CHAPTER 6

DESIGN CURVES FOR THAI FISHING VESSELS

From 1958 to 1986, Thailand built a large volume of fishing vessels mainly in woods. The size of the boats has been increasing steadily. Table (6.1) show the number of vessels built during the prescribed period classified by length over all (LOA) and the year built. Note that there was no boat less than 10.0 metres being built anymore and vessels over 40.0 metres in length have rarely been built.

Fortunately that the author has been engaged into fishing business since 1977. He has been visiting many boatyards and fishermen of the eastern and southern parts of Thailand. Information and raw data on fishing vessels are readily obtained apart from huge data supplied from fishery department.

To provide more pictures on the fishing industry, Table (6.2) and (6.3) give more information on the location of boatbuilding and kinds of main engines used.

For serious readers, [39;78] provides a good background on general aspects of fishing vessels' statistics.

Total number of fishing vessels is 4217. This report does not include the offset tables of these boats.

The author has been working out, by means of statistics, with the vessels'line plans and other particulars. The results come up by using boat length as a classified factor. Graphical representation of fishing vessels are plotted in Fig. (6.1) through Fig. (6.22). Hence main particulars of the vessels could be easily visualized. This gives the whole pictures of Thai fishing boat fleet. One main point of interests is that any naval architect could use this information to design traditional Thai fishing boats currently in used and time saving in the design process can be reduced enormously.

The purpose of doing so is to construct a family of design curves for Thai fishing boats.

Anyone who is interested in this field, should attempt to study further especially in view of the design and powering aspects.

TABLE 6.1

THAI FISHING VESSELS BUILT DURING 1958-1985

SIZE / YEAR	LOA (m)																																	TOTAL
	<10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	>40	
1958			2					1	3	8	5	8	2	1																				30
1959						1					2	3																						6
1960					1					1	1	1	3																					7
1961					1									2																				3
1962							1	1							2		1																	5
1963						1			1	1		1	1	1		1	1																	8
1964		1		1		1	1	1	3	1		3	10	3	2	4	2																	33
1965						2	2	3	2	4	2	8	13	7	1	2		2																48
1966						1	1	8	3	5	5	4	18	21	6	7																		79
1967					2	1		7	7	17	12	12	21	14	13	10	5																	121
1968		1		1	2	2	5	8	22	20	15	8	5	4	9	6	4	1	3															116
1969				1		1		3	6	17	6	12	11	6	5	16	5	11	4	5	2													111
1970			1			3	1	12	10	26	16	7	10	12	13	15	12	13	1	5	2	2			1									162
1971							6	10	9	23	19	12	9	8	3	8	2	2		2	2					2									117
1972			2	1	1	3	19	24	21	38	24	22	13	10	7	7	4		1	1	1	1		1										201
1973				1	1	8	26	66	36	80	51	36	37	14	13	8	6	3	1	2	2		3	3	2	2	1	2	1					405
1974		1	1		1	4	17	36	40	44	40	33	28	24	2	5	5	5	2	5	2	3	5	2	1	1	1	2		1				311
1975				1		7	3	19	19	27	37	30	22	34	7	11	9	1	1	4	5		1		3	1		1	1		2	1	4	251
1976			2	2	1	1	4	16	20	42	22	19	22	19	7	2	3	3	2	1			1			1								190
1977			2		3	7	11	17	30	45	70	34	37	46	20	14	7	11	3	3		1		1	1									363
1978		1		3		6	4	16	23	52	126	84	87	66	44	33	25	23	10	5	1	1	1									2		613
1979				3	2	4	7	8	12	42	89	58	55	32	25	20	11	12	13	5	3	1				3	1					1	1	408
1980					1	1		4	10	27	26	17	10	8	4				1			1		2								1		113
1981			2		1	3	1	1	3	17	12	5	7	4							1	3												60
1982				2	1	1	1	8	8	30	21	22	16	14	5	3	2	2																136
1983			1		1	2	1	2	9	28	38	30	25	9	8	11	7	5																177
1984						2	2	2	5	8	15	26	19	9	8	2																			98
1985									1	4	7	6	16	6	1	1	3																		45
TOTAL		4	13	16	19	62	113	273	303	607	661	501	497	374	205	186	114	94	42	38	21	13	11	9	8	10	3	5	2	1	2	5	5	4217

TABLE (6.2) LOCATION OF FISHING BOATBUILDING YARDS

PROVINCE	NUMBER OF BOAT BUILDING & REPAIRING YARDS			TOTAL
	BUILDING	BUILD/REPAIR	REPAIRING	
1. TRAD	15	6	2	23
2. CHANTRABURI	2	1	3	6
3. RAYONG	9	-	5	14
4. CHOLBURI	5	2	7	14
5. CHACHURGSAO	2	-	2	4
6. SAMUTPRAKARN	14	10	5	29
7. SAMUTSAKORN	36	14	6	56
8. SAMUTSONGKRAM	16	9	5	30
9. PETCHBURI	8	1	4	13
10. PRACHUABKIRIKUN	9	1	3	13
11. CHUMPORN	1	-	5	6
12. SURATHANI	1	5	2	8
13. NAKORNSRIDHUMRAJ	10	7	13	30
14. SONGKLA	1	-	5	6
15. PATTANI	5	2	4	11
16. NARATHIWAT	N.A.	N.A.	N.A.	N.A.
17. RANONG	N.A.	1	6	7
18. PUNGHA	N.A.	N.A.	N.A.	N.A.
19. PHUKET	N.A.	2	4	6
20. KRABI	N.A.	N.A.	N.A.	N.A.
21. TRUNG	N.A.	1	2	3
22. SATOOL	1	N.A.	4	5
23. BANGKOK	7	25	6	38
TOTAL	142	87	93	322

SOURCE : FISHERY DEPARTMENT
AND FIELD SURVEY

TABLE 6.3

MAIN ENGINES USED ON BOARD (1958-1985)

ENGINE BRANDS / YEAR	Marine Diesel Engine																										TRUCK ENGINE						TOYAL
	CUMMINS	CATERPILLAR	VOLVOPENTA	DAIYA	KELVIN	YANMAR	DORMAN	BENTZ	M.W.M.	KUBOTA	NIIGATA	LISTER	DOIZT	M.A.N.	SCANNIA	G.M.DELROLT	DODOUTZ	STROKE	CROMITE	BETMISTER	B.L.W.ALPHA	ENTERPRIZE	ALISZAMER	A.E.C.	ROLLROYCE	DOLIBDER	ETC	GARDNER	NISSAN	LEYLAND	HINO	ISUZU	ETC	
1958	2	2	4	2		4	3	2	2	1			1						1								1	4	1					30
1959	2		1				1	1																				1						6
1960	3		2						1																			1						7
1961	2																											1						3
1962	1							1														2						1						5
1963	3					1	1															1	1				1							8
1964	6	3	3		1	4	1		1				2			1				1							4	5		1				33
1965	12	5	2	6		6	3	6		1			1											1		1		3			1				48
1966	13	20	6	4		9	7	10		1			3														3	2		1				79
1967	16	32	23	8		16	7	5	4	1			4						1								1	1		2				121
1968	15	8	27	3	1	10	12	7	9		1		5			2			3						2			5	2	4				116
1969	16	3	10	7	1	7	17	6	17		7	2	5	3		4											3	1		2				111
1970	18	14	25	17	7	14	15	4	14	1	7	2	4			5		5	2								1	3		3	1			162
1971	16	4	20	7	5	21	5	10	3		5	4	1			3		2									2	6		3				117
1972	33	23	44	14	7	21	6	10	6	6	2		1			1		3	3								2	8		11				201
1973	71	45	62	42	56	33	2	10	6	20	2	6		1				2	1	1	2		1			1	2	20		16	1	2		405
1974	45	62	38	33	27	16	3	2	4	9		5	1			1	1			1			1				3	43	1	7	4	4		311
1975	47	40	45	17	17	6	4	5	4	6	3	8									1						2	34		3	6	3		251
1976	37	28	19	18	11	5		3		3		2												1			2	48	4	4	4	1		190
1977	59	63	33	37	25	9			2	2	8	1												1			3	105	3	4	6	2		363
1978	138	137	53	55	36	6		2			6	2	2	1		1	3	1	2								7	136	15	3	6	1		613
1979	91	70	33	60	10	7			1		4	5	2		14		5								1		2	91	9	1	2			408
1980	14	4	6	23	6	5					2	2			5		1									1		38	3		2	1		113
1981	5	4	6		4	1					1		1		1													26	6	1	4			60
1982	12	7	7	2	1	1	1	1				2		6													1	48	34	1	10	2		136
1983	31	3	7		4	5						1		12	1		1										6	23	72		7	4		177
1984	20	5	12	1	4	3								3	5		1										1	11	27		6			99
1985	11	2	6			2								6	2		2											1	7		4	1		45
TOTAL	739	584	494	356	223	212	88	85	74	51	48	42	33	32	28	18	14	13	13	3	3	3	3	3	3	3	47	666	184	68	63	21		4217

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**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT12
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 3.28
        f(10.9) = 3.48
        f(12.75) = 4.1
        f(13.65) = 4.4
        f(14.56) = 4.65
        f(15.47) = 4.9
        f(17.3) = 5.5
        f(18.2) = 5.75
        f(19.1) = 6
        f(20) = 6.25
        f(20.93) = 6.5
        f(21.84) = 6.75
        f(22.75) = 7
        f(23.65) = 7.25
        f(25.48) = 7.6
        f(26.39) = 7.82
        f(27.3) = 8
        f(29.12) = 8.4
        f(30) = 8.5
        f(30.95) = 8.7
        f(31.85) = 8.8
        f(33.67) = 9.1
        f(34.58) = 9.3
        f(36.4) = 9.5

        $ substlevel = 0

**************************************************************

Solution:

 Variables    Values

 A          =    -.72970760

 B          =     .43269095

 C          =  -.0041500847

 Maximum error is    .097806585


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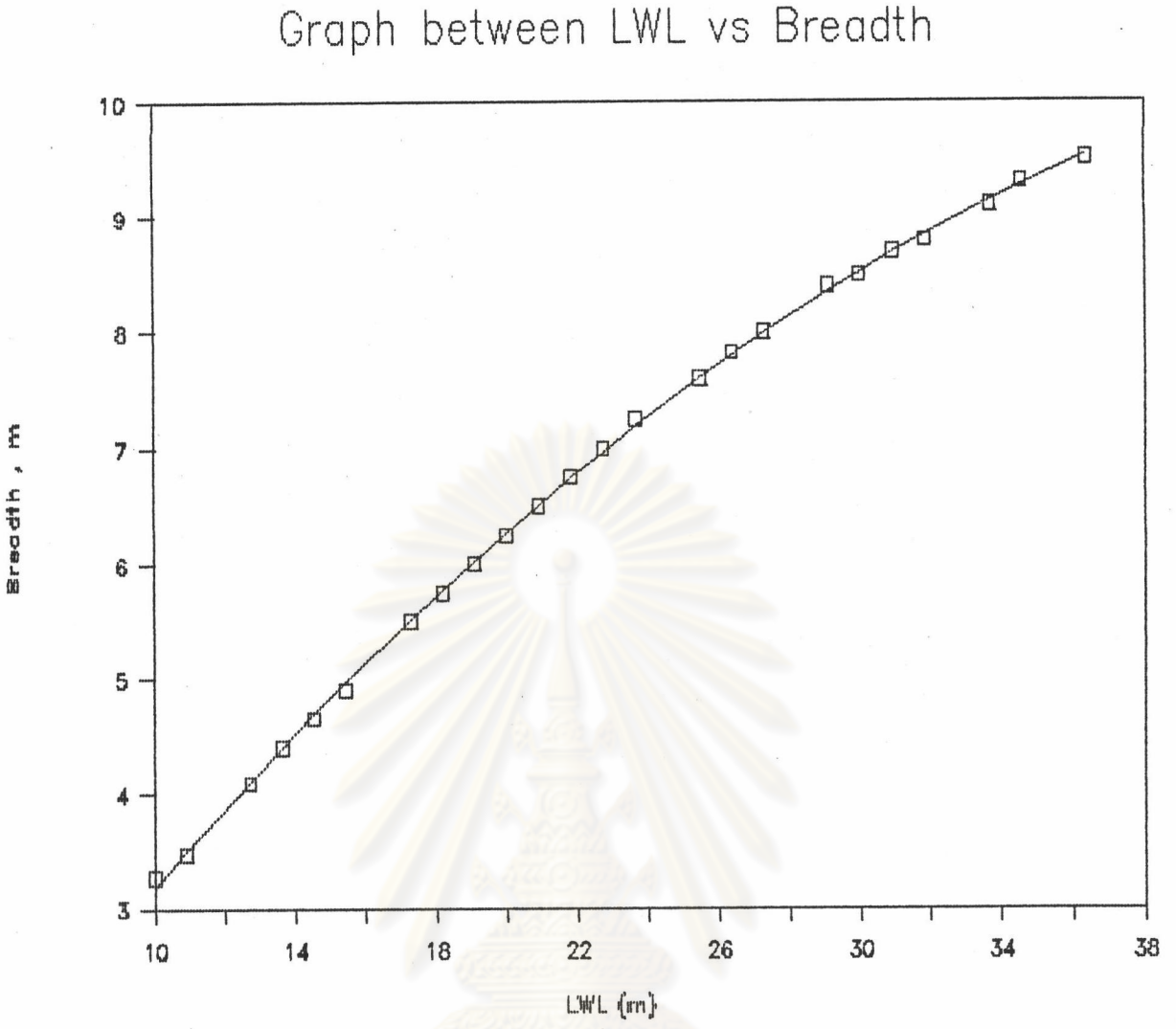

Fig 6.1

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**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT13
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 1.48
        f(10.9) = 1.60
        f(12.75) = 1.88
        f(13.65) = 2.00
        f(14.56) = 2.14
        f(15.47) = 2.27
        f(17.3) = 2.53
        f(18.2) = 2.66
        f(19.1) = 2.80
        f(20) = 2.90
        f(20.93) = 3.05
        f(21.84) = 3.20
        f(22.75) = 3.30
        f(23.65) = 3.45
        f(25.48) = 3.70
        f(26.39) = 3.80
        f(27.3) = 3.95
        f(29.12) = 4.20
        f(30) = 4.32
        f(30.95) = 4.40
        f(31.85) = 4.50
        f(33.67) = 4.70
        f(34.58) = 4.80
        f(36.4) = 5.00

        $ substlevel = 0

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        Solution:

          Variables     Values

         A          =    -.20423092

         B          =     .17308342

         C          = -.00080143043

        Maximum error is     .053015572

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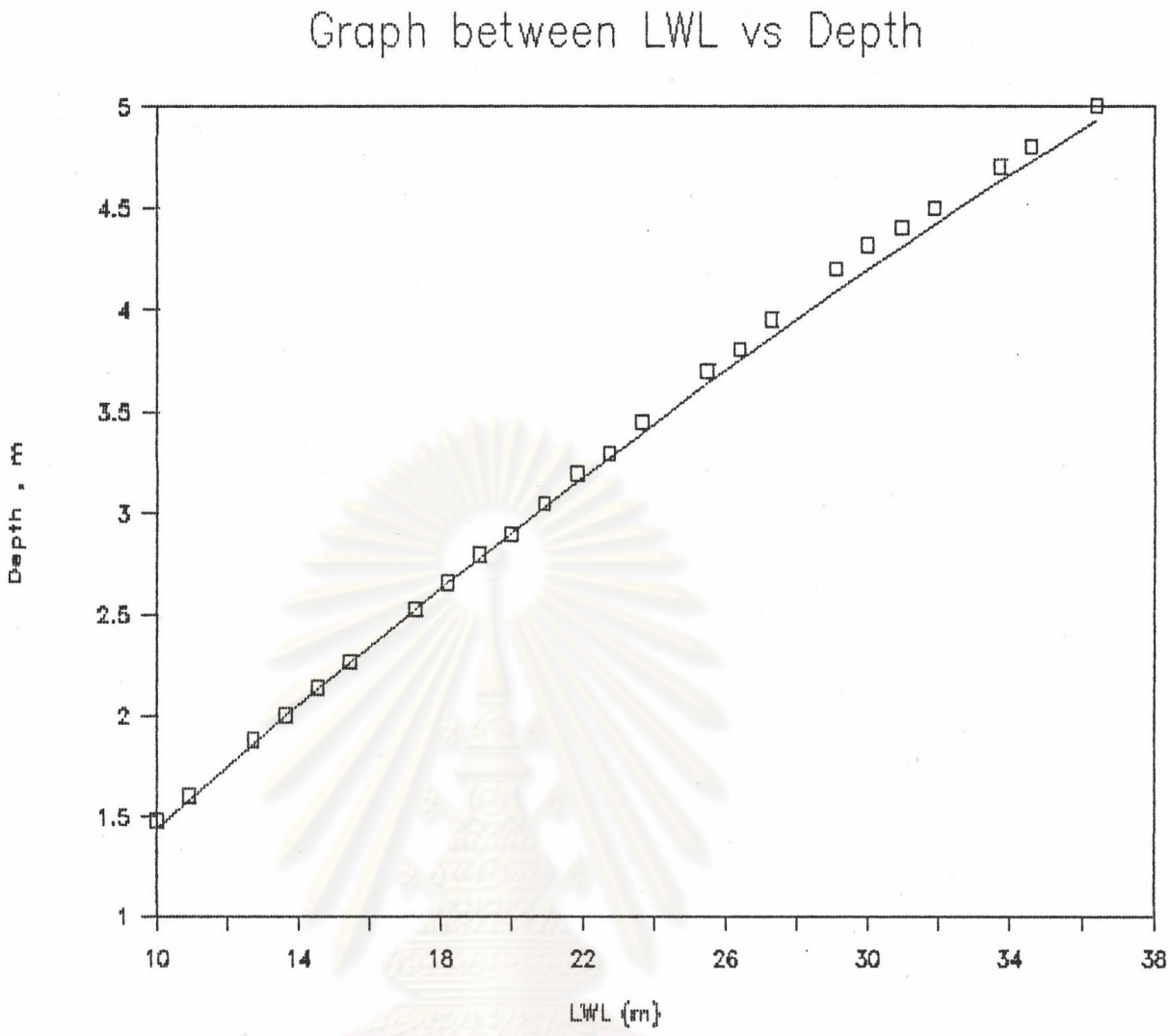

Fig 6.2

Name of input file: A:\FIT14

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; This example demonstrates Eureka's ability to find
; values for constants in a function that make the
; function best fit empirical data.  Because the equation
; file includes a $ substlevel = 0 directive, Eureka will
; perform a Least Squares Fit to find the function (of
; the required form) that best matches the points
; x, (f(x) given.
; In this example, the function is
;       f(x) := EXP(a * x^N + B)
; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

f(x) := A+B*x+C*x^2

f(10.0) = 0.96
f(10.9) = 1.05
f(12.75) = 1.22
f(13.65) = 1.30
f(14.56) = 1.40
f(15.47) = 1.47
f(17.3) = 1.64
f(18.2) = 1.73
f(19.1) = 1.82
f(20) = 1.90
f(20.93) = 2.00
f(21.84) = 2.07
f(22.75) = 2.16
f(23.65) = 2.25
f(25.48) = 2.40
f(26.39) = 2.50
f(27.3) = 2.55
f(29.12) = 2.73
f(30) = 2.81
f(30.95) = 2.87
f(31.85) = 2.94
f(33.67) = 3.07
f(34.58) = 3.13
f(36.4) = 3.25

$ substlevel = 0
```

Solution:

Variables	Values
A	= -.13603374
B	= .11294541
C	= -.00052465854

Maximum error is .030027521

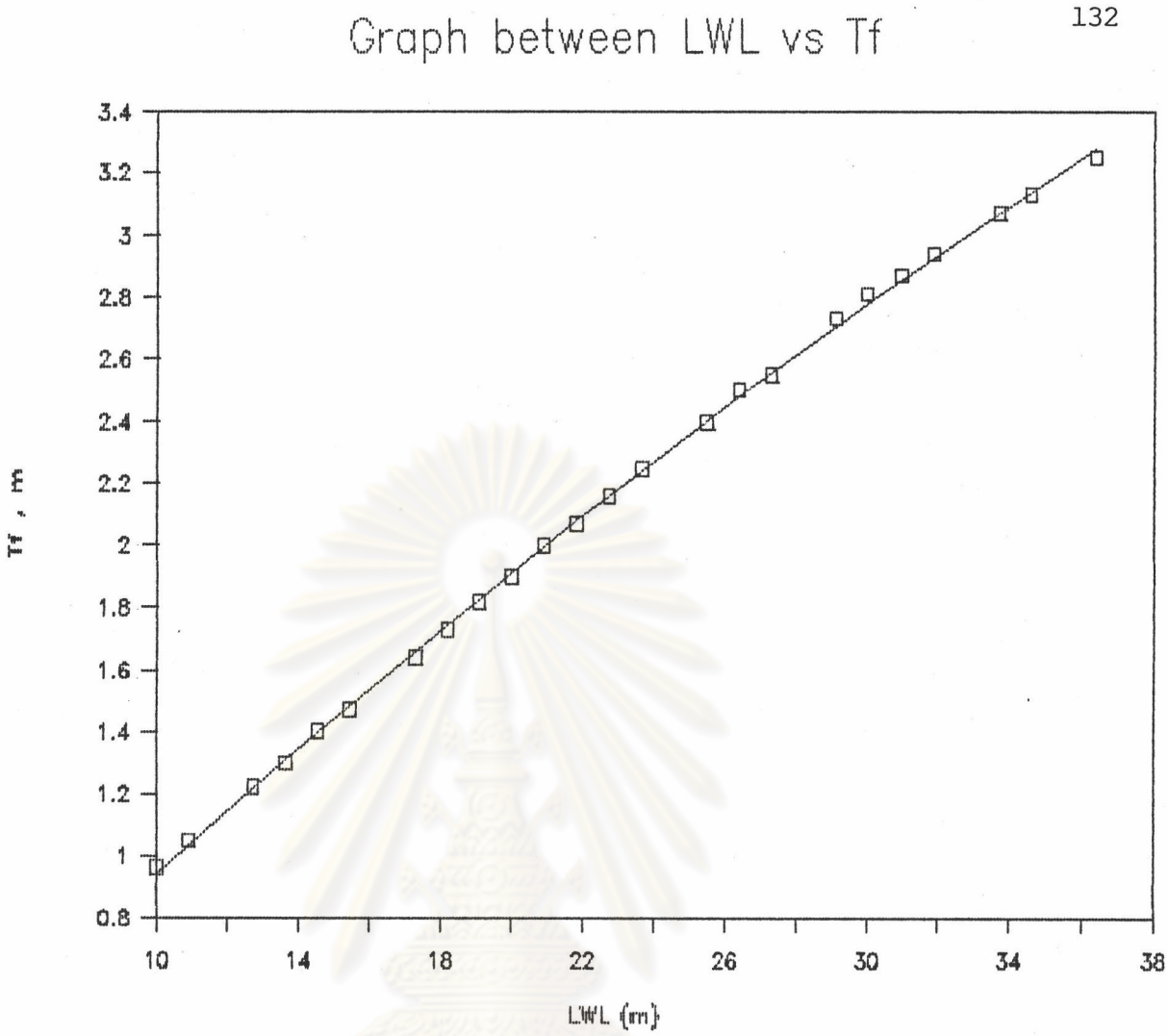

Fig 6.3

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**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT15
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 1.02
        f(10.9) = 1.14
        f(12.75) = 1.40
        f(13.65) = 1.52
        f(14.56) = 1.64
        f(15.47) = 1.76
        f(17.3) = 2.00
        f(18.2) = 2.14
        f(19.1) = 2.25
        f(20) = 2.36
        f(20.93) = 2.48
        f(21.84) = 2.60
        f(22.75) = 2.70
        f(23.65) = 2.80
        f(25.48) = 3.00
        f(26.39) = 3.08
        f(27.3) = 3.17
        f(29.12) = 3.35
        f(30) = 3.44
        f(30.95) = 3.52
        f(31.85) = 3.60
        f(33.67) = 3.77
        f(34.58) = 3.84
        f(36.4) = 4.00

        $ substlevel = 0

**************************************************************

        Solution:

         Variables     Values

        A          =    -.63545024

        B          =     .17751764

        C          =  -.0013871832

        Maximum error is     .020434825

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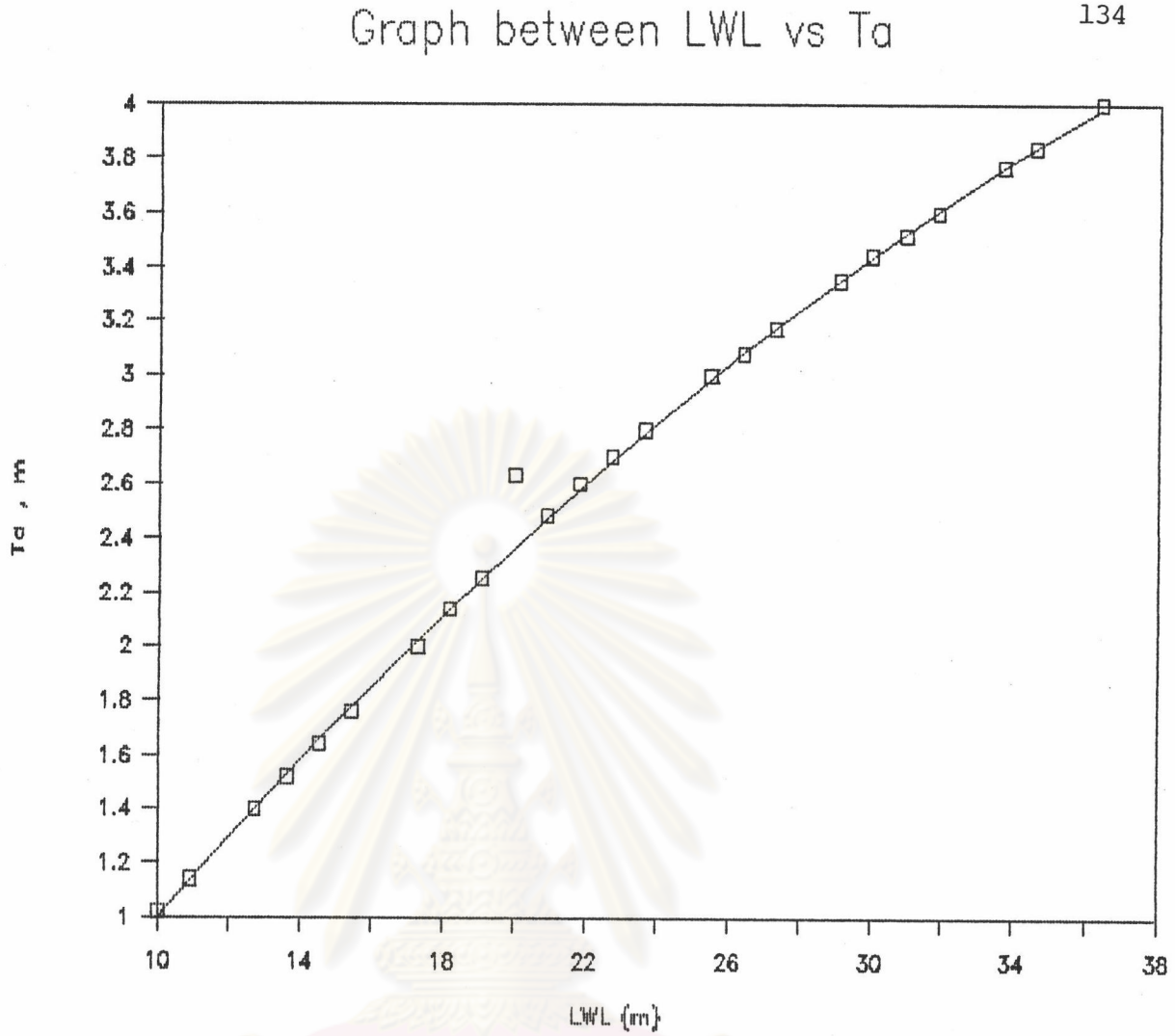

Fig 6.4

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**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT16
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 0.46
        f(10.9) = 0.46
        f(12.75) = 0.48
        f(13.65) = 0.48
        f(14.56) = 0.50
        f(15.47) = 0.51
        f(17.3) = 0.53
        f(18.2) = 0.52
        f(19.1) = 0.55
        f(20) = 0.54
        f(20.93) = 0.57
        f(21.84) = 0.60
        f(22.75) = 0.60
        f(23.65) = 0.65
        f(25.48) = 0.70
        f(26.39) = 0.72
        f(27.3) = 0.78
        f(29.12) = 0.85
        f(30) = 0.88
        f(30.95) = 0.88
        f(31.85) = 0.90
        f(33.67) = 0.93
        f(34.58) = 0.96
        f(36.4) = 1.00

        $ substlevel = 0

**************************************************************

        Solution:

         Variables    Values

        A          =     .43128735

        B          =  -.0044404371

        C          =  .00058588135

        Maximum error is    .054632546

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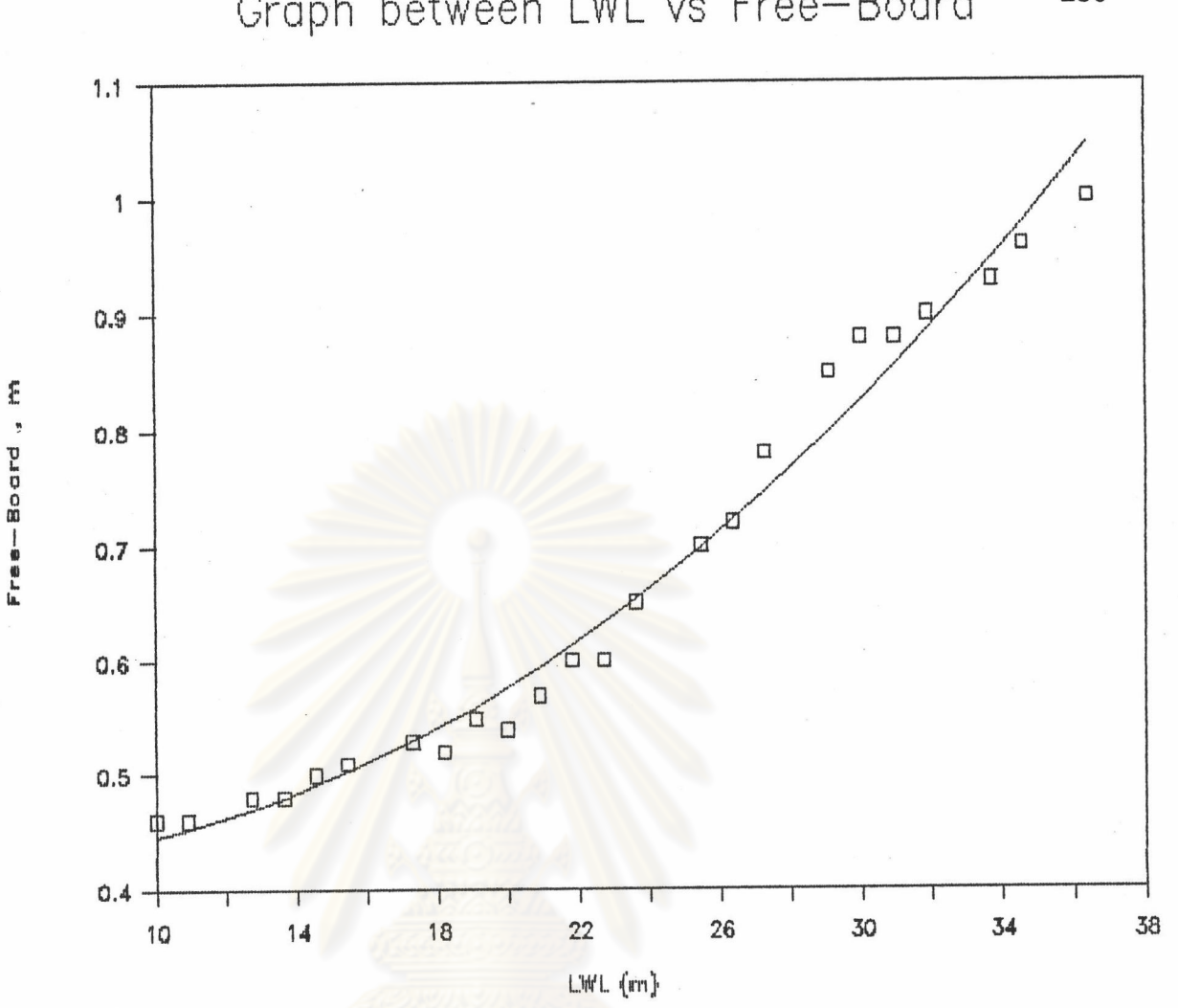

Fig 6.5

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**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT17
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 0.45
        f(10.9) = 0.45
        f(12.75) = 0.61
        f(13.65) = 0.61
        f(14.56) = 0.61
        f(15.47) = 0.61
        f(17.3) = 0.76
        f(18.2) = 0.76
        f(19.1) = 0.76
        f(20) = 0.76
        f(20.93) = 0.76
        f(21.84) = 0.76
        f(22.75) = 0.91
        f(23.65) = 0.91
        f(25.48) = 0.91
        f(26.39) = 0.91
        f(27.3) = 0.91
        f(29.12) = 1.00
        f(30) = 1.00
        f(30.95) = 1.00
        f(31.85) = 1.00
        f(33.67) = 1.00
        f(34.58) = 1.00
        f(36.4) = 1.00

        $ substlevel = 0
**************************************************************

        Solution:

         Variables     Values

        A          =   -.047685362

        B          =    .057172979

        C          = -.00076918018

        Maximum error is    .074084624

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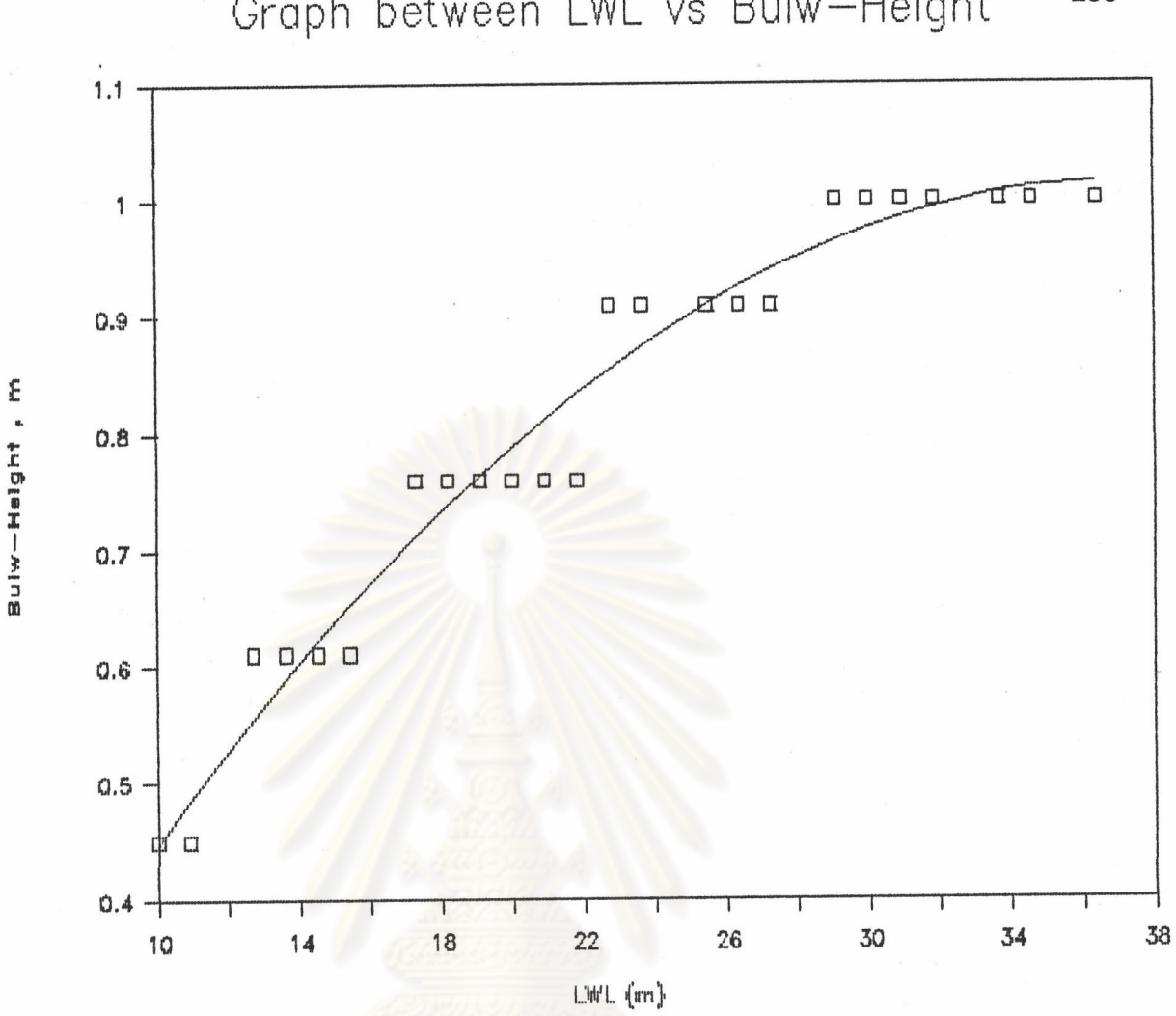

Fig 6.6

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****************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT18                                    139
****************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+d*x^3+E*x^4

        f(10.0) = 53.0
        f(10.9) = 66.0
        f(12.75) = 108.0
        f(13.65) = 131.0
        f(14.56) = 160.0
        f(15.47) = 190.0
        f(17.3) = 263.0
        f(18.2) = 304.0
        f(19.1) = 353.0
        f(20) = 400.0
        f(20.93) = 456.0
        f(21.84) = 514.0
        f(22.75) = 578.0
        f(23.65) = 644.0
        f(25.48) = 788.0
        f(26.39) = 870.0
        f(27.3) = 953.0
        f(29.12) = 1126.0
        f(30) = 1217.0
        f(30.95) = 1307.0
        f(31.85) = 1400.0
        f(33.67) = 1600.0
        f(34.58) = 1700.0
        f(36.4) = 1900.0

        $ substlevel = 0

****************************************************************

        Solution:

         Variables     Values

        A           =    -76.160194
        B           =     21.032352
        C           =    -2.1523850
        D           =     .15174370
        E           =  -.0018549928


        Maximum error is      4.8005339

****************************************************************
```

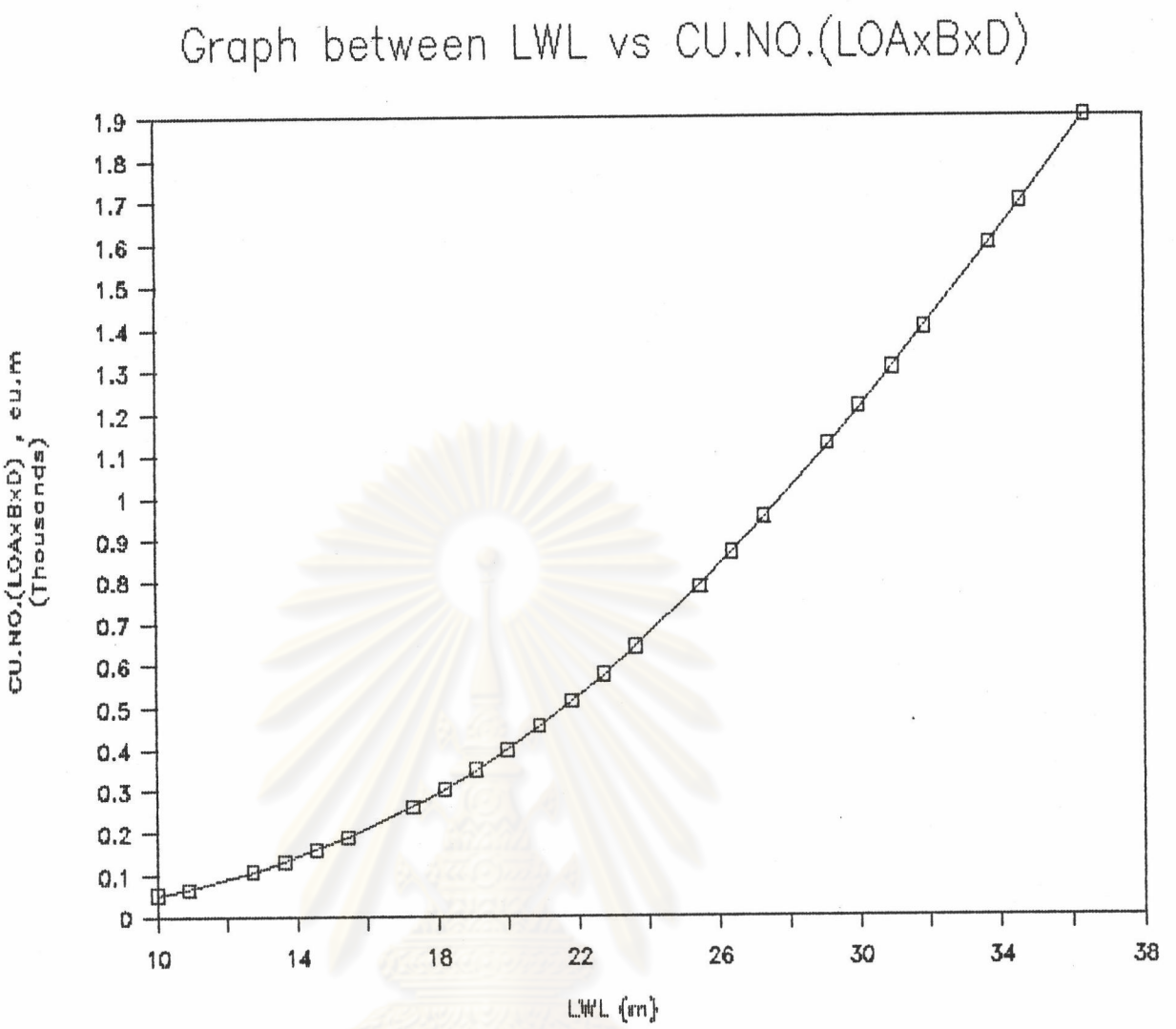

Fig 6.7

```
************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT19
************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 10.93
        f(10.9) = 13.57
        f(12.75) = 21.94
        f(13.65) = 26.76
        f(14.56) = 32.42
        f(15.47) = 38.51
        f(17.3) = 53.42
        f(18.2) = 61.53
        f(19.1) = 71.23
        f(20) = 80.85
        f(20.93) = 91.86
        f(21.84) = 103.41
        f(22.75) = 115.63
        f(23.65) = 128.36
        f(25.48) = 156.65
        f(26.39) = 172.78
        f(27.3) = 188.20
        f(29.12) = 221.24
        f(30) = 238.34
        f(30.95) = 255.55
        f(31.85) = 273.10
        f(33.67) = 309.67
        f(34.58) = 329.61
        f(36.4) = 366.74

        $ substlevel = 0

************************************************************

        Solution:

         Variables     Values

        A          =    -.38267806
        B          =     .86677978
        C          =    -.16655328
        D          =     .022165816
        E          = -.00029221199

        Maximum error is      .84635763

************************************************************
```

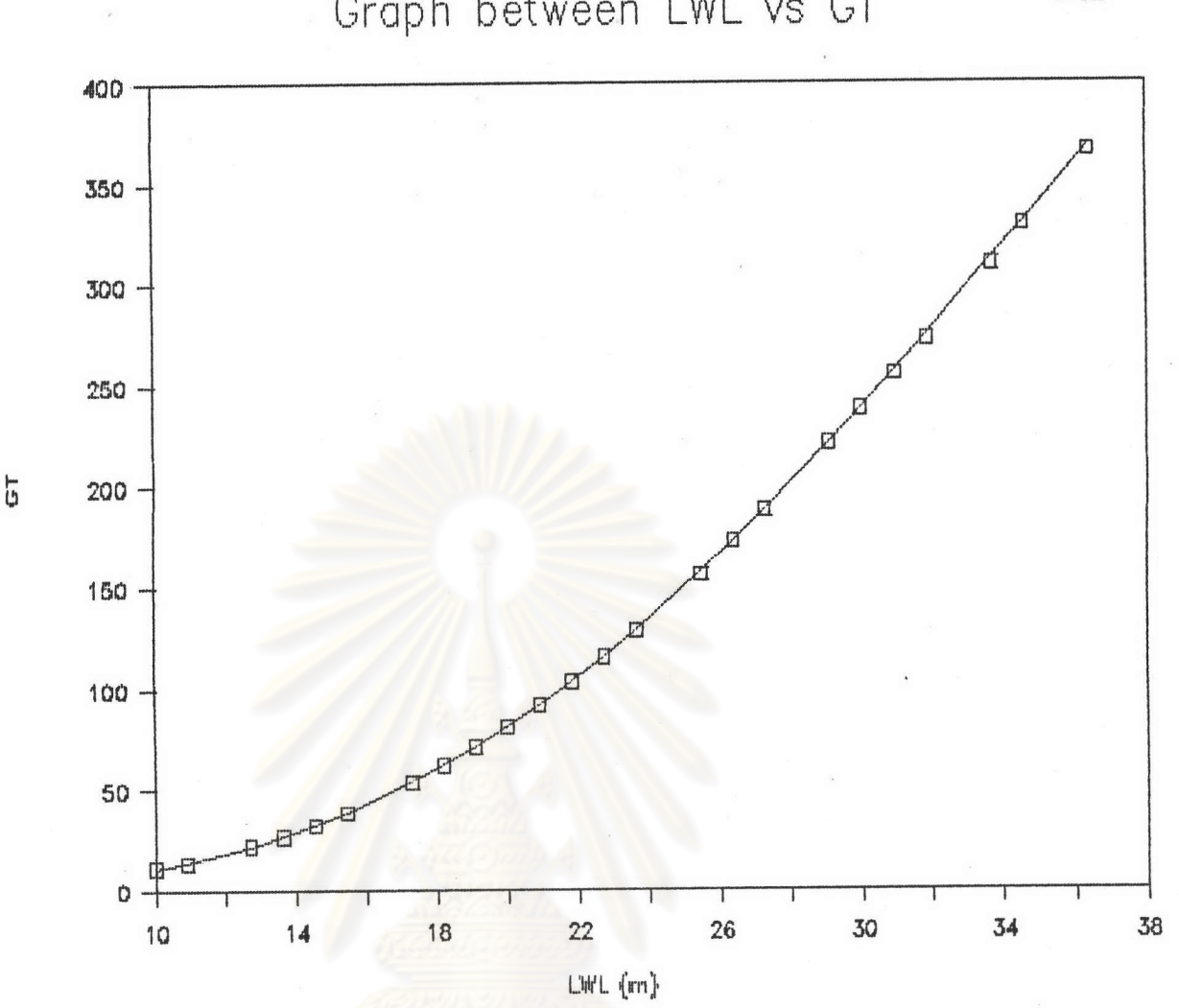

Fig 6.8

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT110
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 7.43
        f(10.9) = 9.23
        f(12.75) = 14.92
        f(13.65) = 18.20
        f(14.56) = 22.05
        f(15.47) = 26.19
        f(17.3) = 36.32
        f(18.2) = 41.84
        f(19.1) = 48.44
        f(20) = 54.97
        f(20.93) = 62.47
        f(21.84) = 70.32
        f(22.75) = 78.63
        f(23.65) = 87.29
        f(25.48) = 106.52
        f(26.39) = 117.22
        f(27.3) = 127.98
        f(29.12) = 150.44
        f(30) = 162.07
        f(30.95) = 173.78
        f(31.85) = 185.71
        f(33.67) = 210.58
        f(34.58) = 224.13
        f(36.4) = 249.38

        $ substlevel = 0

**************************************************************

        Solution:

         Variables    Values

        A          =    -.92582351
        B          =     .72327585
        C          =    -.12244506
        D          =    .015329051
        E          = -.00020120207


        Maximum error is     .58740562

**************************************************************
```

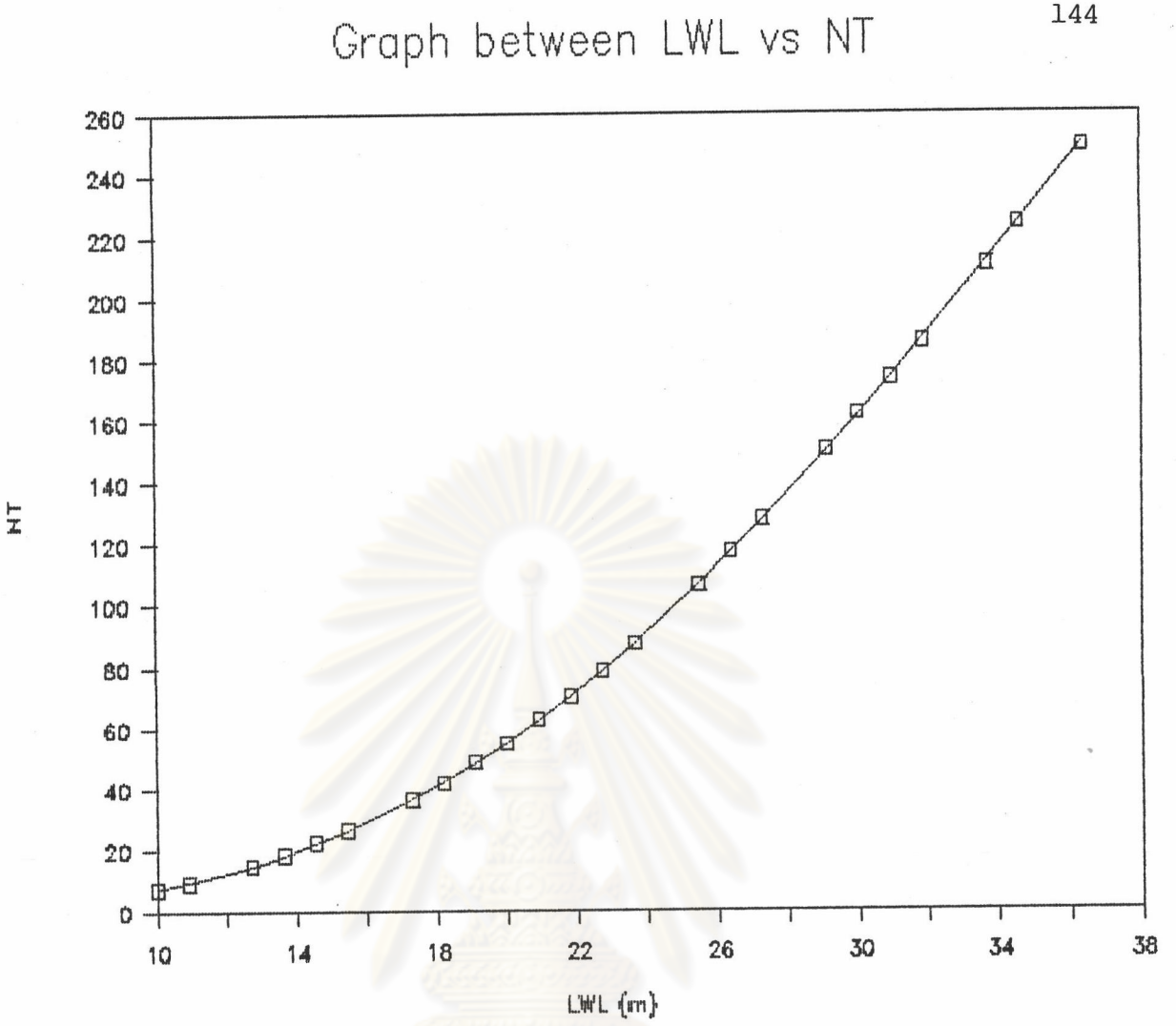

Fig 6.9

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT111
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 16.0
        f(10.9) = 21.0
        f(12.75) = 34.0
        f(13.65) = 41.0
        f(14.56) = 50.0
        f(15.47) = 60.0
        f(17.3) = 84.0
        f(18.2) = 98.0
        f(19.1) = 117.0
        f(20) = 130.0
        f(20.93) = 150.0
        f(21.84) = 170.0
        f(22.75) = 190.0
        f(23.65) = 215.0
        f(25.48) = 265.0
        f(26.39) = 295.0
        f(27.3) = 323.0
        f(29.12) = 386.0
        f(30) = 420.0
        f(30.95) = 453.0
        f(31.85) = 488.0
        f(33.67) = 561.0
        f(34.58) = 600.0
        f(36.4) = 680.0

        $ substlevel = 0

**************************************************************

        Solution:

         Variables     Values

        A           =    -18.276775
        B           =     5.7387967
        C           =    -.65218031
        D           =     .047726411
        E           = -.00054070441


        Maximum error is      2.9965494
```

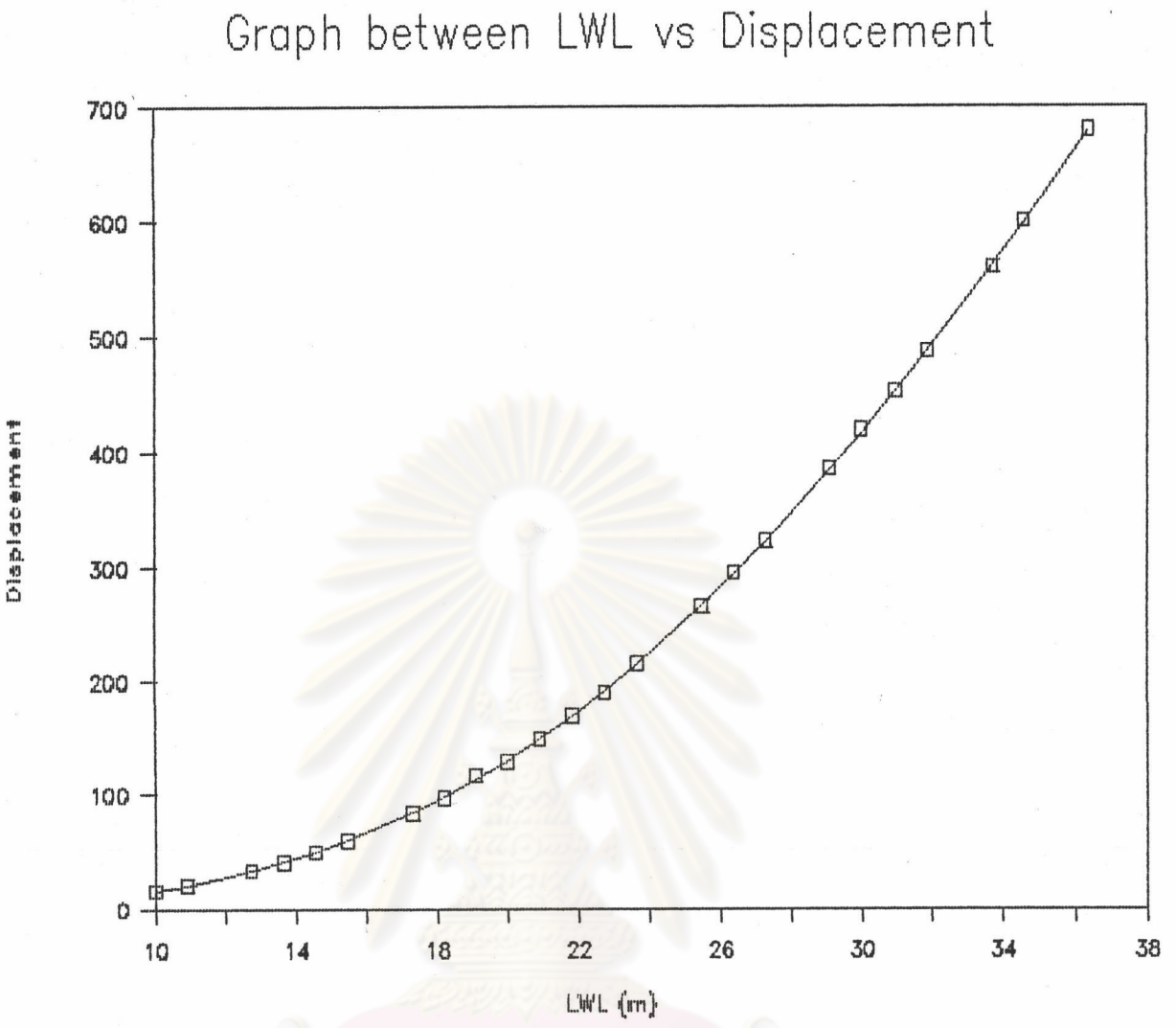

Fig 6.10

```
************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT112                                    147
************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 45.0
        f(10.9) = 65.0
        f(12.75) = 110.0
        f(13.65) = 140.0
        f(14.56) = 180.0
        f(15.47) = 200.0
        f(17.3) = 240.0
        f(18.2) = 280.0
        f(19.1) = 300.0
        f(20) = 350.0
        f(20.93) = 380.0
        f(21.84) = 410.0
        f(22.75) = 450.0
        f(23.65) = 500.0
        f(25.48) = 650.0
        f(26.39) = 700.0
        f(27.3) = 750.0
        f(29.12) = 850.0
        f(30) = 900.0
        f(30.95) = 1000.0
        f(31.85) = 1050.0
        f(33.67) = 1125.0
        f(34.58) = 1150.0
        f(36.4) = 1250.0

        $ substlevel = 0

************************************************************

        Solution:

         Variables     Values

        A          =    -867.65515
        B          =     187.24666
        C          =    -14.140499
        D          =     .51100510
        E          =  -.0060512559

        Maximum error is      25.916607

************************************************************
```

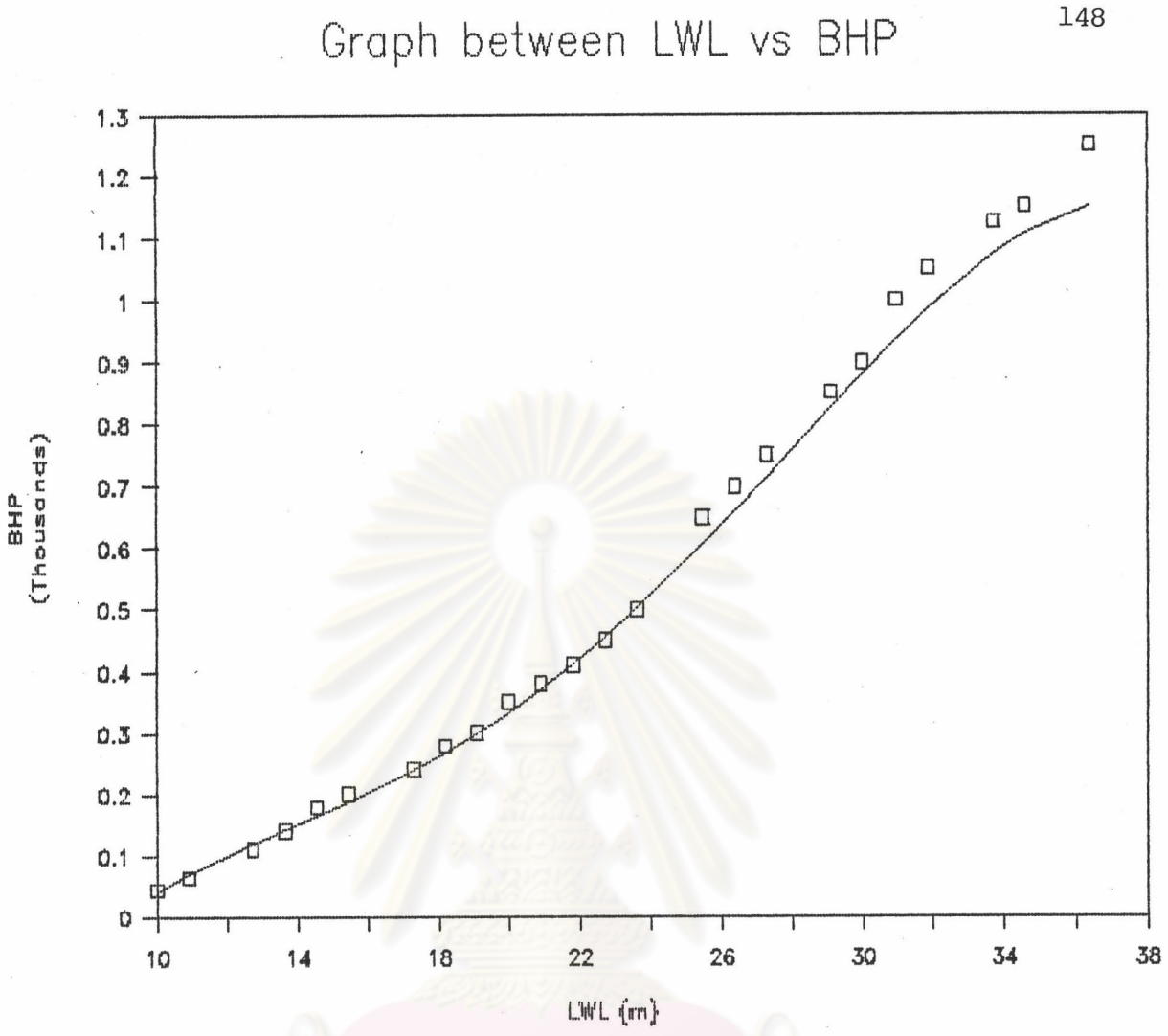

Fig 6.11

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT113                                    149
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 10.0
        f(10.9) = 13.0
        f(12.75) = 21.00
        f(13.65) = 26.0
        f(14.56) = 32.0
        f(15.47) = 38.0
        f(17.3) = 52.0
        f(18.2) = 60.0
        f(19.1) = 70.0
        f(20) = 80.0
        f(20.93) = 90.0
        f(21.84) = 115.0
        f(22.75) = 125.0
        f(23.65) = 135.0
        f(25.48) = 170.0
        f(26.39) = 187.0
        f(27.3) = 205.0
        f(29.12) = 242.0
        f(30) = 265.0
        f(30.95) = 288.0
        f(31.85) = 308.0
        f(33.67) = 350.0
        f(34.58) = 374.0
        f(36.4) = 420.0

        $ substlevel = 0

**************************************************************

        Solution:

         Variables    Values

        A          =    -1.8518574
        B          =     2.4988900
        C          =    -.41950340
        D          =    .033685528
        E          = -.00042073796

        Maximum error is     7.1830274

**************************************************************
```

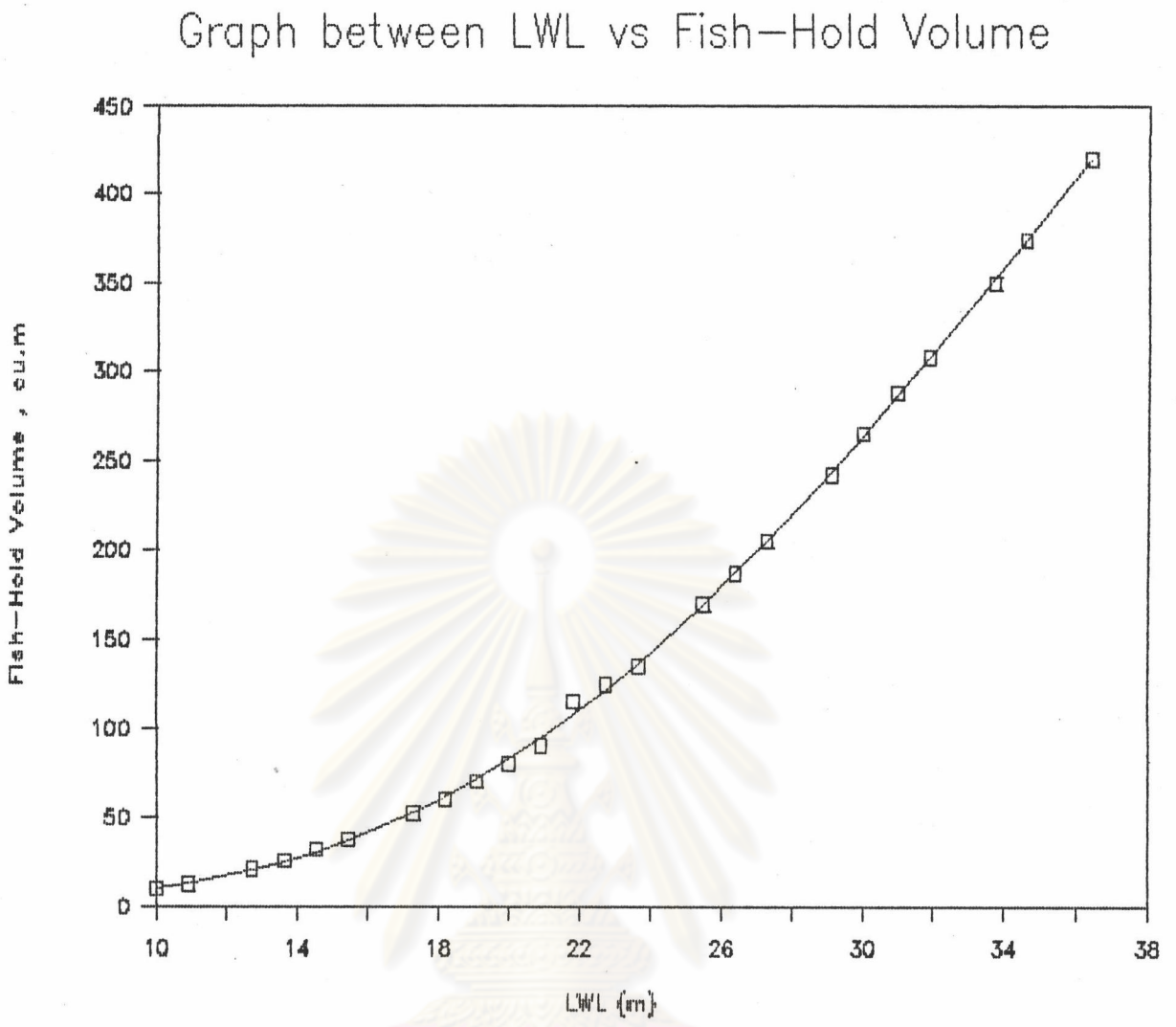

Fig 6.12

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT114
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 1.20
        f(10.9) = 1.60
        f(12.75) = 3.00
        f(13.65) = 4.00
        f(14.56) = 5.00
        f(15.47) = 6.00
        f(17.3) = 9.00
        f(18.2) = 12.00
        f(19.1) = 14.00
        f(20) = 16.00
        f(20.93) = 20.00
        f(21.84) = 24.00
        f(22.75) = 26.00
        f(23.65) = 32.00
        f(25.48) = 45.00
        f(26.39) = 50.00
        f(27.3) = 60.00
        f(29.12) = 70.00
        f(30) = 75.00
        f(30.95) = 86.00
        f(31.85) = 100.00
        f(33.67) = 120.00
        f(34.58) = 130.00
        f(36.4) = 150.00

        $ substlevel = 0

**************************************************************

        Solution:

         Variables    Values

         A          =    -26.504118
         B          =     6.5550103
         C          =    -.58032769
         D          =    .022072714
         E          = -.00020300034

         Maximum error is     4.3842704

**************************************************************
```

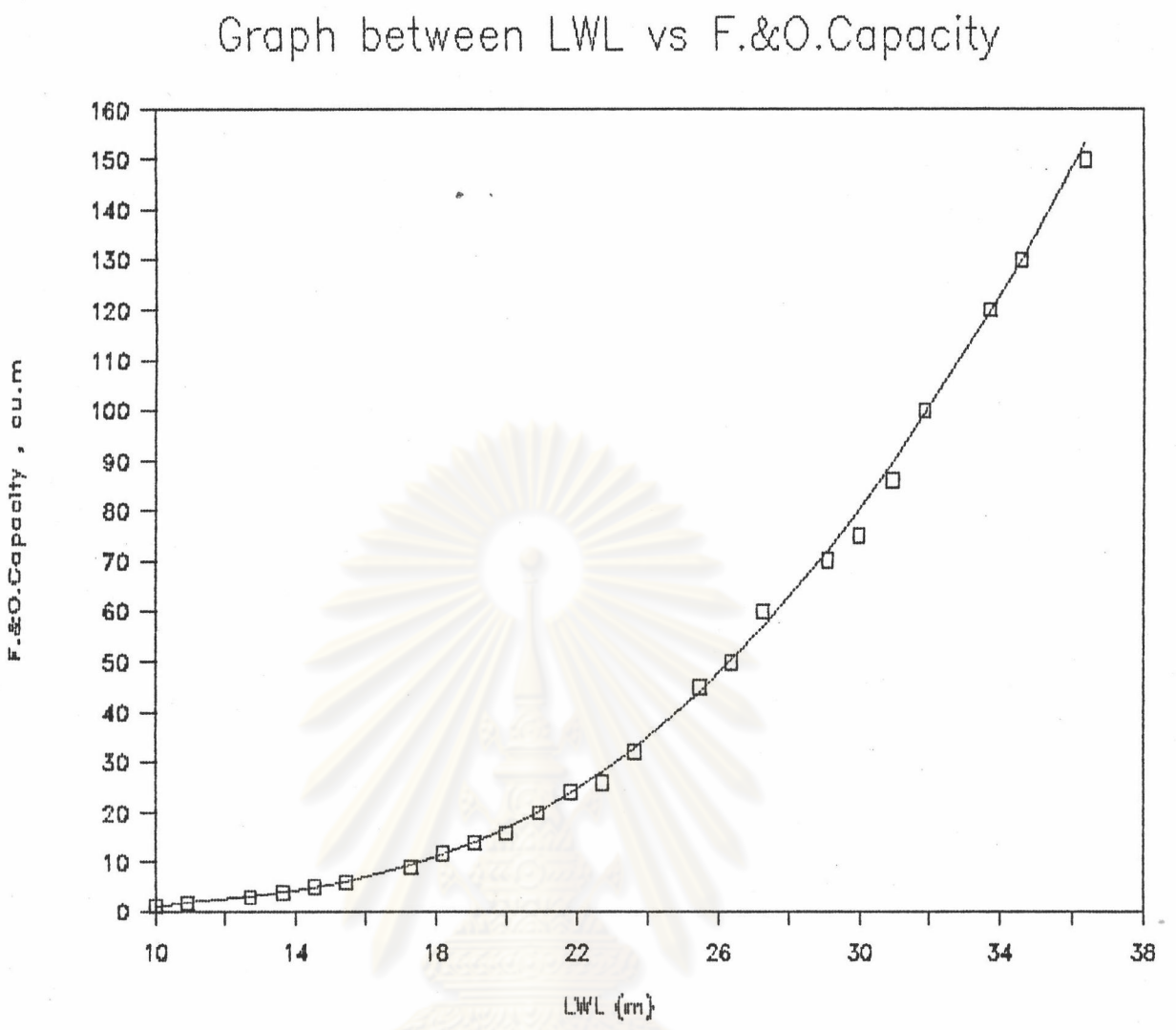

Fig 6.13

```
************************************************************
Eureka: The Solver, Version 1.0                                    153

Name of input file: A:\FIT115
************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 0.40
        f(10.9) = 0.60
        f(12.75) = 1.00
        f(13.65) = 1.20
        f(14.56) = 1.50
        f(15.47) = 1.80
        f(17.3) = 2.50
        f(18.2) = 3.00
        f(19.1) = 4.00
        f(20) = 4.50
        f(20.93) = 5.00
        f(21.84) = 6.00
        f(22.75) = 7.00
        f(23.65) = 8.00
        f(25.48) = 10.00
        f(26.39) = 12.00
        f(27.3) = 14.00
        f(29.12) = 18.00
        f(30) = 20.00
        f(30.95) = 22.00
        f(31.85) = 24.00
        f(33.67) = 30.00
        f(34.58) = 32.00
        f(36.4) = 36.00

        $ substlevel = 0

************************************************************

        Solution:

         Variables     Values

        A           =    -21.201002
        B           =     4.7549753
        C           =    -.37518346
        D           =     .012634112
        E           = -.00012964962

        Maximum error is      .80914714


************************************************************
```

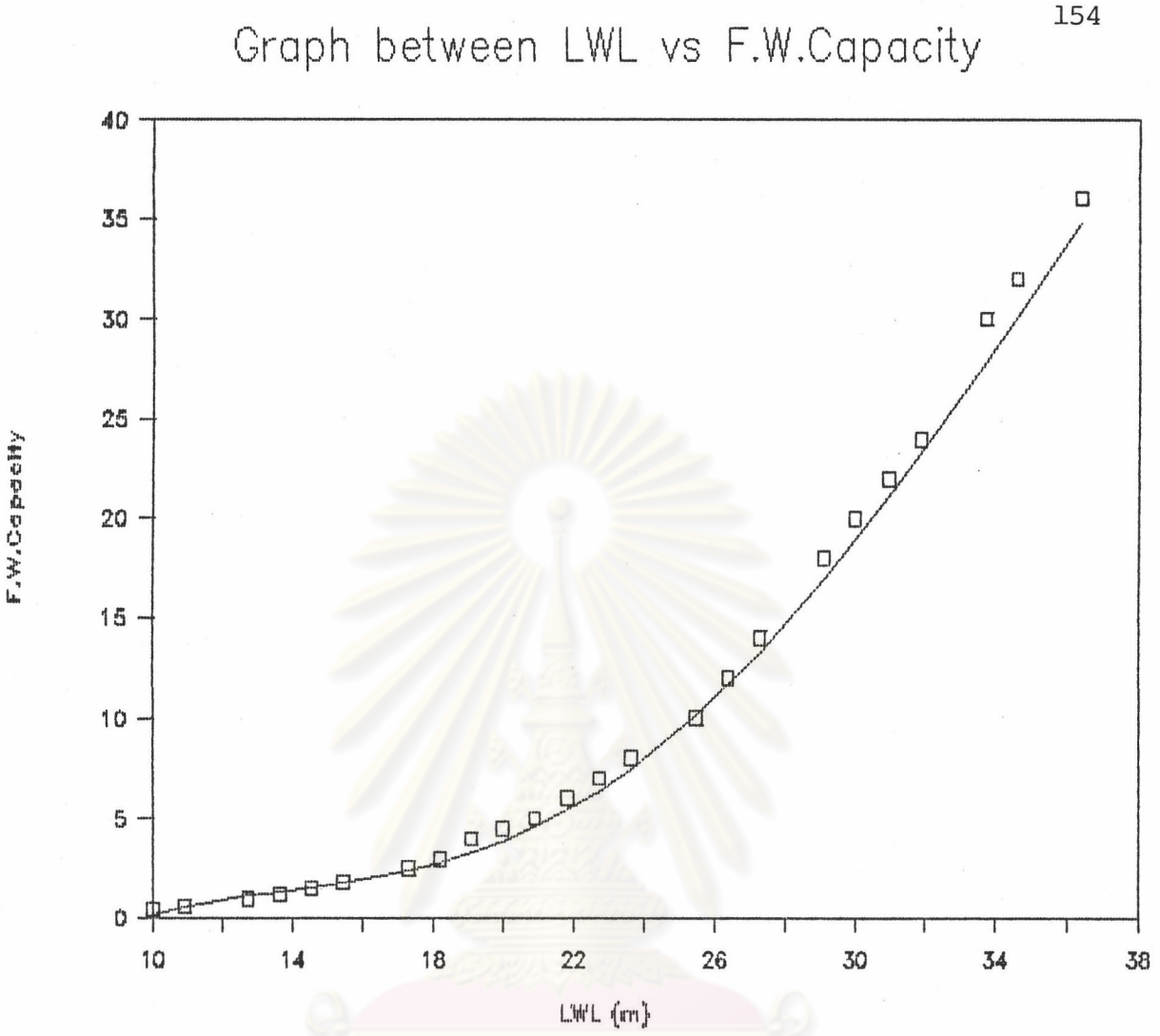

Fig 6.14

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT116
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 5
        f(10.9) = 5
        f(12.75) = 6
        f(13.65) = 8
        f(14.56) = 8
        f(15.47) = 10
        f(17.3) = 12
        f(18.2) = 12
        f(19.1) = 14
        f(20) = 14
        f(20.93) = 16
        f(21.84) = 16
        f(22.75) = 18
        f(23.65) = 18
        f(25.48) = 20
        f(26.39) = 22
        f(27.3) = 22
        f(29.12) = 24
        f(30) = 26
        f(30.95) = 26
        f(31.85) = 26
        f(33.67) = 28
        f(34.58) = 28
        f(36.4) = 30

        $ substlevel = 0

**************************************************************

       Solution:

        Variables    Values

       A          =     6.1785288
       B          =    -1.2543817
       C          =     .14169465
       D          =  -.0034697156
       E          = .000027821363

       Maximum error is     1.0747529

**************************************************************
```

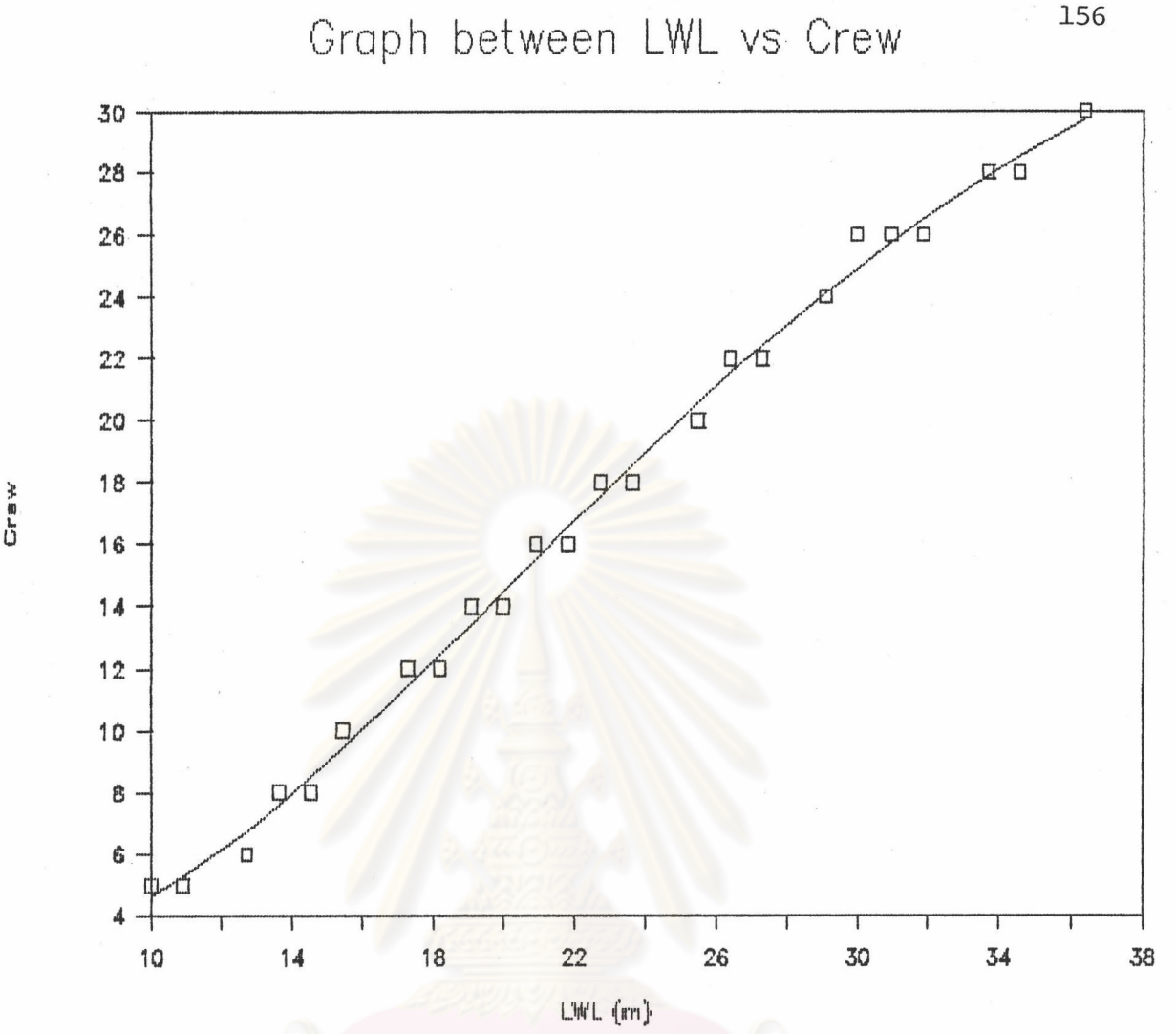

Fig 6.15

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT117
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 6.87
        f(10.9) = 7.18
        f(12.75) = 7.75
        f(13.65) = 8.03
        f(14.56) = 8.29
        f(15.47) = 8.55
        f(17.3) = 9.04
        f(18.2) = 9.27
        f(19.1) = 9.50
        f(20) = 9.72
        f(20.93) = 9.94
        f(21.84) = 10.16
        f(22.75) = 10.37
        f(23.65) = 10.57
        f(25.48) = 10.97
        f(26.39) = 11.17
        f(27.3) = 11.36
        f(29.12) = 11.73
        f(30) = 11.91
        f(30.95) = 12.09
        f(31.85) = 12.27
        f(33.67) = 12.61
        f(34.58) = 12.78
        f(36.4) = 13.10

        $ substlevel = 0

**************************************************************

        Solution:

         Variables     Values

        A           =     3.5976131
        B           =     .36093548
        C           =  -.0027744251


        Maximum error is     .059525382


**************************************************************
```

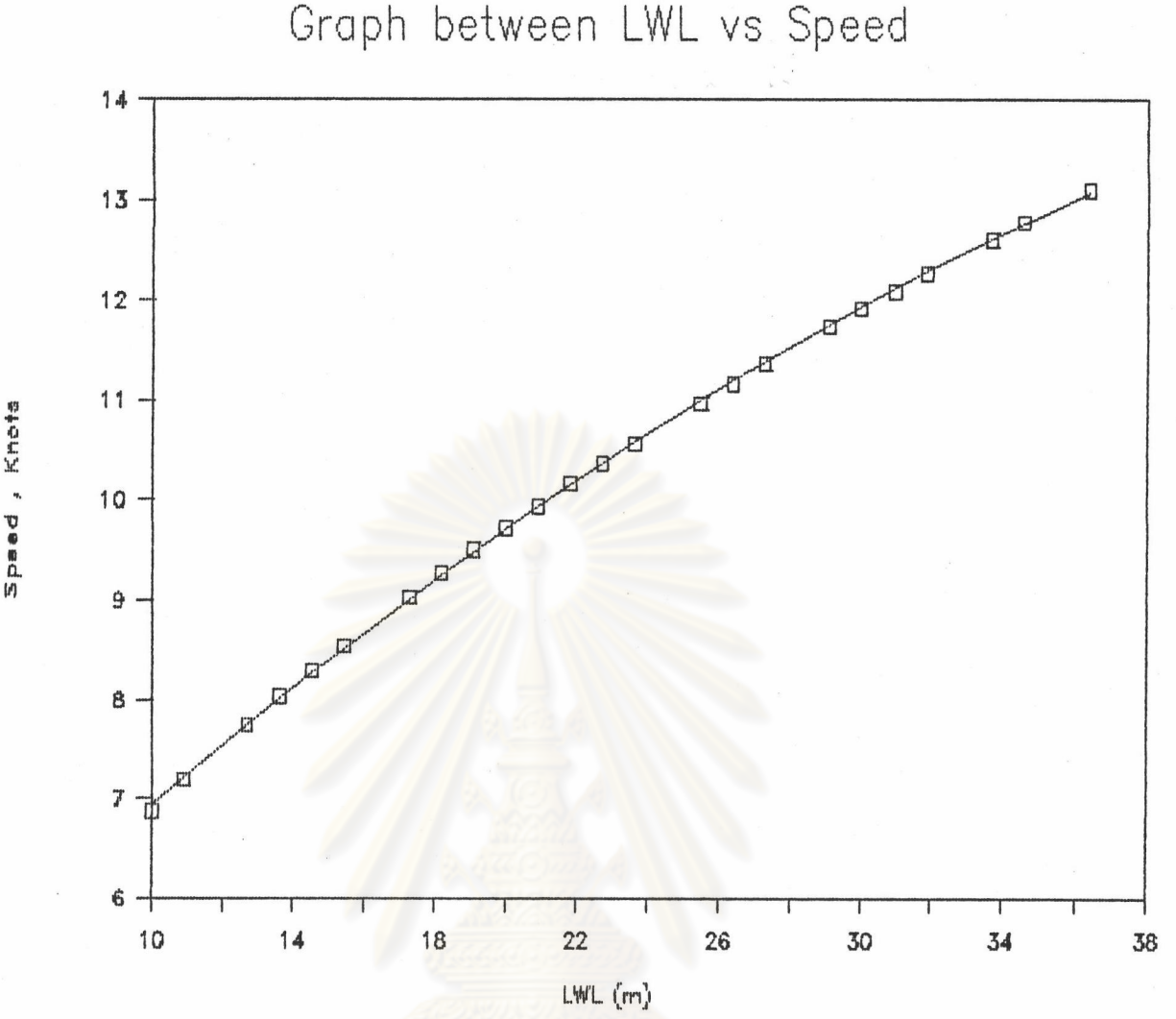

Fig 6.16

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT118
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 900
        f(10.9) = 950
        f(12.75) = 1100
        f(13.65) = 1200
        f(14.56) = 1300
        f(15.47) = 1400
        f(17.3) = 1750
        f(18.2) = 2000
        f(19.1) = 2200
        f(20) = 2400
        f(20.93) = 2700
        f(21.84) = 3000
        f(22.75) = 3300
        f(23.65) = 3500
        f(25.48) = 4000
        f(26.39) = 4200
        f(27.3) = 4800
        f(29.12) = 5200
        f(30) = 5300
        f(30.95) = 5400
        f(31.85) = 6000
        f(33.67) = 7000
        f(34.58) = 7800
        f(36.4) = 9000

        $ substlevel = 0

**************************************************************

        Solution:

         Variables     Values

        A           =     9988.8955
        B           =    -2049.2705
        C           =     157.01680
        D           =    -4.7289119
        E           =    .053343520

        Maximum error is      319.51037

**************************************************************
```

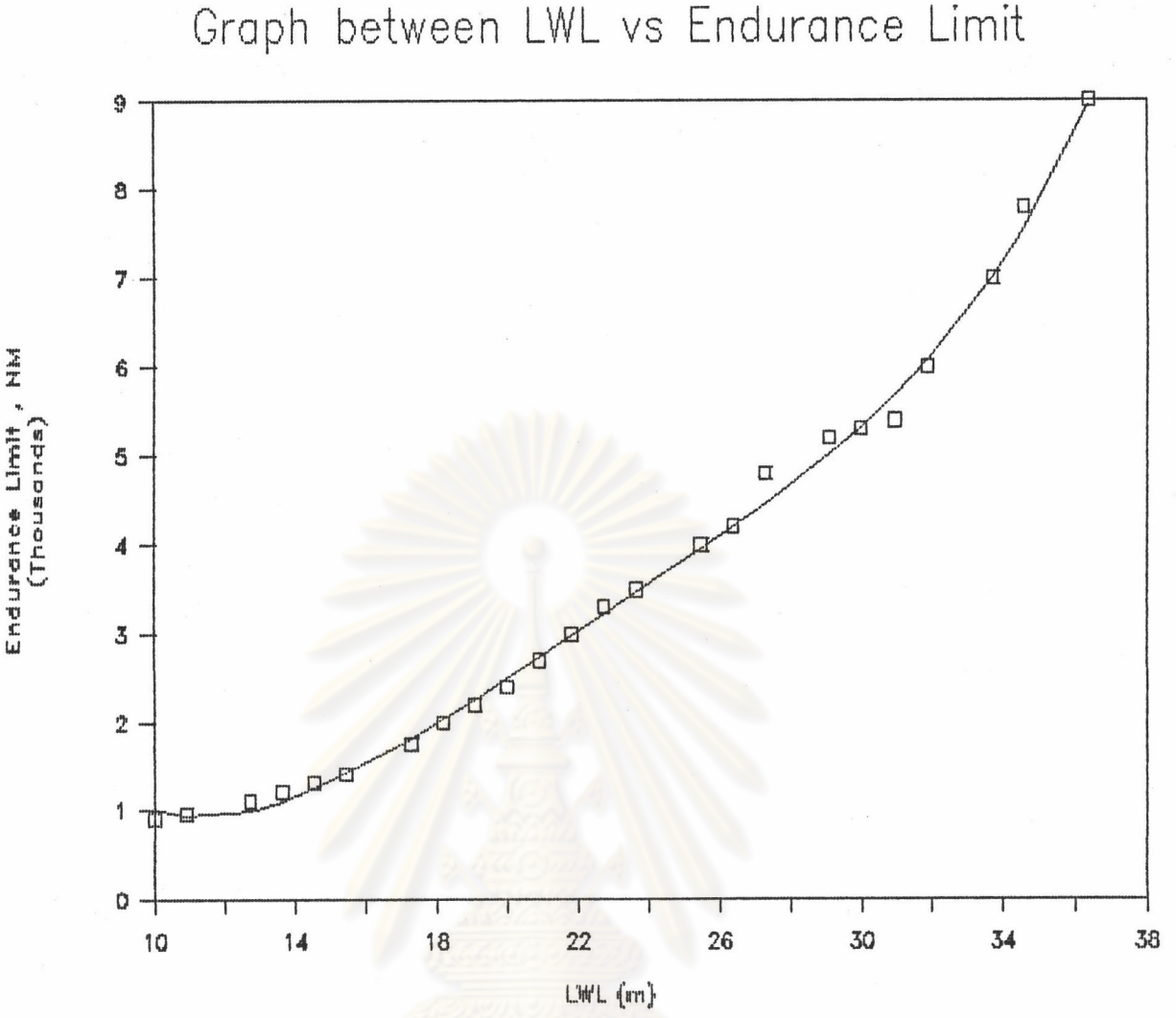

Fig 6.17

```
************************************************************
Eureka: The Solver, Version 1.0                                    161

Name of input file: A:\FIT119
************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2+D*x^3+E*x^4

        f(10.0) = 3.98
        f(10.9) = 3.99
        f(12.75) = 3.98
        f(13.65) = 4.00
        f(14.56) = 3.98
        f(15.47) = 3.98
        f(17.3) = 3.98
        f(18.2) = 3.98
        f(19.1) = 3.94
        f(20) = 3.98
        f(20.93) = 3.98
        f(21.84) = 3.98
        f(22.75) = 3.98
        f(23.65) = 3.98
        f(25.48) = 4.00
        f(26.39) = 3.99
        f(27.3) = 4.00
        f(29.12) = 4.03
        f(30) = 4.04
        f(30.95) = 4.06
        f(31.85) = 4.08
        f(33.67) = 4.11
        f(34.58) = 4.13
        f(36.4) = 4.17

        $ substlevel = 0

************************************************************

        Solution:

         Variables     Values

        A           =     3.7211858
        B           =    .059089623
        C           =  -.0044977308
        D           =  .00013329131
        E           = -1.2364379e-06

        Maximum error is     .033184137


************************************************************
```

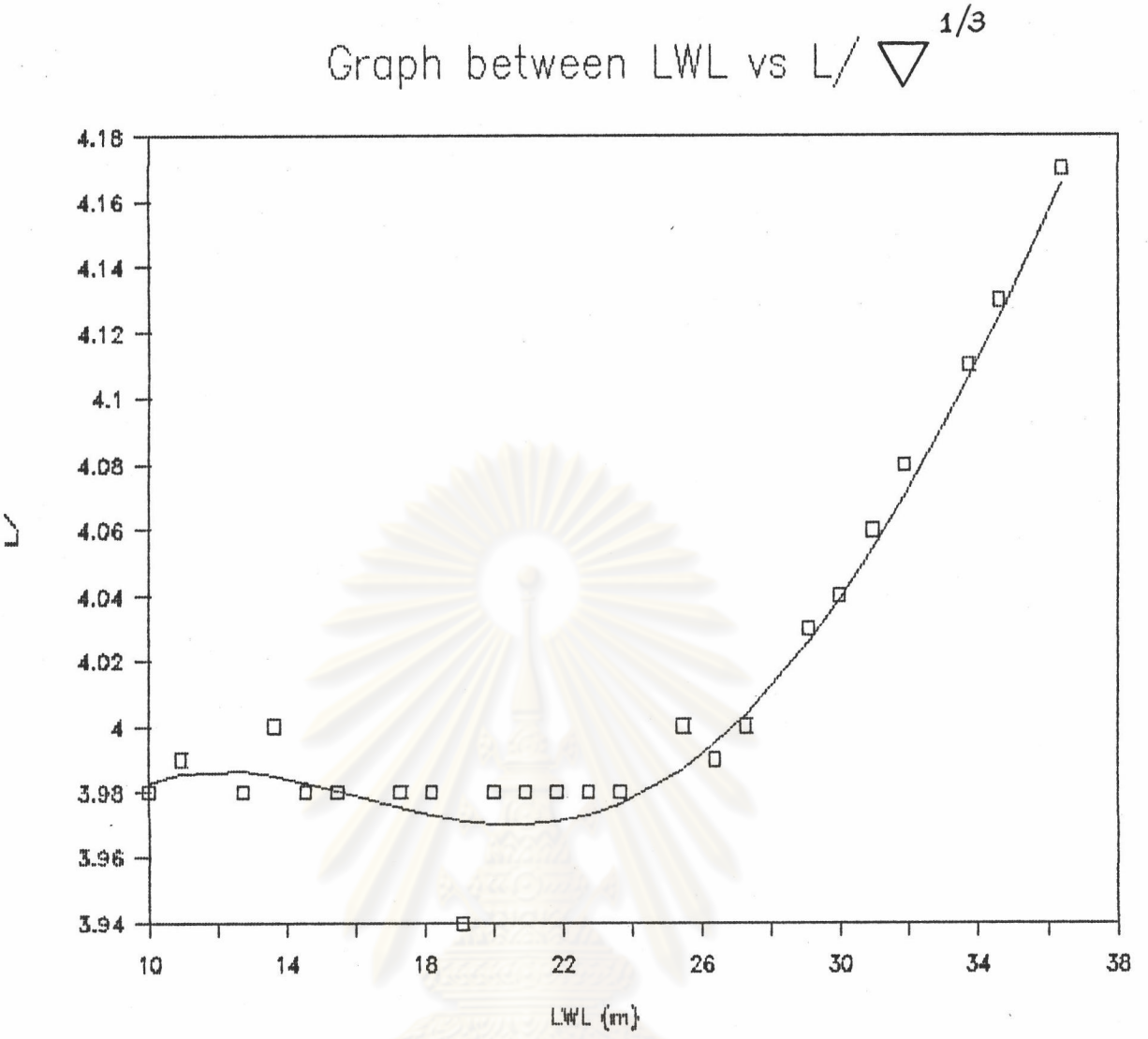

Fig 6.18

Name of input file: A:\FIT120

```
; This example demonstrates Eureka's ability to find
; values for constants in a function that make the
; function best fit empirical data.  Because the equation
; file includes a $ substlevel = 0 directive, Eureka will
; perform a Least Squares Fit to find the function (of
; the required form) that best matches the points
; x, (f(x) given.
; In this example, the function is
;       f(x) := EXP(a * x^N + B)
; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

f(x) := A+B*x+C*x^2+D*x^3+E*x^4

f(10.0) = 461
f(10.9) = 456
f(12.75) = 460
f(13.65) = 458
f(14.56) = 460
f(15.47) = 458
f(17.3) = 460
f(18.2) = 460
f(19.1) = 475
f(20) = 460
f(20.93) = 460
f(21.84) = 460
f(22.75) = 460
f(23.65) = 458
f(25.48) = 452
f(26.39) = 454
f(27.3) = 449
f(29.12) = 443
f(30) = 439
f(30.95) = 446
f(31.85) = 427
f(33.67) = 416
f(34.58) = 411
f(36.4) = 400

$ substlevel = 0
```

Solution:

Variables		Values
A	=	503.18650
B	=	-10.447520
C	=	.82236928
D	=	-.024164121
E	=	.00020034096

Maximum error is 13.062434

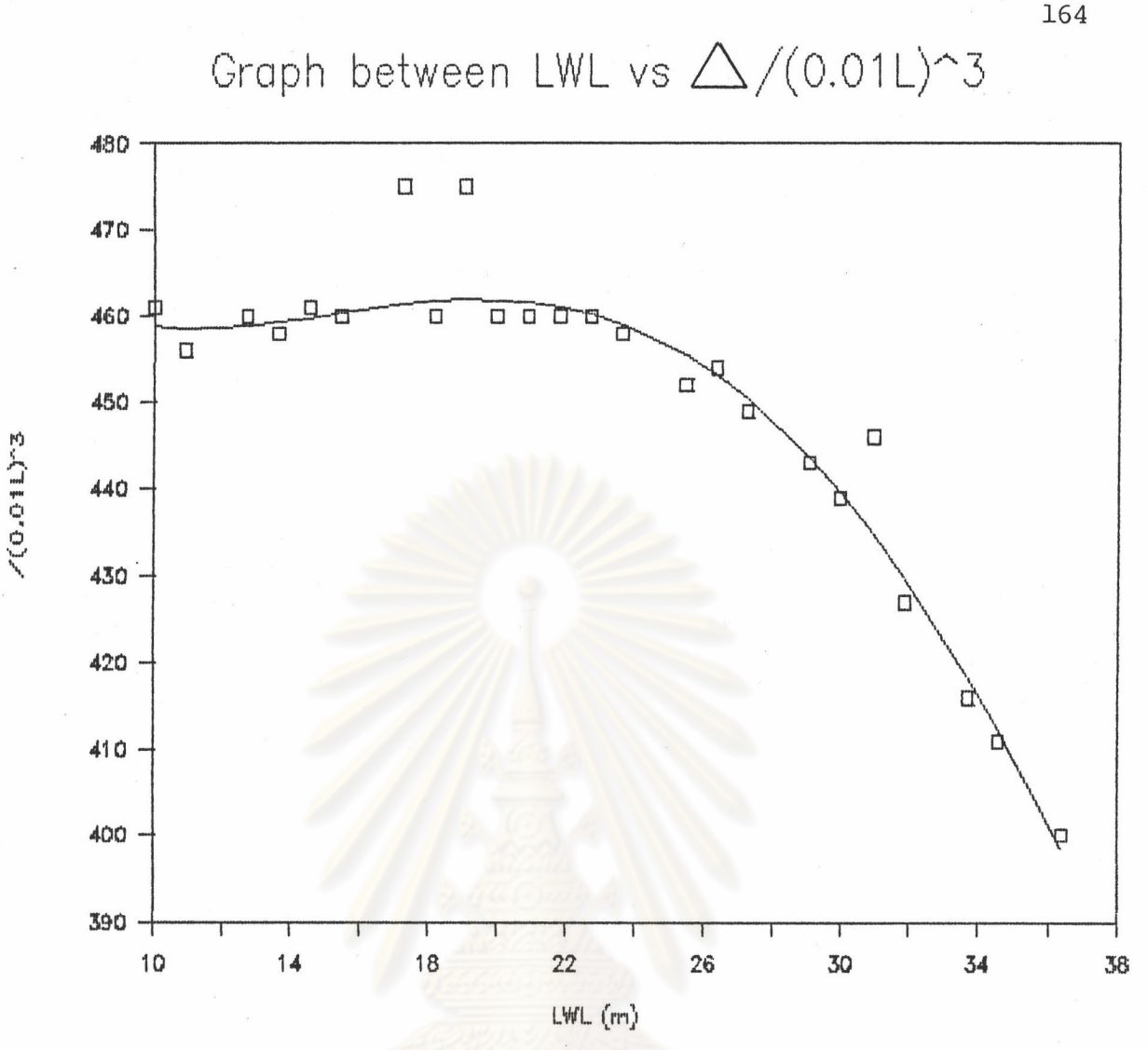

Fig 6.19

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT121
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 3.35
        f(10.9) = 3.45
        f(12.75) = 3.41
        f(13.65) = 3.42
        f(14.56) = 3.43
        f(15.47) = 3.45
        f(17.3) = 3.47
        f(18.2) = 3.49
        f(19.1) = 3.50
        f(20) = 3.53
        f(20.93) = 3.54
        f(21.84) = 3.56
        f(22.75) = 3.59
        f(23.65) = 3.61
        f(25.48) = 3.68
        f(26.39) = 3.70
        f(27.3) = 3.74
        f(29.12) = 3.82
        f(30) = 3.86
        f(30.95) = 3.90
        f(31.85) = 3.96
        f(33.67) = 4.05
        f(34.58) = 4.09
        f(36.4) = 4.21

        $ substlevel = 0
**************************************************************

        Solution:

         Variables     Values

        A           =     3.5143960
        B           =   -.022466751
        C           =   .0011354010

        Maximum error is     .053268540

**************************************************************
```

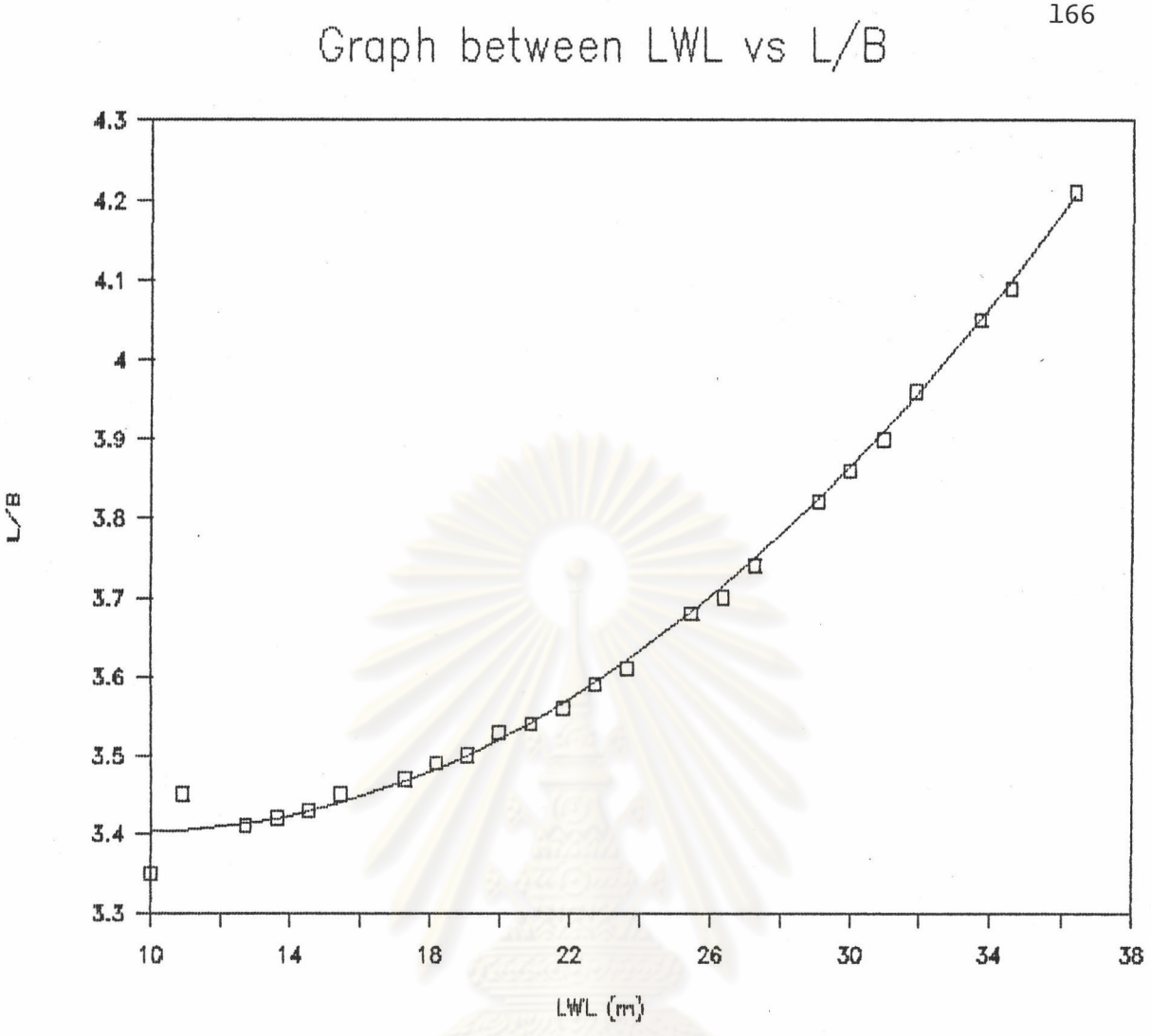

Fig 6.20

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT122
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 7.43
        f(10.9) = 7.50
        f(12.75) = 7.44
        f(13.65) = 7.50
        f(14.56) = 7.48
        f(15.47) = 7.49
        f(17.3) = 7.51
        f(18.2) = 7.52
        f(19.1) = 7.50
        f(20) = 7.53
        f(20.93) = 7.54
        f(21.84) = 7.55
        f(22.75) = 7.53
        f(23.65) = 7.56
        f(25.48) = 7.57
        f(26.39) = 7.53
        f(27.3) = 7.57
        f(29.12) = 7.62
        f(30) = 7.64
        f(30.95) = 7.60
        f(31.85) = 7.72
        f(33.67) = 7.82
        f(34.58) = 7.88
        f(36.4) = 8.00

        $ substlevel = 0

**************************************************************

        Solution:

         Variables     Values

        A          =     7.7177896
        B          =   -.031581452
        C          =    .0010144974


        Maximum error is      .11213334

**************************************************************
```

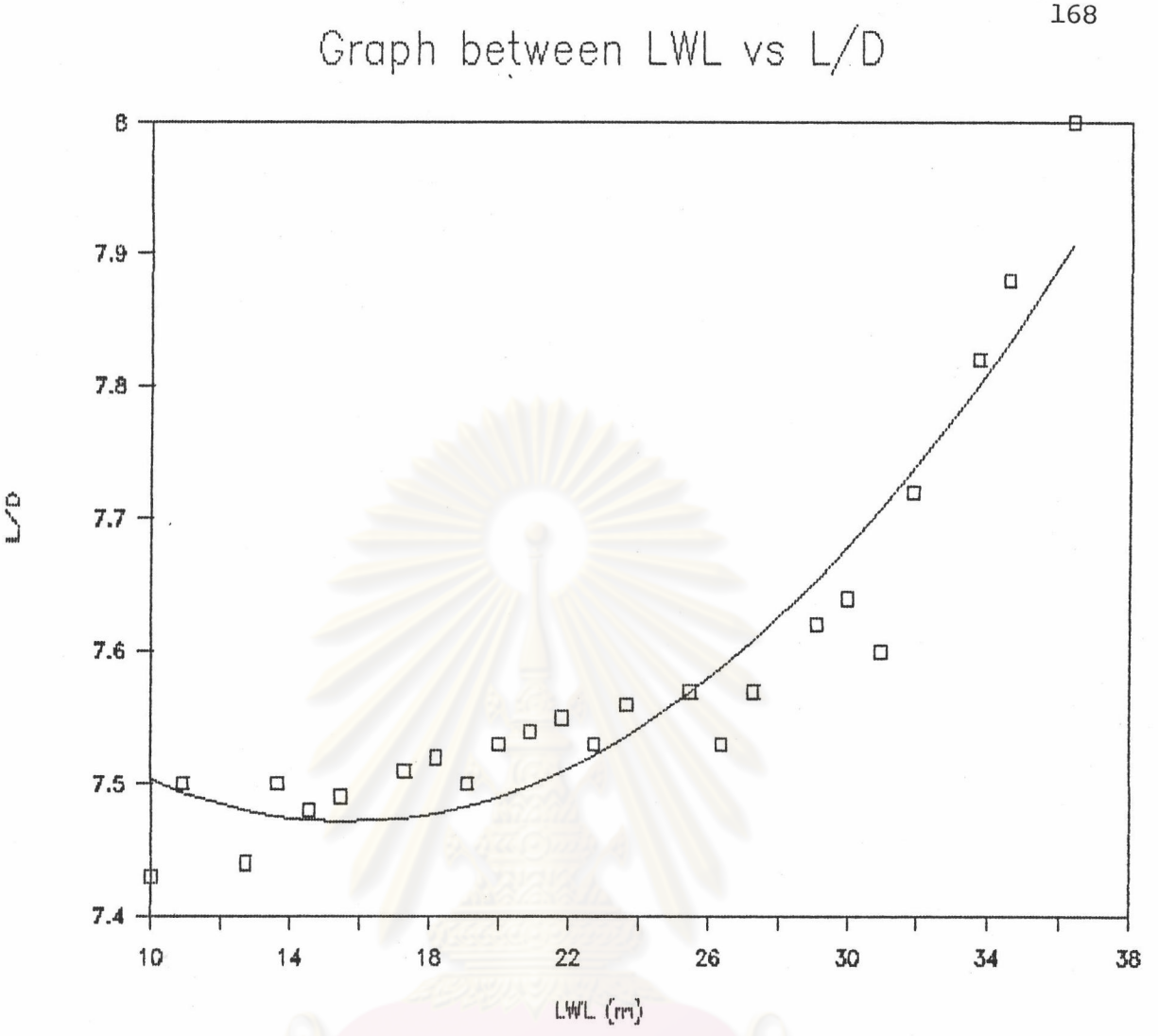

Fig 6.21

```
**************************************************************
Eureka: The Solver, Version 1.0

Name of input file: A:\FIT123
**************************************************************

        ; This example demonstrates Eureka's ability to find
        ; values for constants in a function that make the
        ; function best fit empirical data.  Because the equation
        ; file includes a $ substlevel = 0 directive, Eureka will
        ; perform a Least Squares Fit to find the function (of
        ; the required form) that best matches the points
        ; x, (f(x) given.
        ; In this example, the function is
        ;       f(x) := EXP(a * x^N + B)
        ; where the ideal solution is a = 0.25, b = 0.15 and N = 1.5

        f(x) := A+B*x+C*x^2

        f(10.0) = 2.22
        f(10.9) = 2.18
        f(12.75) = 2.18
        f(13.65) = 2.19
        f(14.56) = 2.18
        f(15.47) = 2.17
        f(17.3) = 2.17
        f(18.2) = 2.15
        f(19.1) = 2.14
        f(20) = 2.14
        f(20.93) = 2.13
        f(21.84) = 2.12
        f(22.75) = 2.10
        f(23.65) = 2.09
        f(25.48) = 2.06
        f(26.39) = 2.03
        f(27.3) = 2.02
        f(29.12) = 2.00
        f(30) = 1.98
        f(30.95) = 1.97
        f(31.85) = 1.95
        f(33.67) = 1.93
        f(34.58) = 1.92
        f(36.4) = 1.90

        $ substlevel = 0

**************************************************************

        Solution:

         Variables    Values

        A           =     2.2374872
        B           = -.00013226152
        C           = -.00026725646


        Maximum error is    .024292777


**************************************************************
```

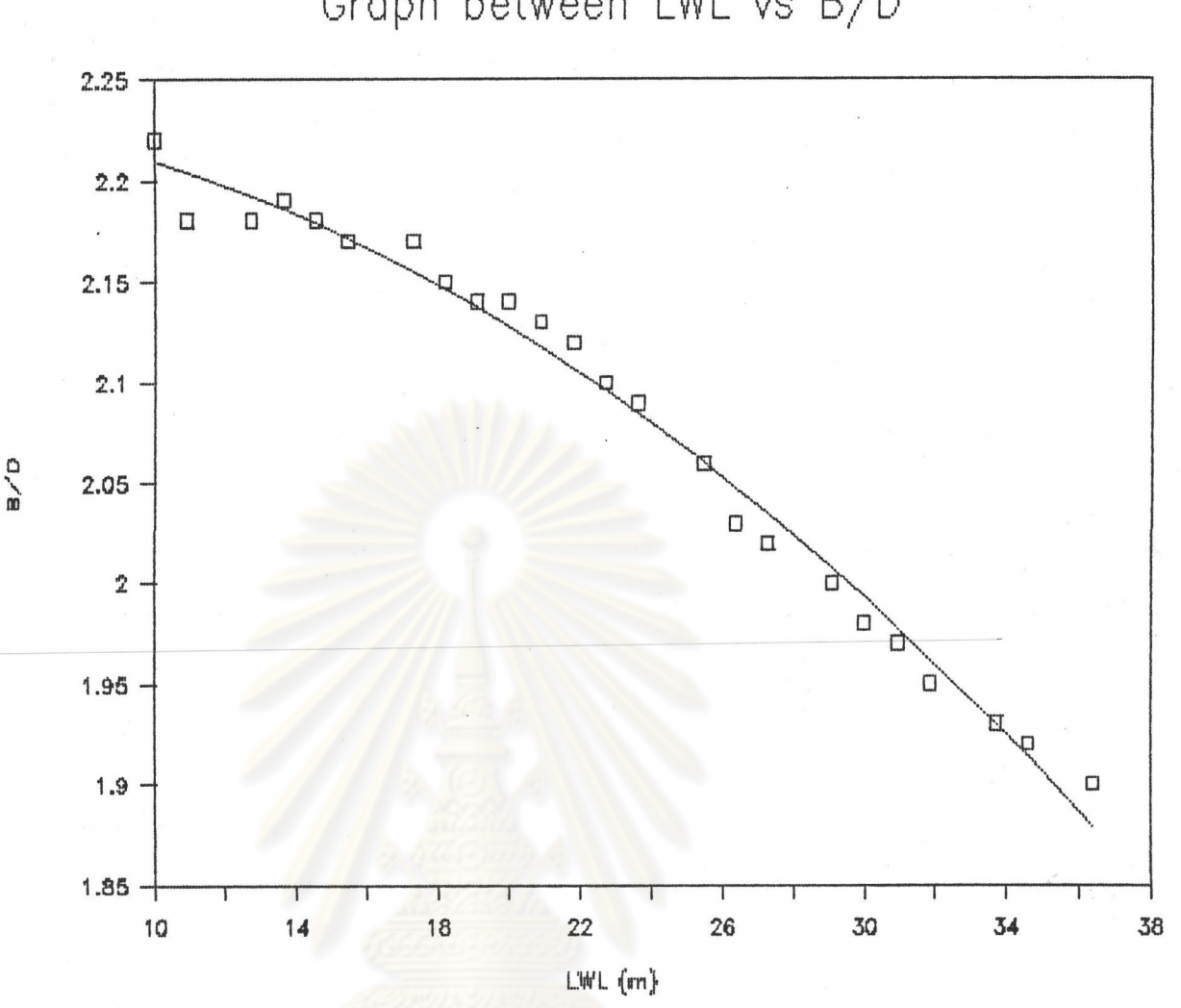

Fig 6.22