guiding device was designed and fabricated at College of Agricultural Engineering and Technology Workshop for conducting the above experiments using standard material specifications of American society of testing material. The reaction on rear wheel of tractor was measured by using load cell, which converts the force acting on rear wheel of tractor into electrical signals, which is displayed on the digital control panel. The field capacity of elevator was 0.08 ha/hr for mango harvesting. The net mango harvested by using TMHE was 510 kg/day.

Key words : Tractor mounted hydraulic elevator, Load cell, Mango orchards, Stability

Konkan region is well regarded as fruit belt of Maharashtra. The production of horticultural fruits in India is 63,503,000 MT and 11,047,600 MT in Maharashtra till 2008. Konkan region of Maharashtra is narrow strip of 40 km width and running 750 km of length from north to south lying between sahyadri ranges in the East and Arabian Sea in West. This region is famous for alphanso mango, vengurla cashew nut, kalipatti sapota and shrivardhanee variety of arecanut. The mango is the favourite fruit through out the country and has repeatedly been acclaimed as the "King of fruits". The production and popularity of mango tops the list of fruits. No other country in the world can surpass India in the number of mango varieties and the richness of the flavours. The climate of the country is ideally suited for mango cultivation. Alphanso is a very famous variety of mango fruit all over the world. The manual harvesting of this fruit is drudgerious and time consuming. During peak season, it is very difficult to get required number of skilled labours. Morever, skilled labours for climbing on mango trees are reducing day by day because of drudgery involve in this operation. Hence, the Tractor mounted hydraulic elevator (TMHE) Developed by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli is used for mango harvesting up to 12 m height of tree. The above elevator works on principal of hydraulics and operated by multi position multi direction control valve to control the height of harvesting bucket, position of bucket and angle of rotation of harvesting bucket.

A load cell is an electric device transducer used to convert a force into an electrical signal. It consists of four strain gauges in a whetstone bridge. Through a mechanical arrangement, the sensed force deforms a strain gauge which in turn causes Whetstone Bridge to become unbalanced. This deformation gets converted into an electrical signal and displays on the digital panel. Thus using digital load cell reaction on rear wheel of tractor was measured for testing the performance of TMHE for mango harvesting.

India is the largest mango producing country, accounting about 60 per cent of world production, the export of fresh fruits are limited to Alphonso and Dashehari varieties. India's share in the world mango market is about 15 per cent. Manually operated low capacity gadgets and tree-shaking methods of mango harvesting are time consuming, drudgerious, damage fruits and also damage the tree branches. Mango fruits harvested with 8-10 mm long stalks appear better on ripening as undesired spots on skin caused by sap burn are prevented. Such fruits are less prone to stem-end and other storage diseases (Sapovadia *et al.,* 2001). The mango harvesting was carried out by pluck-and-drop method with a rod of 3 m long pole with a hook at the end. The pole and collection bag method consist of a plucking technique using a rod of convenient length (1 –2 m) equipped with a collecting bag near the hook. The plucked mangos were gathered and selection was made to minimize variation in the sizes. The pluck-and-drop

method was modified by dropping the fruits on foam (foam method) or grass (grass method).

The present study was conducted for the stability analysis of tractor mounted hydraulic elevator for various height of harvesting bucket from ground surface and angle of rotation of harvesting bucket, whereas the performance of TMHE was carried out to predict the actual field capacity of the above machine for mango harvesting.

METHODOLOGY

The stability study of TMHE was conducted using digital strain gauge load cell. The digital load cell (S-beam type) is placed in load cell guiding device with minimum clearance between the two surfaces. The load cell guiding device was designed and fabricated at College of Agricultural Engineering and Technology, Dapoli workshop using mild steel plate of 5 mm thickness. The composition and mechanical properties of selected material for the fabrication of above load cell guiding device are given in Table1. Ref.- *International Journal of Agril. Engg. Vol. 2 No. 2, (Oct. 2009- Mar 2010).*

Table 1: Specifications of 6-20 mm thick mild steel plate

Sr. No.	Chemical composition		Mechanical properties	
1.	C	0.25	Tensile strength (N/mm^2)	410-530
2.	S	0.055	Yield (N/mm^2)	240
3.	P	0.055	Stress elongation (%)	23
4.	Si	-		
5.	Cu	0.20-0.35		

The load cell was placed in middle of load cell guiding device in such a manner that the total load of tractor act on the S-beam of load cell. The load cell with load guiding device was kept below the left rear wheel of tractor and the another load cell guiding device without load cell was placed below the right rear wheel of tractor for balancing of both wheels. The experimental setup of stability analysis is shown in Fig.1. The experiments were carried out in three stages by changing the operating parameters of the elevator.

Stage 1- In this stage the height of elevator from ground surface was kept constant at 1.4 meter. The load inside the bucket was kept 50 kg, for set of this condition different reaction on tractor rear wheel were noted on strain gauge display panel by changing angle of rotation from 0^0 to 360^0 at an interval of 30^0.

Stage 2- In this stage the height of bucket was increased up to 1.7 meter and for varying loads of 50 kg;

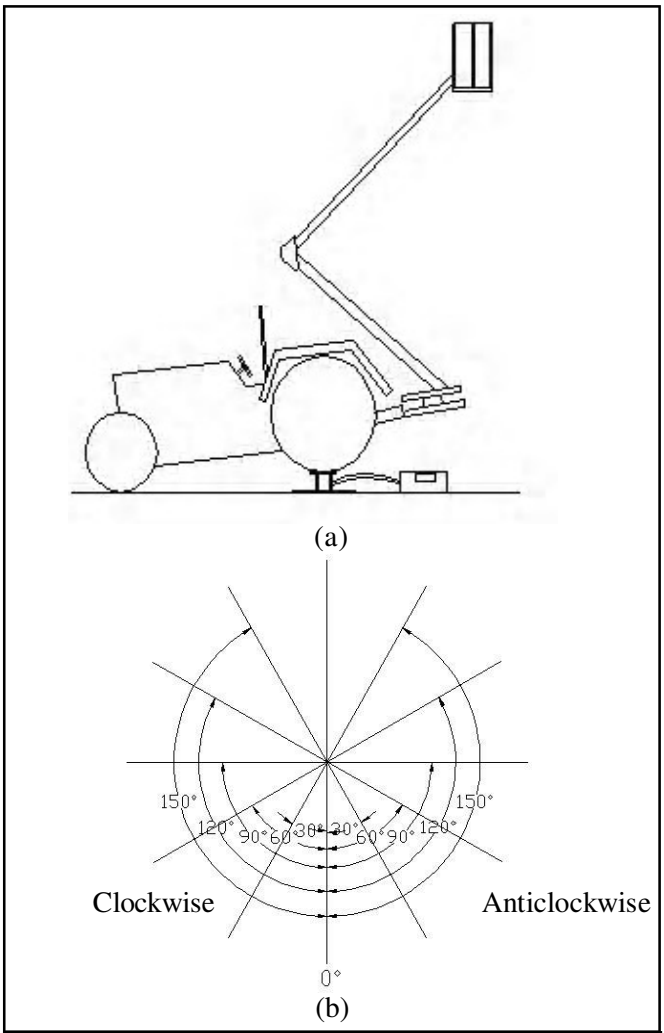

Fig. 1 : Experimental set-up for testing the stability of TMHE

75 kg and 105 kg with varying angle of rotation from 0 to 360^0, the reaction on left rear wheel of tractor were noted from digital display panel of load cell.

Stage 3- In this stage the height of bucket from ground surface was kept constant at 1.4 meter and for varying load of 25 to 150 kg with constant angle of rotation, the reaction on left rear wheel with ground of tractor were noted from digital display panel of load cell.

The field performance of TMHE for mango harvesting was conducted on plot No. 13 and 15 of University Horticultural mango plot for 18 trees of various mango varieties like Suvarnrekha, Totapuri, Chinn Suvernrekha and Alphanso for finding out the weight of fruits harvested in kg and field capacity of the elevator.

RESULTS AND DISCUSSION

The results of stability analysis of tractor mounted hydraulic elevator using digital load cell for different angle of rotation of turn table in clockwise and anticlockwise

direction are presented as in Table 2 and 3.

The results of reaction on left rear wheel of Tractor for different load inside the harvesting bucket are shown in Table 4.

The results of field performance of TMHE for mango harvesting are presented in Table 5 and 6.

From Table 2, for fixed load of 50 kg and harvesting platform 1.4 m, if the angle of rotation of turn table increased in anticlockwise direction, the reaction on tractor rear wheel decreased. Where as for the same conditions, if the angle of rotation of turn table increased in clockwise direction, the reaction of tractor rear wheel increases as shown in Table 3. The reaction of rear wheel of tractor varied in same manner for different operating parameters. From Fig. 1a and 1b, for a fixed height of 1.4 m at constant position of harvesting bucket, the reaction of rear wheel increaseds with an increase in load in harvesting bucket. The above variations in the reaction were noted due to load transfer during operating condition of the elevator.

Table 2 : Reaction on left rear wheel of tractor in clockwise direction

Sr. No.	Load (kg)	Height (m)	Reaction on left rear wheel of tractor (kg) Clockwise					
			Ø=0^0	Ø1=30^0	Ø2=60^0	Ø3=90^0	Ø4=120^0	Ø5=150^0
1.	50	1.4	395.2	398.3	401.6	404.2	406.7	409.5
2.	50	1.7	398.4	399.9	402.3	405.2	407.4	409.7
3.	75	1.7	401.7	403.2	405.8	406.1	408.7	410.3
4.	105	1.7	403.8	405.7	407.6	410.4	412.6	412.8

Table 3 : Reaction on left rear wheel of tractor in anticlockwise direction

Sr. No.	Load (kg)	Height (m)	Reaction on left rear wheel of tractor (kg) Anticlockwise					
			Ø=0^0	Ø1=30^0	Ø2=60^0	Ø3=90^0	Ø4=120^0	Ø5=150^0
1.	50	1.4	395.2	393.4	391.7	389.5	387.4	383.1
2.	50	1.7	398.4	396.1	394.3	391.6	389.2	387.7
3.	75	1.7	401.7	398.6	396.5	394.3	391.7	389.6
4.	105	1.7	403.8	401.6	398.5	396.8	393.2	390.8

Table 4 : Reactions on left rear wheel of tractor for constant height 1.4 m with varying loads

Sr. No.	Load in bucket (kg)	Reaction on rear wheel (kg)
1.	0	381.1
2.	25	389.5
3.	50	392
4.	75	394.6
5.	100	397.8
6.	125	400.1
7.	150	402.3

Table 5 : Test results of TMHE at plot number 13 for mango harvesting

Tree No. variety	TH (m)	Time (sec) Lifting	Harvesting	Lowering	T (sec)	NF (Number)	WF (kg)
Totapuri							
1	10.1	23	198	20	241	13	7.8
2	9.6	41	332	26	399	20	12
3	8.9	42	443	24	509	17	10.2
4	9.81	38	378	24	440	21	12.6
Chinn Suvarnrekha							
5	10.75	50	334	28	412	26	5.85
6	10.7	26	497	22	545	23	5.175
7	10.1	43	468	26	537	28	6.3
8	10.41	35	373	28	436	31	6.975
		Total			3519	179	66.9

Table 6 : Test results of TMHE at plot number 15 for mango harvesting

Tree No. variety	TH (m)	Time (sec)			T (sec)	NF (Number)	WF (kg)
		Lifting	Harvesting	Lowering			
Alphanso							
1	9.75	28	288	21	337	15	4.8
2	10.3	32	408	26	466	19	6.08
3	9.4	51	282	48	381	14	4.48
4	9.9	29	505	24	558	32	10.24
5	10.75	63	405	56	524	28	8.96
Suvarnrekha							
6	10.41	41	420	30	491	25	9
7	10.6	43	480	32	555	29	10.44
8	9.4	40	288	19	347	16	5.76
9	10.1	29	378	24	431	22	7.92
10	9.8	25	324	20	469	19	6.84
		Total			4559	219	74.52

TH- Tree height, T-Total time, NF- Number of fruits, WF- Weight of fruit.

For better stability of the elevator minimum variations in the reaction are needed. Hence, for obtaining the minimum variation of reaction it is recommended to use the machine on plain land while in operating condition.

Conclusion:

– The over turning of the elevator was not observed, up to 6 meter height of harvesting bucket from ground including 150 kg load in bucket.

– The average weight of mango fruits harvested was observed 63.64 kg/hr.(178 fruits/hr)

– The average field capacity of TMHE was 0.08 ha/hr (10mX10m).

– The average lifting time required for harvesting bucket to reach up to height of 10.04m was 38 seconds.

– The average lowering time required for harvesting bucket to lower down from height of 10.04m was 28 seconds.

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