CHAPTER 7
CONCLUSION AND SUGGESTION

After doing all the analysis on fleet sizing using simulation approach in ARENA simulation software and economic profitability analysis using Microsoft® Excel, the conclusions of the research are drawn. Suggestion for further research in fleet sizing problem also explained in the last section of this chapter.

7.1. Conclusion

Research highlight is about determining optimum number of I-Trolley used in production floor to prevent waste occurred in form of waiting time of material and also maximize production volume. To solve this research, fleet sizing problem is treated same as queuing theory and solve using simulation approach due to non-exponential in inter-arrival time of material. According to simulation result and profitability analysis, conclusion is drawn as follows:

a. The optimum situation with lowest material waiting time and maximum production volume is reached with 14 I-Trolley with details in phase one and phase two need respectively six and eight I-Trolley.
b. There is not any significance difference tested using ANOVA if another I-Trolley added in the optimum solution.
c. There are two methods chose to analyze economic profitability
    1. Payback period to analyze economic profitability without considering time value of money conclude that the payback period is between 11th and 12th month
    2. Internal Rate of Return to analyze economic profitability with considering time value of money conclude that the value of IRR is 62 percent in two years which is larger than interest rate.
d. The result on economic profitability analysis conclude that investment on I-Trolley is feasible in two years, which is fulfill management requirement before implementing in production floor.
e. Sensitivity analysis shows that decision on accepting investment is not changing if maintenance cost is 100 percent of operational cost and operator adjustment cost is below 96 percent of initial investment

7.2. Suggestion

In this research, it is assumed that production floor is 100 percent operated due to high demand to see how many automated material handling can cover the activity. For further research, considering demand pattern in certain period is highly recommended since useful life of automated material handling is long enough.

REFERENCES

Ahmad, S., Yeong, C., Su, E., & Tang, S. (2014). Improvement of Automated Guided Vehicle Design Using Finite Element Analysis. *Applied Mechanics and Materials, 607*, 317-320. doi:10.4028/www.scientific.net/AMM.607.317

Bank of Thailand. (2016). *Home Page: Bank of Thailand*. Retrieved September 15, 2016, from Bank of Thailand Web site: https://www.bot.or.th/English/Pages/default.aspx

Barnes, R. M. (1980). *Motion and Time Study: Design and Measurement of Work* (7th ed.). Singapore: John Wiley & Sons.

Bluman, A. G. (2012). *Elementary Statistics: a Step by Step Approach* (8th ed.). New York: McGraw-Hill.

Buzacott, J. A., & Shanthikumar, J. G. (1993). *Stochastic Models of Manufacturing Systems.* New Jersey: Prentice-Hall.

Chang, K.-H., Chang, A.-L., & Kuo, C.-Y. (2014). A simulation-based framework for multi-objective vehicle fleet sizing of automated material handling systems: an empirical study. (P. Macmillan, Ed.) *Journal of Simulation, 8*(4), 271-280. doi:10.1057/jos.2014.6

Fazlollahtabar, H., & Saidi-Mehrabad, M. (2015). Methodologies to Optimize Automated Guided Vehicle Scheduling and Routing Problems: A Review Study. *Journal of Intelligent & Robotic Systems, 77*(3-4), 525-545. doi:10.1007/s10846-013-0003-8

Gosavi, A., & Grasman, S. (2009). Simulation-based optimization for determining AGV capacity in a manufacturing system. *IIE Annual Conference* (pp. 574-578). Norcross: Institute of Industrial Engineers-Publisher.

Grewal, M., Weill, L., & Andrews, A. (2007). *Global Positioning Systems, Inertial Navigation, and Integration.* Hoboken, New Jersey, USA: John Wiley & Sons.

Groover, M. P. (2007). *Automation, Production System, and Computer-Integrated Manufacturing* (3rd ed.). New Jersey: Prentice Hall Press Upper Saddle River.

Hall, N., Sriskandarajah, C., & Ganesharajah, T. (2001). Operational decision in AGV-served flowshop loops: Fleet sizing and decomposition. *Annals of Operations Research, 107*(1), 189-209.

Kelton, W. D., Sadowski, R. P., & Sturrock, D. T. (2006). *Simulation with Arena* (4th ed.). New York: McGraw-Hill.

Koo, P., Lee, W., & Jang, D. (2004). Fleet sizing and vehicle routing for container transportation in a static environment. *OR Spectrum, 26*(2), 193-209. doi:10.1007/s00291-003-0152-4

Koo, P.-H., Jang, J., & Suh, J. (2004). Estimation of Part Waiting Time and Fleet Sizing in AGV Systems. *International Journal of Flexible Manufacturing Systems, 16*(3), 211-228. doi:10.1007/s10696-005-1008-9

Lee, J., Hyun, C.-H., & Park, M. (2013). A Vision-Based Automated Guided Vehicle System with Marker Recognition for Indoor Use. *Sensors, 13*(8), 10052-10073. doi:10.3390/s130810052

Leite, L., Esposito, R., Vieira, A., & Lima, F. (2015). SIMULATION OF A PRODUCTION LINE WITH AUTOMATED GUIDED VEHICLE: A CASE STUDY. *Independent Journal of Management & Production, 6*(2), 269-285.

Lin, L., Shinn, S. W., Gen, M., & Hwang, H. (2006). Network model and effective evolutionary approach for AGV dispatching in manufacturing system. *Journal of Intelligent Manufacturing, 17*(4), 465-477. doi:10.1007/s10845-005-0019-4

Marchwinski, C., & Shook, J. (2003). *Lean Lexicon: a Graphical Glossary for Lean Thinkers.* Cambridge: Lean Enterprise Institute.

Metropolitan Electricity Authority. (2013). *About Electricity Bills: Large General Service*. Retrieved June 9, 2016, from Metropolitan Electricity Authority Web Site: http://www.mea.or.th/profile/index.php?l=en&tid=3&mid=114&pid=109

Montgomery, D., & Runger, G. (2010). *Applied Statistics and Probability for Engineers.* John Wiley & Sons.

Niebel, B. W., & Freivalds, A. (2003). *Methods, Standards, and Work Design* (11th ed.). New York: Mcgraw-Hill Higher Education.

Papier, F., & Thonemann, U. (2008). Queuing Models for Sizing and Structuring Rental Fleets. *Transportation Science, 42*(3), 302-317.

Parikh, S. (1977). ON A FLEET SIZING AND ALLOCATION PROBLEM. *Management Science, 23*(9), 972-977.

Rinkacs, A., Gyimesi, A., & Bohacs, G. (2014). Adaptive Simulation of Automated Guided Vehicle Systems Using Multi Agent Based Approach for Supplying Materials. *Applied Mechanics and Materials*(474), 79-84. doi:10.4028/www.scientific.net/AMM.474.79

Sargent, R. G. (2012). Verification and Validation of Simulation Models. *Journal of Simulation*, 12-24. doi:10.1057/jos.2012.20

Savant Automation, Inc. (2015). *FAQ: Savant Automation, Inc.* Retrieved September 16, 2016, from Savant Automation, Inc. Web Site: http://www.agvsystems.com/faqs/

Sayarshad, H., & Marler, T. (2010). A new multi-objective optimization formulation for rail-car fleet sizing problem. *Operational Research International Journal, 10*(2), 175-198. doi:10.1007/s12351-009-0068-0

Sayarshad, H., Javadian, N., Tavakkoli-Moghaddam, R., & Forghani, N. (2010). Solving multi-objective optimization formulation for fleet planning in a railway industry. *Annals of Operation Research, 181*(1), 185-197. doi:10.1007/s10479-010-0714-1

Schmidt, J. W., & Taylor, R. E. (1970). *Simulation and Analysis of Industrial Systems.* Richard D. Irwin.

Shneor, R., Edan, Y., Paz, E., Naor, N., & Berman, S. (2006). Fuzzy Dispatching of Automated Guided Vehicles. *IIE Annual Conference* (pp. 1-6). Norcross: Institute of Industrial Engineers-Publisher.

Sullivan, G. W., Wicks, E. M., & Luxhoj, J. T. (2006). *Engineering Economy.* New Jersey: Pearson Education.

Taha, H. A. (1997). *Operation Research: an Introduction* (6th ed.). New Jersey: Prntice-Hall, Inc.

Vis, I., de Koster, R., & Savelsbergh, M. (2005). Minimum Vehicle Fleet Size Under Time-Window Constraints at a Container Terminal. *Transportation Science, 39*(2), 249-260.

Winston, W. L., & Goldberg, J. B. (2004). *Operations Research: Applications and Algorithms.* Belmont: Duxbury Press.

Zajac, J., Slota, A., Krupa, K., Wiek, T., Chwajol, G., & Malopolski, W. (2013). Some Aspects of Design and Construction of an Automated Guided Vehicle. *Applied Mechanics and Material, 282*, 59-65. doi:10.4028/www.scientific.net/AMM.282.59

APPENDIX

Work Element : Loading I-Trolley
Location : Stop Point

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		20

Data Amount	30	$(\text{Sum Xi})^2$	34225
Subgroup Amount	6	Subgroup Average	6.166667
Total Subgroup Average	37	Sum Xi^2	1157
Standard Deviation	0.74664	Allowance	7%
Sum Xi	185	Cycle Time	7.24

Data

Subgroup	Xi					Average	Remarks	$(\text{Xi})^2$				
1	7	7	6	6	7	6.6	Uniform	49	49	36	36	49
2	6	6	5	6	6	5.8	Uniform	36	36	25	36	36
3	7	6	5	6	5	5.8	Uniform	49	36	25	36	25
4	6	6	6	6	7	6.2	Uniform	36	36	36	36	49
5	8	5	6	7	6	6.4	Uniform	64	25	36	49	36
6	6	5	7	6	7	6.2	Uniform	36	25	49	36	49

Uniformity Test

Deviation of Distribution Mean	0.3339
Upper Control Limit	7.1684
Lower Control Limit	5.1649
Conclusion	**Uniform**

Sufficiency Test

Value of N Calculated	5.668371074
Conclusion	**Sufficient**

Appendix 1. Uniformity and Sufficiency Test Loading I-Trolley

Work Element : Unloading I-Trolley
Location : Stop Point

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		**20**

Data Amount	30	**$(Sum\ Xi)^2$**	24336
Subgroup Amount	6	**Subgroup Average**	5.2
Total Subgroup Average	31.2	**Sum Xi^2**	834
Standard Deviation	0.886683	**Allowance**	7%
Sum Xi	156	**Cycle Time**	**6.27**

Data

Subgroup	**Xi**					**Average**	**Remarks**	**$(Xi)^2$**				
1	5	5	4	4	6	4.8	Uniform	25	25	16	16	36
2	5	4	5	7	5	5.2	Uniform	25	16	25	49	25
3	7	6	6	5	6	6	Uniform	49	36	36	25	36
4	6	5	4	6	5	5.2	Uniform	36	25	16	36	25
5	5	4	6	5	5	5	Uniform	25	16	36	25	25
6	4	6	5	4	6	5	Uniform	16	36	25	16	36

Uniformity Test

Deviation of Distribution Mean	0.3965
Upper Control Limit	6.3896
Lower Control Limit	4.0104
Conclusion	**Uniform**

Sufficiency Test

Value of N Calculated	11.24260355
Conclusion	**Sufficient**

Appendix 2. Uniformity and Sufficiency Test Unloading I-Trolley

Work Element : Transport to Pack 2
Location : Pack 2

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		**20**

Data Amount	30	**$(Sum\ Xi)^2$**	344569
Subgroup Amount	6	**Subgroup Average**	19.56667
Total Subgroup Average	117.4	**$Sum\ Xi^2$**	11683
Standard Deviation	2.608783	**Allowance**	7%
Sum Xi	587	**Cycle Time**	**20.64**

Data

Subgroup	Xi					Average	Remarks	$(Xi)^2$				
1	18	20	20	21	14	18.6	Uniform	324	400	400	441	196
2	22	19	25	23	23	22.4	Uniform	484	361	625	529	529
3	19	21	20	19	18	19.4	Uniform	361	441	400	361	324
4	17	18	17	20	24	19.2	Uniform	289	324	289	400	576
5	21	16	17	18	21	18.6	Uniform	441	256	289	324	441
6	17	18	17	20	24	19.2	Uniform	289	324	289	400	576

Uniformity Test

Deviation of Distribution Mean	1.1667
Upper Control Limit	23.0667
Lower Control Limit	16.0666
Conclusion	**Uniform**

Sufficiency Test

Value of N Calculated	6.873514448
Conclusion	**Sufficient**

Appendix 3. Uniformity and Sufficiency Test Transporting to Pack 2

Work Element : Transport from Pack 2
Location : Pack 2

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		**20**

Data Amount	30	**(Sum Xi)^2**	319225
Subgroup Amount	6	**Subgroup Average**	18.83333
Total Subgroup Average	113	**Sum Xi^2**	10913
Standard Deviation	3.063504	**Allowance**	7%
Sum Xi	565	**Cycle Time**	**19.90**

Data

Subgroup	Xi					Average	Remarks	(Xi)^2				
1	21	18	17	18	20	18.8	Uniform	441	324	289	324	400
2	16	21	24	17	20	19.6	Uniform	256	441	576	289	400
3	25	21	22	20	18	21.2	Uniform	625	441	484	400	324
4	19	15	16	15	20	17	Uniform	361	225	256	225	400
5	25	24	18	16	17	20	Uniform	625	576	324	256	289
6	16	15	20	16	15	16.4	Uniform	256	225	400	256	225

Uniformity Test

Deviation of Distribution Mean	1.3700
Upper Control Limit	22.9435
Lower Control Limit	14.7232
Conclusion	**Uniform**

Sufficiency Test

Value of N Calculated	10.23102827
Conclusion	**Sufficient**

Appendix 4. Uniformity and Sufficiency Test Transporting from Pack 2

Work Element : Transport to Backend Stream Line
Location : Backend Stream Line

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		20

Data Amount	30	$(Sum\ Xi)^2$	828100
Subgroup Amount	6	Subgroup Average	30.3333333
Total Subgroup Average	182	$Sum\ Xi^2$	27762
Standard Deviation	2.339073	Allowance	7%
Sum Xi	910	Cycle Time	31.40

Data

Subgroup	Xi					Average	Remarks	$(Xi)^2$				
1	30	32	27	30	31	30	Uniform	900	1024	729	900	961
2	31	30	26	27	31	29	Uniform	961	900	676	729	961
3	32	35	30	29	28	30.8	Uniform	1024	1225	900	841	784
4	27	31	35	33	34	32	Uniform	729	961	1225	1089	1156
5	32	31	30	31	31	31	Uniform	1024	961	900	961	961
6	31	30	27	27	31	29.2	Uniform	961	900	729	729	961

Uniformity Test

Deviation of Distribution Mean	1.0461
Upper Control Limit	33.4715
Lower Control Limit	27.1951
Conclusion	Uniform

Sufficiency Test

Value of N Calculated	2.299239222
Conclusion	Sufficient

Appendix 5. Uniformity and Sufficiency Test Transporting to Backend Stream Line

Work Element : Transport from Backend Stream Line
Location : Backend Stream Line

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		20

Data Amount	30	$(\text{Sum Xi})^2$	707281
Subgroup Amount	6	Subgroup Average	28.0333333
Total Subgroup Average	168.2	Sum Xi^2	23875
Standard Deviation	3.210794	Allowance	7%
Sum Xi	841	Cycle Time	29.10

Data

Subgroup	Xi					Average	Remarks	$(Xi)^2$				
1	27	30	31	26	25	27.8	Uniform	729	900	961	676	625
2	27	28	22	27	26	26	Uniform	729	784	484	729	676
3	27	32	28	28	28	28.6	Uniform	729	1024	784	784	784
4	26	25	24	24	28	25.4	Uniform	676	625	576	576	784
5	29	33	25	31	31	29.8	Uniform	841	1089	625	961	961
6	35	36	27	28	27	30.6	Uniform	1225	1296	729	784	729

Uniformity Test

Deviation of Distribution Mean	1.4359
Upper Control Limit	32.3411
Lower Control Limit	23.7256
Conclusion	**Uniform**

Sufficiency Test

Value of N Calculated	5.072382829
Conclusion	**Sufficient**

Appendix 6. Uniformity and Sufficiency Test Transporting from Backend Stream Line

Work Element : Unloading Lift
Location : Lift

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		20

Data Amount	30	$(\text{Sum Xi})^2$	13242321
Subgroup Amount	6	Subgroup Average	121.3
Total Subgroup Average	727.8	Sum Xi^2	442473
Standard Deviation	6.052358	Allowance	7%
Sum Xi	3639	Cycle Time	122.37

Data

Subgroup	Xi					Average	Remarks	$(\text{Xi})^2$				
1	120	122	121	130	134	125.4	Uniform	14400	14884	14641	16900	17956
2	124	131	122	102	117	119.2	Uniform	15376	17161	14884	10404	13689
3	118	115	120	132	118	120.6	Uniform	13924	13225	14400	17424	13924
4	119	122	119	120	117	119.4	Uniform	14161	14884	14161	14400	13689
5	119	120	120	120	125	120.8	Uniform	14161	14400	14400	14400	15625
6	120	120	118	130	124	122.4	Uniform	14400	14400	13924	16900	15376

Uniformity Test	
Deviation of Distribution Mean	2.7067
Upper Control Limit	129.4201
Lower Control Limit	113.1799
Conclusion	**Uniform**

Sufficiency Test	
Value of N Calculated	0.962640915
Conclusion	**Sufficient**

Appendix 7. Uniformity and Sufficiency Test Unloading from Lift

Work Element : Loading Lift
Location : Lift

Parameter	%	Value
Confidence Level	95	2
Precision Level	10	0.1
K/S		**20**

Data Amount	30	**$(Sum\ Xi)^2$**	11108889
Subgroup Amount	6	**Subgroup Average**	111.1
Total Subgroup Average	666.6	**$Sum\ Xi^2$**	370631
Standard Deviation	3.397261	**Allowance**	7%
Sum Xi	3333	**Cycle Time**	**112.17**

Data

Subgroup	Xi					Average	Remarks	$(Xi)^2$				
1	115	110	110	116	110	112.2	Uniform	13225	12100	12100	13456	12100
2	111	112	112	112	112	111.8	Uniform	12321	12544	12544	12544	12544
3	116	111	110	104	112	110.6	Uniform	13456	12321	12100	10816	12544
4	115	117	112	111	111	113.2	Uniform	13225	13689	12544	12321	12321
5	110	110	107	116	110	110.6	Uniform	12100	12100	11449	13456	12100
6	115	110	106	105	105	108.2	Uniform	13225	12100	11236	11025	11025

Uniformity Test

Deviation of Distribution Mean	1.5193
Upper Control Limit	115.6579
Lower Control Limit	106.5421
Conclusion	**Uniform**

Sufficiency Test

Value of N Calculated	0.361548306
Conclusion	**Sufficient**

Appendix 8. Uniformity and Sufficiency Test Loading to Lift

Appendix 9. Result on Simulation Running

Replication	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8	
	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume
1	18	1687	19	1662	18	1641	18	1675	19	1687	15	1693	16	1668	17	1660
2	17	1660	18	1686	17	1663	18	1680	16	1638	20	1660	16	1680	18	1689
3	20	1709	16	1690	18	1677	16	1669	18	1704	17	1687	20	1726	24	1686
4	26	1677	17	1664	16	1681	17	1670	17	1661	17	1632	19	1687	17	1644
5	19	1683	21	1664	28	1657	18	1686	18	1702	19	1645	15	1652	20	1683
6	20	1705	15	1698	19	1732	18	1700	19	1683	17	1710	16	1729	16	1697
7	18	1656	18	1669	18	1662	16	1702	18	1657	15	1664	17	1667	23	1697
8	17	1671	17	1657	17	1642	16	1663	17	1642	18	1674	19	1690	16	1691
9	19	1735	16	1656	18	1671	15	1697	17	1705	16	1695	16	1676	25	1680
10	17	1674	17	1662	18	1652	18	1697	19	1663	18	1692	20	1684	15	1693
11	17	1658	18	1664	18	1664	21	1651	18	1644	15	1666	22	1684	16	1658
12	20	1661	17	1672	19	1659	17	1665	16	1688	17	1664	18	1710	15	1657
13	23	1619	19	1660	18	1676	23	1663	21	1675	16	1677	16	1669	17	1661
14	19	1668	17	1668	16	1659	18	1672	20	1628	17	1672	16	1679	19	1658
15	20	1699	17	1694	16	1653	20	1642	18	1696	16	1672	16	1672	17	1654
16	16	1668	19	1695	17	1649	20	1694	18	1649	16	1683	21	1664	22	1665
17	19	1674	23	1656	16	1639	17	1665	18	1691	15	1662	15	1704	19	1666
18	22	1673	21	1620	19	1673	16	1694	18	1643	17	1667	17	1676	15	1650
19	17	1672	17	1657	17	1671	16	1705	18	1673	17	1669	17	1684	17	1672
20	17	1655	18	1675	17	1691	16	1687	16	1677	28	1684	17	1681	17	1654
21	20	1674	16	1637	19	1664	15	1664	22	1654	16	1697	21	1693	15	1661
22	20	1670	20	1630	16	1665	18	1682	22	1663	19	1674	16	1686	22	1671

Appendix 9. Continue

Replication	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8	
	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume
23	17	1673	17	1704	35	1703	17	1688	23	1680	16	1686	21	1674	18	1692
24	21	1663	18	1654	16	1666	19	1683	19	1682	16	1697	16	1663	15	1697
25	18	1693	17	1671	16	1706	17	1659	17	1690	20	1672	18	1684	16	1686
26	20	1643	18	1684	20	1659	20	1671	21	1686	17	1692	18	1672	18	1663
27	26	1695	18	1691	17	1675	16	1691	16	1693	18	1667	18	1700	17	1705
28	18	1666	18	1651	19	1656	19	1651	16	1656	17	1675	18	1656	21	1694
29	18	1694	21	1681	16	1687	19	1688	19	1713	17	1708	29	1689	20	1672
30	17	1670	17	1699	18	1702	17	1682	18	1681	16	1673	17	1668	16	1673
31	17	1636	17	1664	19	1655	23	1665	17	1643	17	1642	15	1692	15	1661
32	18	1643	18	1653	15	1673	15	1674	17	1683	15	1678	18	1661	33	1701
33	19	1662	16	1678	24	1642	16	1700	19	1691	17	1672	17	1692	16	1692
34	17	1679	16	1677	18	1694	18	1663	20	1699	19	1726	18	1688	25	1707
35	21	1672	19	1701	21	1707	19	1693	15	1709	22	1694	17	1708	16	1706
36	18	1667	18	1689	20	1678	16	1701	17	1613	17	1681	16	1661	17	1659
37	16	1702	17	1695	17	1661	17	1678	15	1652	16	1711	18	1676	17	1710
38	17	1723	17	1683	25	1656	17	1673	16	1673	16	1649	17	1678	15	1681
39	18	1685	18	1668	16	1681	16	1695	17	1706	17	1703	16	1702	16	1710
40	18	1667	19	1651	21	1686	20	1666	19	1697	20	1643	18	1679	22	1683
41	20	1643	18	1656	17	1690	17	1674	19	1664	18	1648	16	1682	17	1657
42	22	1708	16	1663	18	1688	16	1654	16	1671	22	1674	18	1664	16	1702
43	18	1686	16	1648	22	1682	14	1709	17	1653	17	1664	16	1693	20	1684
44	17	1651	17	1711	18	1658	18	1695	19	1652	15	1699	16	1689	17	1666

Appendix 9. Continue

Replication	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8	
	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume
45	17	1653	17	1687	18	1674	17	1677	19	1669	17	1662	17	1735	17	1660
46	20	1705	17	1656	18	1701	20	1672	22	1695	18	1666	15	1712	21	1663
47	23	1720	19	1679	18	1658	23	1699	21	1692	16	1700	16	1668	17	1673
48	19	1670	17	1676	16	1635	18	1640	20	1703	17	1685	16	1657	19	1669
49	20	1698	17	1642	16	1683	20	1685	18	1715	16	1678	16	1682	17	1654
50	16	1657	19	1682	17	1686	20	1689	18	1693	16	1710	21	1685	22	1675
51	19	1668	23	1667	16	1651	17	1678	18	1661	15	1632	15	1671	19	1701
52	22	1675	21	1683	19	1664	16	1704	18	1681	17	1689	17	1717	15	1715
53	17	1720	17	1645	17	1661	16	1690	18	1706	17	1680	17	1653	17	1659
54	17	1686	18	1686	17	1678	16	1666	16	1696	28	1709	17	1652	17	1688
55	20	1705	16	1669	19	1691	15	1634	22	1683	16	1648	21	1680	15	1639
56	20	1680	20	1679	16	1704	18	1675	22	1695	19	1692	16	1655	22	1660
57	17	1661	17	1666	35	1700	17	1666	23	1714	16	1681	21	1713	18	1708
58	21	1668	18	1696	16	1664	19	1684	19	1695	16	1688	16	1659	15	1678
59	18	1659	17	1678	16	1664	17	1662	17	1681	20	1667	18	1675	16	1655
60	20	1697	18	1662	20	1670	20	1655	21	1668	17	1681	18	1680	18	1662
61	26	1697	18	1690	17	1643	16	1688	16	1664	18	1652	18	1669	17	1703
62	18	1688	18	1676	19	1689	19	1723	16	1654	17	1693	18	1672	21	1689
63	18	1712	21	1722	16	1667	19	1701	19	1705	17	1653	29	1711	20	1663
64	17	1660	17	1647	18	1667	17	1659	18	1682	16	1659	17	1692	16	1679
65	17	1675	17	1686	19	1673	23	1684	17	1703	17	1698	15	1696	15	1674

Appendix 9. Continue

Replication	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8	
	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume	Flow Time	Production Volume
66	18	1657	18	1649	15	1685	15	1644	17	1690	15	1641	18	1665	33	1662
67	19	1682	16	1659	24	1718	16	1652	19	1673	17	1677	17	1684	16	1695
68	17	1668	16	1660	18	1674	18	1695	20	1662	19	1669	18	1679	25	1670
69	21	1660	19	1673	21	1705	19	1650	15	1669	22	1693	17	1647	16	1680
70	18	1675	18	1679	20	1726	16	1680	17	1688	17	1680	16	1680	17	1693
71	16	1665	17	1691	17	1694	17	1684	15	1677	16	1659	18	1684	17	1657
72	17	1654	17	1643	25	1655	17	1645	16	1656	16	1676	17	1639	15	1654
73	18	1684	18	1650	16	1689	16	1665	17	1712	17	1683	16	1678	16	1650
74	18	1669	19	1663	21	1698	20	1654	19	1681	20	1681	18	1676	22	1683
75	20	1646	18	1667	17	1646	17	1713	19	1701	18	1671	16	1668	17	1661
76	22	1688	16	1677	18	1666	16	1667	16	1663	22	1673	18	1688	16	1646
77	18	1687	16	1690	22	1680	14	1682	17	1687	17	1678	16	1674	20	1709
78	17	1674	17	1660	18	1662	18	1645	19	1703	15	1646	16	1637	17	1678
79	17	1670	17	1669	18	1665	17	1694	19	1680	17	1669	17	1711	17	1671
80	20	1661	17	1665	18	1653	20	1654	22	1659	18	1688	15	1661	21	1665