

THE AERODYNAMICS AND PROCESS IN THE VORTEX CHAMBERS

J.J. Smulsky

Institute of Earth's Cryosphere,
625026, Tyumen, Malygin Str. 86, Russia.
Tel.: +7-3452-68-87-14 : E-mail: JSmulsky@mail.ru

This book had published in Russian at 1992 by "Science Publisher".

At present, the vortex chambers are widely used in the existing technological process and new technologies are appeared on its base. Such usage should be more effective if there are the methods of the aerodynamics and process in the vortex chambers calculation. In literature it is known separate researches of the aerodynamics and process in the vortex chambers, made by different authors. There are also the methods of the aerodynamics different sides calculation.

Suggested monograph is distinguished itself by the systematic character these problems complete set and completion of the considering. Here it is researched incompressible and compressible flow of the mono-phased medium, and two-phased medium motion as well. All problems are considered theoretically and experimentally, are given methods process calculation and its realization in the form of programs for computers, are given practical recommendations.

The monograph consists of 10 chapters. The first 6 chapters are devoted to mono-phased medium the chapters from 7 to 9 are devoted to two-phased medium, and the 10-th one - to atmosphere vortices. In the first part the author has received numerical and analytical solutions for Navier-Stokes equations in the one-two-dimensional model of the vortex chamber. It has permitted him to create the method of the incompressible (the 5-th chapter) and compressible (the 6-th chapter) flow in vortex chambers calculation. The fourth chapter is devoted to the experimental researches of the vortex chamber aerodynamics, which are based on the systematical researches, generally by the author himself. The results of the experiments are tabulated and given in the appendixes. The author spared much attention to the truth of the measurement results, that is why given data can be used not only as a bank of data for the further theories but also as the based material for control of the new experiments.

Apparently, here it is for the first time considered the calculation of the compressible flow and it is received the results not only speed and pressure but for density, temperature and other parameters as well. It is of large, practical interest considered in this work the problem of vortex chambers optimization and criteria for its modeling.

In the monograph it is systematized representations on the interaction of the particle and flow in the vortex chamber and received the results for different regimes of the particle motion in the fluid. On this base it is considered the problems of gas clearing for different kinds of separators and, that is very important, it is developed the method of the separation efficiency calculation, which is given in the form of the program-me for computer. It permits to calculate the efficiency of dust separators, not resorting to its testing. It is also considered here the mechanics of rotating and weighted layers. Received methods of process calculations will permit to use more effectively vortex chambers in industrial scales.

The book will be of interest for meteorologists the results, received for tornado. The methods of the whirlpools calculation when outflow from reservoirs can be practically adopted in technique.

The monograph is written in the clear language, it abounds in experimental results and calculations on the whole and will be interest for students and specialists.

CONTENTS

INTRODUCTION.....	6
PRINCIPAL NOTATION	9
CHAPTER 1. GENERAL STATEMENTS.....	13
1.1. Determination of the vortex chambers and its usage	13
1.2. Concise review of research	17
1.3. The swirl degree in the vortex chamber	23
1.4. Creation of the swirl flow in the vortex chamber.....	25
CHAPTER 2. INCOMPRESSIBLE VISCOUS FLOW IN THE VORTEX CHAMBER	29
2.1. Flow model analysis.....	29
2.2. One-dimensional model formulation of the task	36
2.3. A solution for the peripheral region.....	41
2.4. A solutions in the meridian plane.....	43
2.5. A solution for tangential velocity	50
2.6. A solution for pressure.....	53
2.7. Fields of velocity and pressure in the vortex chamber and porous pipe.....	57
2.8. About turbulent model of the flow.....	60
CHAPTER 3. METHODS OF THE VORTEX CHAMBER AERODYNAMICS	
EXPERIMENTAL RESEARCH.....	61
3.1. Review of the research methods	61
3.2. Sonde influence on the rotating flow	63
3.3. Thin cylindrical sonde extended along diameter	65
3.4. Turbulence influence on the cylindrical sonde measurements results	68
3.5. Determination of the real error of sonde	70
3.6. Determination of the tangential speed according to the pressure gradient	74
3.7. Measuring of the pressure with the help of the liquid free surface	75
3.8. Flow visualization in the vortex chamber	78
CHAPTER 4. EXPERIMENTAL RESEARCH OF THE VORTEX CHAMBER	
AERODYNAMICS.....	80
4.1. Geometry of the chambers	80
4.2. Flow structure in vortex chamber	83
4.3. Air flow rate influence	91
4.4. Outlet radius influence	97
4.5. The swirl degree influence	105
4.6. Chamber length influence	108
4.7. Exhaust height influence	111
4.8. Aerodynamical resistance of the vortex chamber	113
CHAPTER 5. INCOMPRESSIBLE FLOW CALCULATION IN THE VORTEX CHAMBER..	114
5.1. Theoretical results and experimental ones comparison	114
5.2. Mains experimental results analysis. Its' generalization.....	120
5.3. Calculation method of the incompressible flow	125
CHAPTER 6. COMPRESSIBLE FLOW IN THE VORTEX CHAMBER	129
6.1. Compressible flow some characteristic property.....	129
6.2. Pressure and tangential velocity	130

6.3. Radial and axis velocities	135
6.4. Calculation method of the compressible flow	140
6.5. Optimal characteristics of the vortex chamber	144
6.6. Criteria of the modeling the vortex chamber aerodynamics	144
CHAPTER 7. PARTICLES MOTION IN THE VORTEX CHAMBER.....	146
7.1. Forces, acted on the particle	146
7.2. Stocks particle motion equations	150
7.3. Light particle motion	153
7.4. The equation of the heavy particle motion	155
7.5. The motion equations at the quadratic regime of resis- tance law. Criteria of the particle difference	158
CHAPTER 8. PARTICLES SEPARATION IN THE VORTEX CHAMBER	161
8.1. One-dimensional model of separation	161
8.2. Separating efficiency of polydispersial flow	165
8.3. Cyclone.....	166
8.4. Anticyclone.....	171
8.5. Forward flow vortex separator.....	175
8.6. Comparable experiments of the vortex separators.....	176
CHAPTER 9. ROTATING LAYER OF PARTICLES IN THE VORTEX CHAMBER	181
9.1. Experimental research of the rotating weighted layer	181
9.2. Rotatable layer mechanics.....	185
9.3. Fully weighted layer mechanics.....	189
9.4. Rotating layer usage.....	192
CHAPTER 10. VORTEXES IN THE ATMOSPHERE.....	196
10.1. Whirlwinds observable properties.....	196
10.2. Discharge's model of the tornado	198
10.3. Model of the whirlpool at discharge from reservoir	199
10.3.1. The discharge with replenishment.....	199
10.3.2. The discharge without replenishment.....	202
10.4. Circulation formation when atmosphere and discharge move relatively	206
10.5. Circulation formation at rotation of the Earth	208
10.6. Potential pressure when the dry atmosphere discharge	210
10.7. Moist atmosphere discharge.....	216
10.8. Mechanics, forecast and prevention of the tornado	220
SUMMARY	225
REFERENCES.....	228
APPENDIXES	237
Appendix 1. The results of the numerical solution.....	237
Appendix 2. The table of speed and pressure measuring profiles	240
Appendix 3. Pressure profiles on the bottom of the vortex chamber with lateral injection.....	248
Appendix 4. Pressure in the center and at the periphery in different chambers at change of flow rate	250
Appendix 5. "Vortex 1" program. Incompressible flow calculation	253

Appendix 6. "Vortex 1" results.....	265
Appendix 7. "Vortex 2" program. Compressible flow calculation	267
Appendix 8. "Vortex 2" results.....	280
Appendix 9. "Separ" program. Calculation of the cyclone clearing level.....	282
Appendix 10. "Separ" results.....	288
Appendix 11. "ROTLAY" program. Calculation of the rotary layer	289
Appendix 12. "ROTLAY" results.....	292
Appendix 13. "Weilay" program. Calculation of the fully weighted layer	293
Appendix 14. "Weilay" results.....	298
Appendix 15. "Discharge" program. Calculation of the water whirl-pool and its results.....	299

The corrected in January 2010 book (Smulsky J.J. The Aerodynamics and Processes in the Vortex Chambers. - Novosibirsk: Publishers "Science". - 1992. - 301 p. (In Russian)) can be copied in a djvu-format here: <http://www.ikz.ru/~smulski/Aerpro/aerpro.djvu>. The computer programs to the book on the FORTRAN can be copied here: <http://www.ikz.ru/~smulski/Aerpro/PrgrmAVC.rar>. Information about program in Russian see: <http://www.ikz.ru/~smulski/Aerpro/ReadMe.pdf> .