CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

5.1 Conclusions

The performance of a solid desiccant dehumidification system depends on a complicated interplay of system operating and design parameters. Optimal system capacity and operating efficiency depend on balancing these operational components against the design limitations of individual equipment components. The current investigation is a strong step on the way of understanding and modeling of the performance of silica gel desiccant wheels as they are widely used in a lot of industrial and cooling/air conditioning applications.

The mechanism of dehumidification/regeneration process in a stationary disc of Silica-Gel desiccant is a highly coupled mass and heat transfer process which depends on different interconnected characteristics of the processed air, the desiccant types and properties the geometry and dimension of desiccant material etc. The proposed coefficient "K_{mcoef}" to augment the mass transfer coefficient used in the early mathematical model depends on the processed air mass flow rate and its speed along the desiccant wheel channels. The polynomial form of the dehumidification rate which is introduced in thesis is nonlinearly related to the dew bulb temperature while it pseudo-linear related to the relative humidity of the processed air. In other words, the effect of the dry bulb temperature is dominant over the effect its humidity ratio on the dehumidification rate. To reach to the optimum dehumidification rate for a fixed value of the processed air relative humidity, a certain combination between the processed air and its mass flow rate need to be used. The air mass flow rate of optimum dehumidification rate is found to be between 69 and 70 kg/hr. Relating the coefficients of the proposed polynomial of the dehumidification rate to the velocity/mass flow rate of the processed air makes the model more comprehensive for more parameters affecting the dehumidification performance.

5.2 Recommendations for Future Work

As the performance of the desiccant wheels depend on their inside structure geometry, their composition and the type of desiccant material beside air-related parameters discussed in this thesis, more points of investigation are recommended for future investigation. These future studies include:

1. Study the effect of desiccant geometry/size on the performance.
2. As the desiccant wheel commercially available is a composite material of various composition of the desiccant, binder and substrate materials, more investigation points related to this need to be stimulated.
3. Deeper chemical/mechanical studies to increase the dehumidification capacity of the desiccant need to be inspired.
4. The effect of macro and micro-structure of the surface of the desiccant wheel/material need to be considered as the dehumidification is a coupled/mass and heat transfer process.
5. The effect of air passage shape inside the wheel need to be studied such that the desiccant subjected area to air stream will increase and the dehumidification rate will accordingly increase.
6. As the current model is based on the stationary of the desiccant wheel, the model needs to be adjusted to consider the effect of rotation speed on the desiccant performance and compare it with other mathematical model of rotary desiccant used in non-cyclic dehumidifier types.
7. More accurate parameters need to be created such that the model will be robust against any changes on which these parameters depend such as mass flow rate air properties initial desiccant water contents etc.

The largest cost associated with desiccant technology in cooling/air conditioning systems are its installation and its distribution, enhancing the characteristics of the desiccant material, trying to use solar energy in regeneration process, and reduce the size of dehumidifier. Based on this fact, some main research points of the desiccant applications in cooling and air conditioning systems are listed below.

- Propose and Improve desiccant component integration with the conventional/commercially available cooling and air condition systems.
- The state-of- art desiccant systems often has coefficients of performance below 1.0. To increase the benefits offered by this technology, its operating efficiency must be improved. This can be accomplished by research projects to develop materials components to cool air in the system more efficiently.
- Proposing better methods of controlling system operation and lowering the cost of the reactivation methods.

REFERENCES

1. "ASHARE Standard 62," 1989.

2. Höfker, G., Eicker, U., Lomas, K. and Eicker, U., “Desiccant Cooling with Solar Energy,” De Montfort University Leicester, Institute of Energy and Sustainable Development, Department of Building Physics, 2001.

3. Harriman III, L. G., Plager, D., and Kosar, D. "Dehumidification and cooling loads from ventilation air," ASHRAE Journal, November 1997.

4. C. Mei, Chen, F. C., Lavan, Z. Collier, R. K. and Meckler G., “An Assessment of Desiccant Cooling Dehumidification Technology,” Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831-6285, July 1992.

5. "Catalog of "Kathbar" products," Somerset Technologies, Inc., New Brunswick, N.J.

6. ASHRAE Fundamentals Handbook, "Chapter18: Nonresidential cooling and heating load calculations," American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, Ga. 2009, p18-1.

7. "Niagara no frost refrigeration unit catalog and research bulletin," Niagara Blower Co., Buffalo, N.Y, 1993.

8. Czanderna, A.W., "Polymers as Advanced Materials for Desiccant Applications: 1-Commercially Available Polymers," ASHRAE Trans. 95; Part 2; December 1988.

9. Staton, J. C., “Heat and Mass Transfer Characteristics of Desiccant Polymers” MSc Thesis, Department of Mechanical Engineering, Faculty of the Virginia Polytechnic Institute and State University, Blacksburg, VA, USA, May 1998.

10. Ge, T. S., Ziegler, F. and Wang, R. Z., "A mathematical model for predicting the performance of a compound desiccant wheel (A model of compound desiccant wheel)," Applied Thermal Engineering; Vol. 30, No. 8, pp.1005-1015, January 2010.

11. Kosar, D. and Novosel, D., "Outline of desiccant cooling program," Gas Research Institute, Chicago, IL., NTIS No. 8817, May 1988,.

12. Liu, S., “Novel Heat Recovery/Desiccant Cooling System," PhD Thesis, University of Nottingham, May 2008.

13. "Energy Standard for Except Low-rise Residential Buildings," ANSI/ASHRAE Standard 90.1-2004, Atlanta, ASHRAE.

14. "Today's Business - Bryant's New Product," Cleveland Press, Jan. 22, 1940.

15. Jeong, J. W., “Simplified Ceiling Radiant Cooling Panel and Enthalpy Wheel models for Dedicated Outdoor Air System Design,” PhD Thesis, Department of Architectural Engineering. State College, Pennsylvania State University, 2004.

16. Shelpuk, B. and Hooker D., “Development program in solar desiccant cooling for residential buildings,” International Journal of Refrigeration, Vol. 2, pp. 173-179, 1979.

17. Fisk, W., “How IEQ Affects Health, Productivity,” ASHRAE Journal, Vol. 44, No. 5, pp. 56-60, 2002.

18. "Handbook of Fundamentals-ASHRAE," Atlanta. ASHRAE, 2001.

19. Abdou, A., "Performance Analysis and Modeling of Desiccant Dehumidifier," PhD Thesis, Department of Mechanical Engineering, Alexandria university, Alexandria, Egypt, 1994.

20. Dhar, P.L., Kaushik, S.C., Jain, S., Pahwa, D., and Kumar, R., “Thermodynamic analysis of desiccant-augmented evaporative cooling cycles for Indian conditions,” Conference Proceeding by ASHRAE, Vol.101, pp. 735-749, 1995.

21. Fathalah, K., and Aly, S. E., “Study of a waste heat driven modified packed desiccant bed dehumidifier,” Energy Conservation and Management, Vol. 37, pp. 457-471, 1996.

22. Fischer, J. C. and Thomas, T. L., "Langmuir Moderate Type 1 Desiccant Mixture for Air Treatment," WO1994016795 A1, U. S. Patent Office. United States, SEMCO Incorporated: 1-28, 1994.

23. Fischer, J. C. and Sand, J., "Field Demonstration of Active Desiccant-Based Outdoor Air Reconditioning Systems," SEMCO, Inc. for Oak Ridge National Lab., Oak Ridge, Tennessee 37831-6285, U.S. Department of Energy, contract DE-AC05-00OR22725, ORNL/SUB/94-SV044/3Report, July, 2001.

24. Slayzak, S. J. and Ryan, J. P., "Desiccant Dehumidification Wheel Test Guide," NREL/TP-550-26131, National Renewable Energy Laboratory, 1617 Cole Boulevard Golden, Colorado 80401-3393, 2000.

25. Factor, H. M. and Grossman, G., "A packed bed dehumidifier/regenerator for solar air conditioning with liquid desiccants," Solar Energy, Vol. 24, Issue 6, 1980, pp 541–550.

26. Shrivastava, N. and Eames, I.W., "A review of adsorbents and adsorbates in solid-vapour adsorption heat pump systems," Applied Thermal Engineering, Vol. 1 pp. 116-127, 1998.

27. Zhang, L. Z. and Niu, J. L., "Performance comparisons of desiccant wheels for air dehumidification and enthalpy recovery," Applied Thermal Engineering, Vol. 22, Issue 12, pp. 1347-1367, August 2002.

28. Camargo, J. R., Ebinuma, C.D. and Silveira J. L., "Thermo economic analysis of an evaporative desiccant air conditioning system," Applied Thermal Engineering, Vol. 23, pp. 1537-1549, 2003.

29. Kanoglu, M., Carpinhoglu, M. O. and Yildirim M., "Energy and exergy analysis of an experimental open cycle desiccant cooling system," Applied Thermal Engineering, Vol. 24, 2004.

30. Hirunlabh, J., Charoenwat, R., Khedari, J. and Teekasap, S., "Feasibility study of desiccant air conditioning system in Thailand," Building and Environment Vol.42, 2007.

31. Yu, J.D., Luo, G. and Zhang, H. F., "New mathematical model of a rotary desiccant wheel and the program of RDCS," Renewable and Sustainable Energy Reviews, Tai Yang Neng Xuebao, Acta Energiae Solaris Sinica, Vol. 16, Issue 4, 1995.

32. Dai, Y. J., Wang, R. Z., Zhang, H. F., "Parameter Analysis to Improve Rotary Desiccant Dehumidification Using a Mathematical Model" International Journal of Thermal Sciences, Volume 40, Issue 4, pp. 400-408, April 2001.

33. Bulck, E., Mitchell, J. W. and Klein, S. A., "The Design of Dehumidifiers for Use in Desiccant Cooling and Dehumidification Systems," L. Harriman. Atlanta, American Society of Heating, Refrigerating and Air conditioning Engineers (ASHRAE), pp.118-126, 1992.

34. Maclaine-Cross, I. L., "Proposal for a desiccant air conditioning system," ASHRAE Trans., Vol. 94, No. 2, pp. 1997-2009, 1988.

35. Barlow R. S., "Analysis of the adsorption Process and of desiccant Cooling systems: Pseudo-Steady-State Model for coupled heat and mass transfer," SERI/TR-631-1330, Golden, CO: Solar Energy Research Institute, December 1982.

36. Collier, R. K., Cohen, B. M., "An analytical investigation of methods for improving the performance of desiccant cooling system," Journal of Solar Energy Engineering-transactions of the ASME, Vol. 113, No. 3, pp. 157-163, 1991.

37. Charoensupaya, D. and Worek, W. M., "Parametric study of an open-cycle adiabatic, solid, desiccant cooling system," Energy, Volume 13, Issue 9, pp. 739–747, September 1988.

38. Zheng, W., Worek, W. M., and Novosel, D., "Performance optimization of rotary dehumidifiers," Journal of Solar Energy Engineering, Vol. 117, No. 1, pp. 40-44, 1995.

39. Zheng, W., Worek, W. M., Novosel D., "Effect of operating conditions on optimal performance of rotary dehumidifiers," Journal of Energy Resources Technology, Vol. 117, No. 1, pp. 62-66, 1995.

40. Durbin, T. E. and Caponegro, M. A., "User Guide for Desiccant Dehumidification Technology," U.S. Army Construction Engineering Research Laboratories, Champaign, IL, 61826-9005, 1997.

41. Hemant, P. and Hindolya, D. A., "Desiccant Cooling System for Thermal Comfort: A Review," International Journal of Engineering Science & Technology, Vol. 3 Issue 5, p2418, 2011.

42. Suyono, T., Soifmat, M. Y., Ruslan, M. H., Zharim, A. and Sopian, K., "Theoretical and Experimental Analysis of Desiccant Wheel Performance for Low Humidity Drying System," Proceeding ICOSSSE'11 Proceedings of the 10th WSEAS international conference on System science and simulation in engineering, pp. 132-137, 2011.

43. Hairer, E., Roche, M. and Lubich, C., "The Numerical Solution of Differential-Algebraic Systems by Runge-Kutta Methods," Lecture notes in mathematics, Vol. 1409, Springer, 1989.

Appendix A

The experimental data of 5 dehumidification process in a non-cyclic desiccant dehumidifier of "stationary" desiccant wheel. These experiments are conducted on an experiment test rig described in details by A. Abdou [19]. The desiccant bed in the test rig is lagged by thin aluminum sheet forming a cylindrical test section of 100 mm diameter and 500 mm length. The air is blown through the section using a compressor of variable speed such that the air velocity can be controlled between 1 m/s and 5 m/s. The desiccant material is silica gel and the cross section of the disc has a corrugated structure of triangular desiccant channels as shown in Figure A.1. The diameter of desiccant wheel is 10 cm and two wheels are used in series as the thickness of each is 20 cm. The air mass flow rate, the velocity of air inside the channel, the regeneration temperature, and the humidity ratio of the air stream are listed above each table containing the experimental data of the dehumidification processes.

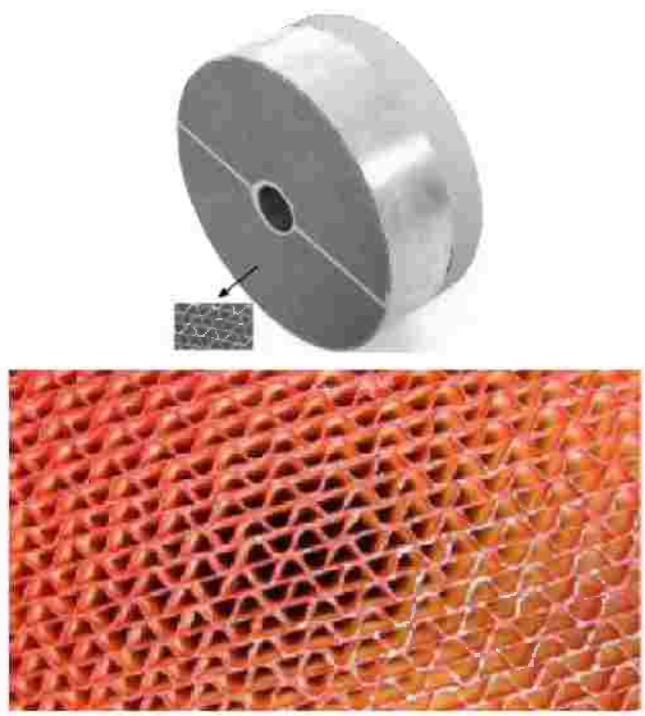

Figure A.1 Cross Section Zoomed-in View of the Desiccant Wheel

Table A.1 the Second Experiment, Air mass flow rate =34.3kg/hr; Intake humidity ratio=.0096 kg/kg, and Presetting bed temperature=90**°C**

Time (sec.)	Intake Temp. (°C)	Middle temp.(°C) at L=10cm	Outlet temp.(°C) L= 20 cm	Outlet Humid Ratio(g/kg)
0.000	42.80	73.50	80.00	9.500
8.000	36.50	69.20	78.00	8.400
16.00	33.70	69.10	76.50	6.700
24.00	30.30	62.10	75.00	3.900
32.00	29.80	75.50	73.80	2.700
40.00	29.30	54.80	67.20	2.200
48.00	28.90	52.70	62.50	2.100
56.00	28.50	51.00	59.80	2.100
64.00	28.40	49.60	57.90	2.100
72.00	28.20	48.30	56.70	2.200
80.00	28.00	47.20	55.70	2.200
88.00	27.90	46.10	54.90	2.300
96.00	27.80	45.10	54.00	2.400
104.0	27.70	44.20	53.10	2.500
112.0	27.50	43.30	52.30	2.600
120.0	27.40	42.70	51.90	2.700
128.0	27.30	42.10	51.10	2.800
136.0	27.20	41.30	50.60	2.900
144.0	27.20	40.70	49.90	3.100
152.0	27.10	40.00	49.20	3.200
160.0	27.00	39.30	48.70	3.300
168.0	27.00	38.90	48.10	3.400
176.0	27.00	38.30	47.40	3.500
184.0	27.00	38.00	46.90	3.600
192.0	27.00	37.50	46.30	3.700
200.0	26.90	37.00	46.00	3.800
208.0	26.80	36.50	45.20	4.000
216.0	26.80	36.10	44.90	4.100
232.0	26.60	35.30	43.90	4.300
248.0	26.60	34.90	43.00	4.500
264.0	26.60	34.20	42.20	4.700
280.0	26.50	33.80	41.40	4.900
296.0	26.40	33.20	40.70	5.100
312.0	26.40	32.80	40.00	5.300
328.0	26.40	32.30	39.20	5.500
360.0	26.30	31.60	38.00	5.700
392.0	26.30	31.00	36.90	6.000
424.0	26.30	30.50	36.00	6.300
456.0	26.20	30.00	35.00	6.500
488.0	26.20	29.80	34.30	6.700
520.0	26.20	29.20	33.80	6.800
552.0	26.20	29.10	33.20	7.000
584.0	26.20	28.80	32.80	7.200
616.0	26.20	28.40	32.10	7.300
648.0	26.20	28.20	31.80	7.500
680.0	26.20	28.10	31.30	7.700

Table A.2 The First Experiment, Air mass flow rate =36.4 kg/hr; Intake humidity ratio=.0088kg/kg, and Presetting bed temperatures=125°C

Time (sec.)	Intake Temp. (°C)	Middle temp.(°C) at L=10cm	Outlet temp.(°C) L= 20 cm	Outlet Humid Ratio(g/kg)
8.00	43.00	101.20	128.6	10.40
16.00	39.80	85.80	124.0	10.40
24.00	36.00	73.40	112.0	8.700
32.00	34.40	66.60	94.00	7.900
40.00	33.40	62.10	78.00	7.500
48.00	32.80	59.40	69.00	7.000
56.00	32.20	57.00	64.30	6.500
64.00	31.80	55.00	61.9	5.700
72.00	31.60	53.80	60.20	5.000
80.00	31.00	52.20	59.20	4.400
88.00	30.70	51.20	58.40	3.700
96.00	30.50	51.10	57.90	3.400
104.0	30.20	48.70	57.30	3.100
112.0	30.00	47.80	56.70	2.800
120.0	29.80	46.50	55.80	2.500
128.0	29.60	45.70	54.90	2.400
136.0	29.50	44.40	54.00	2.300
144.0	29.30	43.90	53.40	2.200
152.0	29.00	43.00	52.52	2.200
160.0	28.80	42.20	52.00	2.200
168.0	28.50	41.70	51.20	2.300
176.0	28.50	41.00	50.50	2.300
184.0	28.30	40.20	49.90	2.300
192.00	28.20	39.90	49.40	2.400
200.0	28.00	39.60	48.80	2.500
208.0	28.00	38.80	48.30	2.600
216.0	27.80	38.20	47.70	2.800
232.0	27.70	37.60	46.40	2.900
248.0	27.60	36.60	45.10	3.200
264.0	27.60	35.80	44.30	3.300
280.0	27.50	34.80	43.50	3.600
296.0	27.40	34.10	42.50	3.700
312.0	27.30	33.70	41.60	4.000
328.0	27.30	33.00	41.00	4.100
360.0	27.20	32.20	39.30	4.500
392.0	27.00	31.70	38.00	4.800
424.0	27.00	31.00	36.70	5.100
456.0	26.90	30.30	35.90	5.400
488.0	26.80	30.10	34.90	5.700
520.0	26.80	29.80	34.10	5.900
552.0	26.70	29.60	33.60	6.100
584.0	26.70	29.40	32.92	6.300

Table A.3 the Second Experiment, Air mass flow rate=49.4 kg/hr; Intake humidity ratio=.00991kg/kg, and Presetting bed temperature=121°C

Time (sec.)	Intake Temp. (°C)	Middle temp.(°C) at L=10cm	Outlet temp.(°C) L= 20 cm	Outlet Humid Ratio(g/kg)
0.000	37.00	93.00	102.0	8.000
8.000	35.00	79.00	97.00	4.000
16.00	33.00	65.80	92.00	2.700
24.00	31.00	59.50	76.00	2.400
32.00	31.00	55.60	66.00	2.400
40.00	30.00	53.20	61.00	2.500
48.00	30.00	50.50	58.60	2.400
56.00	30.00	49.10	57.00	2.500
64.00	30.00	47.90	55.80	2.500
72.00	30.00	46.84	54.40	2.400
80.00	29.80	45.90	53.90	2.200
88.00	29.00	44.80	53.00	2.800
96.00	28.80	43.20	52.90	3.000
104.0	28.60	42.50	50.60	3.100
112.0	28.40	41.60	49.60	3.300
120.0	28.20	40.60	49.00	3.400
128.0	28.10	44.00	48.00	3.500
136.0	28.10	39.20	47.00	3.600
144.0	28.00	38.50	46.00	3.800
152.0	28.00	37.90	45.50	3.900
160.0	28.00	37.30	44.70	4.100
168.0	28.00	36.90	44.00	4.200
176.0	27.90	36.20	43.40	4.300
184.0	27.90	35.90	42.80	4.400
192.0	27.90	35.60	42.10	4.600
200.0	27.90	35.10	41.80	4.800
208.0	27.60	34.50	41.00	4.900
216.0	27.40	34.20	40.51	5.100
232.0	27.00	33.90	39.71	5.400
248.0	27.00	33.70	38.90	5.500
264.0	27.00	33.20	38.00	5.700
280.0	27.00	32.90	37.20	5.900
296.0	27.00	32.50	36.80	6.100
312.0	27.00	32.10	36.00	6.200
328.0	27.00	32.00	35.60	6.600
360.0	27.00	31.30	34.60	6.800
392.0	27.00	31.00	33.60	7.000
424.0	27.00	30.20	33.00	7.200
456.0	27.00	29.80	32.20	7.400
488.0	27.00	29.50	31.80	7.600
520.0	27.00	29.40	31.20	7.700
552.0	27.00	29.00	31.00	7.900
584.0	27.00	28.60	30.60	7.900
616.0	27.00	28.40	30.40	8.000

Table A.4 the Second Experiment, Air mass flow rate =74.3kg/hr; Intake humidity ratio= 0.0094 kg/kg, and Presetting bed temperature=94.5°C

Time (sec.)	Intake Temp. (°C)	Middle temp.(°C) at L=10cm	Outlet temp.(°C) L= 20 cm	Outlet Humid Ratio(g/kg)
0.000	75.00	90.00	91.00	8.000
8.000	57.00	87.00	81.00	2.000
16.00	35.50	69.00	73.00	2.600
24.00	32.60	57.50	70.00	3.400
32.00	31.50	52.10	60.50	3.700
40.00	30.80	49.00	55.30	4.000
48.00	30.00	46.70	52.42	4.300
56.00	29.40	44.80	50.30	4.500
64.00	29.00	43.00	48.60	4.000
72.00	28.60	41.60	47.10	4.100
80.00	28.40	40.50	46.10	4.100
88.00	28.00	39.70	45.00	4.400
96.00	27.90	38.60	44.00	4.600
104.0	27.70	37.80	43.00	4.800
112.0	27.40	36.90	42.20	4.900
120.0	27.20	36.10	41.40	5.100
128.0	27.00	35.50	40.60	5.200
136.0	27.00	34.90	39.80	5.400
144.0	27.00	34.40	39.20	5.500
152.0	26.90	33.90	38.60	5.600
160.0	26.80	33.30	38.00	5.700
168.0	26.70	32.90	37.50	5.900
176.0	26.60	32.50	36.90	6.000
184.0	26.50	32.20	36.50	6.200
192.0	26.40	31.90	36.00	6.300
200.0	26.30	31.60	35.50	6.400
208.0	26.30	31.20	35.10	6.500
216.0	26.30	31.00	34.80	6.600
232.0	26.20	30.40	34.00	6.800
248.0	26.20	30.00	33.40	6.900
264.0	26.10	29.80	32.90	7.100
280.0	26.10	29.30	32.30	7.300
296.0	26.10	29.10	32.00	7.500
312.0	26.10	28.80	31.50	7.600
328.0	26.10	28.60	31.10	7.700
360.0	26.00	28.10	30.50	7.900
392.0	26.00	27.80	30.00	8.100
424.0	26.00	27.60	29.50	8.300
456.0	26.00	27.30	29.00	8.400
488.0	26.00	27.10	28.70	8.600
520.0	26.00	27.00	28.50	8.700
552.0	26.00	27.00	28.20	8.800
584.0	26.00	26.80	28.00	8.900
616.0	26.00	26.70	27.80	8.900
648.0	26.00	26.50	27.60	9.000
680.0	26.00	26.40	27.50	9.100

Table A.5 the Second Experiment, Air mass flow rate = 100.3kg/hr; Intake humidity ratio= 0.0098 kg/kg, and Presetting bed temperature=83°C

Time (sec.)	Intake Temp. (°C)	Middle temp.(°C) at L=10cm	Outlet temp.(°C) L= 20 cm	Outlet Humid Ratio(g/kg)
0.000	40.00	75.50	77.00	8.600
8.000	37.50	65.00	65.00	6.600
16.00	33.00	53.50	63.00	4.200
24.00	32.30	48.80	55.00	4.200
32.00	31.40	46.00	51.00	4.300
40.00	31.00	43.00	48.30	4.900
48.00	30.40	42.10	46.50	5.300
56.00	30.10	40.80	45.00	5.600
64.00	29.80	39.60	43.70	5.900
72.00	29.50	38.60	42.60	6.100
80.00	29.20	37.80	41.60	6.300
88.00	29.10	36.90	40.70	6.500
96.00	28.90	36.10	39.90	6.700
104.0	28.90	35.10	39.20	6.800
112.0	28.70	34.90	38.50	7.000
120.0	28.60	34.40	37.90	7.100
128.0	28.40	33.20	37.20	7.300
136.0	28.40	33.50	36.60	7.400
144.0	28.30	33.10	36.20	7.500
152.0	28.20	32.80	35.80	7.700
160.0	28.10	32.50	35.40	7.800
168.0	28.10	32.20	34.90	7.800
176.0	28.00	31.90	34.60	7.900
184.0	28.00	31.60	34.30	8.000
192.0	28.00	31.20	33.90	8.100
200.0	28.00	31.10	33.70	8.200
208.0	28.00	31.00	33.40	8.300
216.0	28.00	30.80	33.10	8.400
232.0	28.00	30.60	32.70	8.500
248.0	28.00	30.30	32.40	8.600
264.0	28.00	30.00	32.00	8.700
280.0	28.00	29.80	31.50	8.800
296.0	27.90	29.50	31.30	8.900
312.0	27.90	29.40	31.00	8.900
328.0	27.90	29.30	30.80	9.000
360.0	27.90	29.00	30.30	9.100
392.0	27.90	28.90	30.10	9.200
424.0	27.90	28.70	29.80	9.300
456.0	27.90	28.50	29.50	9.400
488.0	27.90	28.40	29.30	9.500
520.0	27.90	28.40	29.20	9.500
552.0	27.90	28.30	29.00	9.600
584.0	27.90	28.20	28.80	9.600
616.0	27.90	28.10	28.70	9.600
648.0	27.90	28.10	28.60	9.600
680.0	27.90	28.00	28.50	9.700

كلية الهندسة
جامعة الاسكندرية

نموذج رياضي مدعم لاسطوانات المجففات لمحاكاة أشمل لمعاملات الأداء

رسالة علمية

مقدمة الى الدرسات العليا بكلية الهندسة – جامعه الاسكندرية

استيفاء للدراسات المقررة للحصول على درجة

ماجستيرالعلوم الهندسية

فى

الهندسة الميكانيكية

مقدمة من

مروة طلعت محمد عبد الغني عويضة

الاسكندرية

ديسمبر 2014

كلية الهندسة

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للحصول على درجة

ماجستيرالعلوم الهندسية فى الهندسة الميكانيكية

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ملخص الرسالة

يوفرالبحث الحالي مزيد من الفهم لكيفية عمل النظم المعتمدة على المجففات، كما يوفر وسيلة للتحقق من النتائج المنمذجة، وايضا يعد مرشدا لتحسين التصاميم المستقبلية المتعلقة بهذه النظم .انطلاقا من مبدئي بقاء الطاقة والكتلة ، تم إنشاء نموذج رياضي بحيث يتم فهم أداء اسطوانات المجففات المستخدمةعلى نطاق واسع وبشكل اكثر عمقا . وقد فشلت النماذج المقترحة من قبل بعض الباحثين في دراسات سابقة في محاكاة الأداء الفعلي لهذه الاسطوانات المجففة لأنهااستندت فقط على الحرارة المحسوسة في استنتاجها .في استنتاجنا للنموذج المقترح في البحث الحالي، تم الأخذ في الاعتبارالحرارة الكامنة إلى جانب تلك المحسوسة كما تم مراعاة الاقتران القوي بين آليتي انتقال الكتلة و الحرارة المشكلتان لآلية التجفيف. تم بناء استنتاج النموذج الرياضي لاسطوانة المجففات على ثباتها حيث ان تأثير دوران اسطوانة المجفف هوخارج نطاق البحث المناقش في هذة الاطروحة.وتحتاج مزيد من التفاصيل المتعلقة بالافتراضات الاخرى التي بني عليها النموذج المقترح حاليا في فصل النمذجة الرياضية في الرسا لة.

تم استخدام طريقة التكامل العددي رونجكوتا من الدرجة الرابعة بحيث يتم الحد بشكل واسع من كلا من خطأ الاقتطاع والخطأ الكلي الملازمين لمعظم طرق التكامل العددي. لاجراء عملية التكامل تم اقتباس كلا من الشروط الحدية والابتدائية للمعادلات من النتائج المعملية المسرودة في الملحق "أ". تم اقتراح معامل جديد يتم ضربه في معامل انتقال الكتلة المستخدم في النمذجة الرياضية. هذا المعامل المتغير المضاف يعكس تاثير كلا من سرعة ومعدل التدفق الكتلي للهواء على آلية المبادلة الكتلية بين الهواء المعالج والمجفف. بعدالتحقق من صحة النموذج المقترح، تم دراسة تأثيرالتغيرفي درجة حرارة الهواء المدخل لاسطوانة المجفف عند قيم مختلفة الرطوبة النسبية للهواء المجفف.تم اقتراح كثيرة حدود لا خطية كمعادلة موصفة لعلاقة معدل إزالة الرطوبة من الهواء بكل من درجة حرارة الهواء المقاسة ببصيلة الترمومتر الجافة وكذلك الرطوبة النسبية لهذا الهواء. حيث ان كثيرة الحدود السابق ذكرها تم استنتاجها عند قيم مختلفة لكلا من سرعة ومعدل التدفق الكتلي للهواء المعالج فكان لابد من ربطهما بمعاملات كثيرة الحدود تلك. ولذلك تم مجددا اقتراح اعتبار كلا من سرعة ومعدل التدفق الكتلي للهواء المعالج المتغيرات المستقلة المستخدمة في تحديد قيم معاملات كثيرة الحدود المذكورة سابقا. واخيرا نستطيع القول ان التعديلات المقدمة في هذة الاطروحة على النمذجة الحسابية لآلية التجفيف بجانب عدم اهمال الحرارة الكامنة جعلت النموذج المقترح أكثر قوة ومرونة مع التباين في المتغيرات التي تؤثر على أداء اسطوانة المجفف.

وتتكون الرسالة من خمسة فصول. حيث ان كلا من المقدمة، الخلفية التاريخية، والمسح التوثيقي المتعلق بالابحاث المتعلقة بموضوع الرسالة قد شكلواالفصل الأول. الفصل الثاني يتحدث عن إزالة الرطوبة من الهواء وعملية اعادة تأهيل المجفف لاعادة استخدامه والأنواع المختلفة لنظم مزيلات الرطوبة بالمجففات وتطبيقاتها في أنظمة التبريد/تكييف الهواء. في الفصل الثالث تمت مناقشة المعادلات التي تحكم الاداء وكيفية النمذجة الرياضية لآليتي انتقال الكتلة و الحرارة خلال عملية التجفيف. في الفصل الرابع تم عرض وتفسير النتائج التي حصلنا عليها. في الفصل الاخير تم عرض ملخص لما تم انجازه في الرسالة مع التوصية ببعض النقاط البحثية لانجازها في المستقبل.