



UNIVERSITI PUTRA MALAYSIA

**DESIGN AND DEVELOPMENT OF AN INTEGRATED INFIELD
COLLECTION-TRANSPORTATION MACHINE FOR OIL PALM FRESH
FRUIT BUNCH**

MUTASIM ELTAYEB ALI

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FRUIT BUNCH**

By

MUTASIM ELTAYEB ALI

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

August 2002



Dedicated

to

My

Parents, for their Dear,

Brothers, sisters and relatives, for their support,

Wife, Alawia .. son, Mohamed, and

*Daughters, Omaira and Nusaiba, for their
motivation*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

**DESIGN AND DEVELOPMENT OF AN INTEGRATED INFIELD
COLLECTION-TRANSPORTATION MACHINE FOR OIL
PALM FRESH FRUIT BUNCH**

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August 2002

Chairman : Assoc. Prof. Dr. Azmi Haji Yahya, Ph.D.

Faculty : Engineering

A prototype oil palm FFB Collector-transporter was designed, developed, modified and tested at the Department of Biological and Agricultural Engineering, Universiti Putra Malaysia (UPM), Malaysia. This four-wheeled, hydrostatic drive, integrated machine was designed for collecting and transporting oil palm fresh fruit bunches in the field and unloading them directly into mainline transporters or trucks at the roadside. The overall dimension of the machine was 4750 mm for length, 2040 mm for width and 2725 mm for height. The overall construction of the machine was consisted of a main chassis and driving unit, collection assembly, operator cab, scissors lift-type fruit bin and associated hydraulic control unit. Various functional components of the machine were hydraulically operated through a solenoid control system. ACAD2000 package was employed to develop the 3D model of the prototype machine. A 29.8 kW @ 2200 rpm KUBOTA V2203-E 4-cylinder diesel engine, a 21.5 gpm @ 1000 rpm VICKERS TA1919 main hydrostatic pump, and a 14.5 gpm @ 1000 rpm SAMHYDRAULIC HIC55 driving motor were



selected based on the computations made to determine the machine total engine power and total hydraulic pressure requirements for the machine to operate under local terrain conditions.

A laboratory test was held on a flat asphalt surface for a controlled performance comparison between the FFB Collector-transporter and the Mini Tractor Trailer with Grabber. Similar comparison test between the modified FFB Collector-transporter and the Mini Tractor-trailer with Grabber was also conducted. Results from these tests showed that the FFB Collector-transporter could give 8.8% output improvement over that of Mini Tractor-trailer with Grabber. The mean expected machine outputs for both systems were found to be 40.98 and 38.10 ton/day, and the difference was significant at 5% level. The FFB Collector-transporter took on average of 11.01 minutes per trip compared to 12.13 minutes per trip by the Mini Tractor-trailer with Grabber in collecting the fresh fruit bunches. The machine gave a loose fruit loss of 62.8% less than that of the Mini Tractor-trailer with Grabber, and consumed 34.1% more fuel.

The modified FFB Collector-transporter was 42.50% faster in the fruit bunch collection than the earlier FFB Collector transporter under the controlled laboratory test. The mean expected output for the modified FFB Collector-transporter was found to be 60.01 ton/day and the difference with the Mini Tractor-trailer with Grabber was statistically significant at 1% level. The modified FFB Collector-transporter had loose fruit loss of 130.9% less than that of the Mini Tractor-trailer with Grabber, and consumed 16.1% less fuel.

A field test was held on a flat, soft, and soggy terrain of 2 hectare area size to evaluate the actual performance of the machine in the plantation. The achievable machine outputs for the modified FFB Collector-transporter in the field were in the range from 18 and 34 ton/day under the described conditions. The measured machine output was found to be very much dependent on the crop yield of the plots. The mean field total collection time per trip for the machine was 11.4 minutes and its achievable capacity was between 2.3 to 4.2 ton/h. Based on the maximum machine capacity of 4.2 ton/h and the machine R&D cost of *RM77708.3 (USD20558)*, the expected infield collection-transportation operation cost with the machine was *RM4.5/ton (USD1.19/ton)*. Consequently, a cost saving of *RM1.13/ton (USD0.30/ton)* was obtained with the machine over the Mini Tractor-trailer with Grabber. Further increase in the cost saving could be obtained with the reduction in the machine initial cost when it was produced in a mass scale.

System evaluation in the harvesting and handling of fresh fruit bunch for a plantation area of 800 ha under steady state condition showed that the FFB Collector-transporter had 17.4% higher system capacity, 16.7% higher labour efficiency, 23% lower system cycle time, and 36% lower idle time than that of the Mini Tractor-trailer with Grabber.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**MEREKABENTUK DAN MEMBANGUN JENTERA BERSEPADU
MENGUMPUL-MENANGKUT TANDAN SEGAR KELAPA SAWIT
DALAM LADANG**

Oleh

MUTASIM EL TAYEB ALI

Ogos 2002

Pengerusi : Profesor Madya Dr. Azmi Haji Yahya, Ph.D.

Fakulti : Kejuruteraan

Satu jentera prototaip mengumpul-mengangkut tandan segar kelapa sawit telah direkabentuk, dibangun dan diuji di Jabatan Kejuruteraan Biologi dan Pertanian, Universiti Putra Malaysia (UPM), Malaysia. Jentera empat roda, pacuan hidrostatik, dan bersepadu ini mampu mengumpul-menangkut tandan-tandan segar kelapa sawit dalam ladang dan memunggah tandan-tandan tersebut terus ke dalam pengangkut utama atau lori di tepi jalan. Dimensi keseluruhan jentera ialah panjang 4750 mm, lebar 2040 mm dan tinggi 2725 mm. Pembinaan keseluruhan jentera terdiri daripada casis utama dan unit pemacu, pemasangan pengumpul, kabin operator, bekas tandan dengan penaik gunting, dan unit kawalan hidraul yang berkaitan. Kesemua komponen berfungsi pada jentera dikendalikan melalui sistem kawalan solinoid. Pakej perisian ACAD2000 telah digunakan untuk membangun model 3D jentera protototaip ini. Enjin diesel KUBOTA V2203-E 4-silinder 29.8 kW @ 2200 psm, pum utama hidrostatik VICKERS TA1919 21.5 gsm @ 1000 psm, dan motor pacuan SAMHYDRAULIC HIC55 14.5 gsm @ 1000 psm telah dipilih berdasarkan kepada pengiraan yang telah dibuat untuk menentu jumlah keperluan

kuasa enjin dan jumlah tekanan hidraul bagi jentera untuk dikendalikan di atas permukaan bumi tempatan.

Satu ujian makmal dalam keadaan terkawal telah dijalankan di atas permukaan berasfalt yang rata untuk membolehkan perbandingan pretasi tak pincang diantara jentera mengumpul-mengangkut tandan segar kelapa sawit dengan traktor-trailer mini dengan Grabber. Ujian perbandingan yang sama juga telah dijalankan ke atas jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai dengan traktor-trailer mini dengan Grabber. Keputusan ujian menunjukkan bahawa jentera mengumpul-mengangkut tandan segar kelapa sawit dapat memberikan 8.8% peningkatan dalam pengeluaran daripada traktor-trailer mini dengan Grabber. Purata anggaran pengeluaran bagi kedua-dua jentera adalah 40.98 dan 38.10 tan metrik/hari dan perbezaannya adalah nyata di peringkat 5%. Jentera mengumpul-mengangkut tandan segar kelapa sawit mengambil purata 11.03 minit per trip manakala traktor-trailer mini dengan Grabber mengambil 12.13 minit per trip untuk mengumpul tandan-tandan segar kelapa sawit. Jentera tersebut memberikan kehilangan buah terlerai 62.8% kurang dari traktor-trailer mini dengan Grabber, dan mengguna 34.1% lebih bahanapi.

Jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai didapati 42.50% lebih cepat dalam kerja mengumpul tandan-tandan segar jika dibandingkan dengan jentera sebelumnya. Purata anggaran pengeluaran bagi jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai adalah 60.01 tan metrik/hari dan perbezaannya manakala traktor-trailer mini dengan

Grabber dengan adalah nyata di peringkat 5%. Jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai memberikan kehilangan buah terlerai 130.9% kurang dari traktor-trailer mini dengan Grabber, dan mengguna 16.1% kurang bahanapi.

Satu ujian ladang telah dijalankan di atas permukaan rata, lembut, lagi basah pada kawasan seluas 2 hektar untuk menilai prestasu sebenar jentera dalam ladang. Pengeluaran maksima yang tercapai bagi jentera mengumpul-mengangkut tandan segar kelapa sawit yang telah diubahsuai dalam ladang dengan keadaan permukaan pada kawasan cerun yang rata dan lembek berukuran 2 hektar, bumi yang basah adalah 34 tan/hari. Pengeluaran yang terukur bagi jentera didapati sangat bergantung kepada hasil tanaman bagi plot yang terbabit. Purata jumlah masa pengumpulan per trip dalam ladang bagi jentera ini adalah 11.4 minit dan kemampuan yang tercapainya adalah diantara 2.3 hingga 4.2 tan/jam. Berdasarkan kepada kemampuan maksima jentera bersamaan 4.2 tan/jam dan kos R&D jentera bersamaan *RM77708.3 (USD20558)*, dianggarkan kos bagi kerja pengumpulan-pengangkutan dalam ladang dengan jentera ini adalah *RM4.5/tan (USD1.19/ton)*. Dengan ini, penjimatan kos sebanyak *RM1.13/tan (USD0.30/ton)* boleh didapati dengan jentera ini ke atas penggunaan traktor-trailer mini dengan Grabber. Peningkatan dalam penjimatan kos dapat diperolehi dengan pengurangan pada harga permulaan jentera tersebut apabila pengeluarannya dibuat dalam kuantiti yang banyak.

Penilaian system dalam penuaian dan pengendalian tandan segar kelapa sawit bagi perladangan yang luasnya 800 ha dalam keadaan mantap menunjukkan jentera

mengumpul-mengangkut tandan segar kelapa sawit masa mempunyai 17.4% lebih tinggi muatan system, 16.7% lebih tinggi kecekapan ladang, 23% lebih rendah masa kitar system, dan 36% lebih rendah masa melalu dari traktor-trailer mini dengan Grabber.

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(May Allah S. W.T. bless all those who kindly helped the author ... A~min.)

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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TABLE OF CONTENTS

		Page
	DEDICATION	2
	ABSTRACT	3
	ABSTRAK	6
	ACKNOWLEDGEMENTS	10
	APPROVAL SHEETS	12
	DECLARATION FORM	14
	LIST OF TABLES	19
	LIST OF FIGURES	23
 CHAPTER		
I	INTRODUCTION	26
	Objectives of the Study	32
II	LITERATURE REVIEW	34
	Mechanisation in Oil Palm Plantations	34
	Cutting Systems	39
	Infield collection and Transportation Systems	42
	Mechanical Buffalo	44
	Iron Horse	46
	Super Crawler	48
	Articulated Fresh Fruit Bunch Carrier	50
	Speed Loader	52
	Mini Tractor-trailer	55
	Mini Tractor-trailer with Grabber	57
	Tracked Picker	63
	Crabbie	66
	Taltrac	68
	Rambo	69
	Wakfoot	71
	Mechanical Loose Fruit Collector	74
	Mainline Loading and Transporting Systems	77
	Summary	80
III	MATERIALS AND METHODS	82
	Relevant Physical Properties of Fresh Fruit Bunches	82
	Mechanical Design Process	86
	Design Requirements	90
	Three-dimensional Conceptual Design	92
	Engine Power Estimation	93
	Machine System Configuration	107
	Chassis and Driving Unit	111



	Collection Assembly	115
	Operator Cab	120
	Scissors Lift Fruit Bin	120
	Hydraulic System	128
	Hydraulic Controls	133
	Manual Operational Mode	133
	Automatic Operational Mode	136
	Machine System Operation	137
	Hydraulic Pressure Estimation	139
	Driving Motor Pressure for Machine System	140
	Motor Pressure for Clamping Jaws	141
	Cylinder Pressure for Clamping Unit	144
	Cylinders Pressure for Scissors Lift	146
	Cylinder Pressure for Fruit Bin	147
	Cylinder Pressure for Fruit Bin Pusher Gate	147
	Close loop Circuit of FFB Collector-transporter	149
	Close loop Circuit of Modified FFB Collector-transporter	155
	Open loop Hydraulic System	159
	Strength and the Deflection of Main Chassis Frame	164
	Tyre Selection	167
	Machine Performance Test Procedure	168
	Laboratory Performance Test	170
	Field Performance Test	175
	Economic Cost Analysis	179
	FFB Collector-transporter	180
	Mini Tractor-trailer with Grabber	184
IV	RESULTS AND DISCUSSION	188
	Relevant Physical Properties of Fresh Fruit Bunches	188
	Performance test of FFB Collector-transporter	196
	Experiment 1	197
	Performance Comparison Between FFB Collector-transporter and Mini Tractor-trailer with Grabber	197
	Picking Time	198
	Travelling Time	200
	Turning Time	201
	Transporting Time	202
	Dumping Time	203
	Total Collection Time	204
	Machine Capacity	206
	Field Capacity	207
	Machine Output	208
	Loose Fruit Loss	211
	Fuel Consumption	212
	Experiment 2	213
	Performance Comparison Between FFB Collector-transporter and Modified FFB Collector-transporter	213



	Picking Time	214
	Travelling Time	216
	Turning Time	217
	Transporting Time	218
	Dumping Time	219
	Total Collection Time	220
	Machine Capacity	222
	Field Capacity	223
	Machine Output	224
	Loose Fruit Loss	225
	Fuel Consumption	226
	Experiment 3	227
	Performance Comparison Between Modified FFB Collector- transporter and Mini Tractor-trailer with Grabber	227
	Picking Time	228
	Travelling Time	230
	Turning Time	231
	Transporting Time	231
	Dumping Time	233
	Total Collection Time	234
	Machine Capacity	235
	Field Capacity	237
	Machine Output	237
	Loose Fruit Loss	239
	Fuel Consumption	240
	Experiment 4	242
	Field Performance of FFB Collector-transporter	242
	System Evaluation in Fresh Fruit Bunch Harvesting and Handling	246
	Fabrication Cost of FFB Collector-transporter	252
	Economic Cost Analysis	253
V	CONCLUSIONS AND RECOMMENDATIONS	257
	Conclusion	257
	Study Limitation	263
	Recommendation	265
	REFERENCES	266
	APPENDICES	273
A1	Mass Analysis of Modified FFB Collector-transporter	273
A2	Engine Power Estimated at Various Soil Strengths and Slopes..	276
A3	Diagonal Ply Agricultural Implement Tyres	277
A4	Speed Category and Load Capacity Indices	278
A5	Machine Engine Specifications	279
A6	Main Pump Specifications (TA1919V1010)	280
A7	Hydrostatic Motor Performance Chart (ME 48)	281



A8	Hydrostatic Motor Performance Chart (H1C55)	282
A9	Clamping Unit Motor Specifications (MB 05)	283
A10	Cost Analysis of Modified FFB Collector-transporter	284
B1	General Machine	287
B2	Transmission Links	288
B3	Main Chassis	289
B4	Collection Assembly	290
B5	Operator Cab	291
B6	Optimum Hand and Foot Control Positions (side view)	292
B7	Optimum Hand and Foot Control Positions (top view)	293
C	Computer Program for Data Analysis	294
D1	Physical Properties Raw Data	299
D2	Laboratory Test Raw Data	304
D3	Field Test Raw Data	310
BIODATA OF THE AUTHOR		311



LIST OF TABLES

Table		Page
1	World's major producers of palm oil from 1994 to 2000	26
2	Factors inhibiting mechanisation in advanced sector of oil palm plantations	36
3	Time and motion comparison between manual and machine-assisted harvesting of oil palm	41
4	Man-hour comparison between manual and machine-assisted harvesting of oil palm	41
5	Technical specifications of mechanical buffalo	45
6	Technical specifications of high-lift mechanical buffalo	47
7	Technical specifications of iron horse	48
8	Technical specifications of super crawler	50
9	Technical specifications of articulated fresh fruit bunch carrier	51
10	Technical specifications of speed loader	53
11	Machine output of oil palm infield machine systems	54
12	Technical specifications of Mini Tractor	56
13	Technical specifications of trailer	57
14	Average cost and machine output of Mini Tractor	58
15	Technical specifications of grabber crane	59
16	Performance comparison between manual and mechanical infield collection	60
17	Capital cost and operating cost of infield transportation	61
18	Mechanical infield transporters with respect to labour requirements...	61

19	Output of manual and mechanical infield collection of Mini Tractor system	62
20	Harvester's output and manpower requirements for mechanised and manual infield collection	62
21	Manpower plan for team-based field operation	63
22	Technical specifications of tracked picker	64
23	Field performance test results of tracked picker	65
24	Technical specifications of crabbie	67
25	Technical specifications of taltrac	68
26	Technical specifications of rambo	70
27	Technical specifications of wakfoot mark 1	72
28	Technical specifications of mechanical loose fruit collector	77
29	Estimated mass component breakdown for the proposed machine system	95
30	Values of CI and Cn for agricultural drive tyres	101
31	Tank capacities for fuel, lubricant oil, and hydraulic oil	110
32	Operational procedure under manual mode	136
33	Operational procedure under automatic mode	137
34	Fresh fruit bunch weight, volume, and density under unpacked conditions	193
35	ANOVA and means for fresh fruit bunch density	193
36	Fresh fruit bunch weight, volume, and density under packed conditions	194
37	Monthly fresh fruit bunch crop yield	195
38	Operational time breakdown for FFB Collector-transporter and Mini Tractor-trailer with Grabber	199
39	ANOVA and means for picking time	199



40	ANOVA and means for travelling time	201
41	ANOVA and means for turning time	202
42	ANOVA and means for transporting time	203
43	ANOVA and means for dumping time	205
44	ANOVA and means for total collection time	205
45	ANOVA and means for machine capacity	206
46	ANOVA and means for field capacity	209
47	ANOVA and means for machine output	209
48	ANOVA and means for loose fruit	212
49	ANOVA and means for fuel consumption	212
50	Operational time breakdown for FFB Collector-transporter and modified FFB Collector-transporter	215
51	ANOVA and means for picking time	215
52	ANOVA and means for travelling time	217
53	ANOVA and means for turning time	218
54	ANOVA and means for transporting time	219
55	ANOVA and means for dumping time	221
56	ANOVA and means for total collection time	221
57	ANOVA and means for machine capacity	223
58	ANOVA and means for field capacity	224
59	ANOVA and means for machine output	225
60	ANOVA and means for loose fruit losses	226
61	ANOVA and means for fuel consumption	227
62	Operational time breakdown for modified FFB Collector-transporter	



	and Mini Tractor-trailer with Grabber	229
63	ANOVA and means for picking time	229
64	ANOVA and means for travelling time	231
65	ANOVA and means for turning time	232
66	ANOVA and means for transporting time	233
67	ANOVA and means for dumping time	234
68	ANOVA and means for total collection time	236
69	ANOVA and means for machine capacity	236
70	ANOVA and means for field capacity	238
71	ANOVA and means for output	238
72	ANOVA and means for loose fruit losses	241
73	ANOVA and means for fuel consumption	241
74	Field performance of modified FFB Collector-transporter	244
75	System evaluation in fresh fruit bunch harvesting and handling breakdown for FFB Collector-transporter and Mini Tractor-trailer with Grabber	251
76	Fabricating cost of FFB Collector-transporter components	253
77	Cost breakdown for FFB Collector-transporter and Mini Tractor- trailer with Grabber	255
78	Technical specifications of prototype FFB collector-transporter	258



LIST OF FIGURES

Figure		Page
1	Layout of Roads and Drains in an Ideal Mechanised System	38
2	Mechanical Buffalo	45
3	High lift Mechanical Buffalo	46
4	Iron Horse	47
5	Super Crawler	49
6	Articulated Infield Fruit Bunch Carrier	52
7	Speed Loader	54
8	Mini Tractor-trailer with Grabber	60
9	Tracked Fresh Fruit Bunch Picker	65
10	Crabbie	66
11	Taltrac	69
12	Rambo	71
13	Wakfoot Mark 1	72
14	Wakfoot Mark 21	73
15	Loose Fruit Collector	75
16	Self-propelled Mechanical Loose Fruit Collector	76
17	Self-propelled Mechanical Buffalo Loose Fruit Collector	76
18	Bedford Diesel Tipper Fitted with a Hiab Speed-loader Crane	78
19	Determining Fresh Fruit Bunch Physical Dimensions	83
20	Determining Fresh Fruit Bunch Weight	84

21	Determining Loose Fruit Weight	85
22	Forklift Concept	89
23	Chute and Pusher Concept	89
24	Bucket Concept	89
25	Direct Clamping and Lifting Concept	89
26	Design Process and Feedback Loops	91
27	Power Transmission Efficiencies for Tractor	106
28	Engine Power as Related to Terrain Strength and Slope	106
29	General Configuration of FFB Collector-transporter	108
30	General Dimensions of FFB Collector-transporter	109
31	Three-dimension Schematic-diagram of Chassis and Driving Unit..	112
32	Side View Diagram of Chassis and Driving Unit	113
33	Principle Diagram of Power Steering System	116
34	Principle Diagram of Brake System	116
35	Three-dimension Schematic-diagram of Collection Assembly	117
36	Side and Front Views of Collection Assembly	118
37	Three-dimension Schematic-diagram of Operator Cab	121
38	Side and Back Views of Operator Cab	122
39	Three-dimension Schematic-diagram of Scissors lift	123
40	Side and Front Views of Fruit Bin	124
41	Three-dimension Schematic-diagram of Fruit Bin Pusher Gate	126
42	Fully Developed FFB Collector-transporter	127
43	Schematics of Close loop and Open loop Circuits of Hydraulics System	128