

Contents

PREFACE	V
PART 1. NOMINATION OF SPECIFIED LIFE AND DEVELOPMENT OF INSPECTION PROGRAM FOR FATIGUE-PRONE AIRFRAME	1
1. NOMINATION OF SPECIFIED LIFE	2
1.1. Introduction	2
1.2. Definition of p -set function and p -bound for random vector and variables	2
1.3. P -bound for distribution with location and scale parameters	4
1.4. Application of the specified life nomination to the problem	5
1.4.1. Nomination of specified life	5
1.4.2. Numerical examples of test time nomination	7
1.4.3. Optimality criterion for p -bound used for airframe specified life nomination	8
1.4.4. Bayes-fiducial approach	9
1.4.5. P -bound as function of order statistics	12
1.4.6. Influence of cumulative distribution function type on specified life nomination	14
1.4.7. Economic approach	17
1.5. References	21
2. INSPECTION PROGRAM DEVELOPMENT	22
2.1. Introduction	22
2.2. P -set function and inspection program	22
2.3. Minimax approach to inspection program development	23
2.4. Exponential approximation of fatigue crack growth function	24
2.5. Failure probability calculation using Monte Carlo method	27
2.6. Equations for failure probability calculation	29
2.7. Aircraft failure probability calculation using Markov chain theory	31
2.7.1. Failure probability calculation for fixed inspection program	31
2.7.2. Failure probability calculation for specific inspection program control	33
2.8. Numerical examples	40
2.8.1. Random variable $\log(Q)$ has normal distribution $N(\theta_{0X}, \theta_{1X}^2)$ but values C_c and C_d are constants. There are $N=100$ aircraft in service	40
2.8.2. Random variable $\log(C_c)$ also has normal distribution $N(\theta_{0Y}, \theta_{1Y}^2)$. Vector $(\theta_{1X}, \theta_{1Y}, r)$ is supposed to be known. There are $N=1$ aircraft in service	41
2.9. Reliability of airline	44
2.9.1. Formal setting of the problem	45
2.9.2. Choice of inspection number if parameter of fatigue crack growth trajectory is known. Numerical example 47	47
2.9.3. Minimax choice of inspection number	49
2.10. References	51
PART 2. STATISTICAL ANALYSIS OF STATIC STRENGTH AND FATIGUE LIFE OF COMPOSITE	53
3. ANALYSIS OF COMPOSITE TENSILE STRENGTH	54
3.1. Introduction	54
3.1.1. Reliability of series systems with defects	56
3.1.2. Probability structure of series system with defected items	56
3.2. Specification of the models	58
3.2.1. A source of defects. The distribution function of the number of defects	59
3.2.2. Cumulative distribution function of strength of a single link	60
3.2.3. Specification of sequence of loads (stresses) in framework of probability structures MA and MB	61
3.3. The processing of test data	61
3.4. Reliability of series of parallel systems with defects. MinMaxDM distribution family	66
3.4.1. Randomized Daniels's model	66
3.4.2. Description of reliability of a parallel system using Markov chain theory	68
3.4.3. Modeling of reliability of parallel system using Monte Carlo method	68
3.4.4. Numerical example	70
3.5. Reliability of series of parallel systems with defects	73

3.5.1.	MinMaxDM distribution family.....	73
3.5.2.	Processing of test data using MinMaxD_RDM model.....	73
3.6.	<i>Conclusions</i>	74
3.7.	<i>References</i>	74
4.	MARKOV MODEL OF CONNECTION BETWEEN DISTRIBUTION OF STATIC STRENGTH AND FATIGUE LIFE OF COMPOSITE.....	76
4.1.	<i>Introduction</i>	76
4.2.	<i>Unidirectional composite fatigue model based on the Markov chains theory</i>	79
4.2.1.	One-step Markov model.....	79
4.2.2.	Binomial Markov model.....	81
4.3.	<i>Estimation of the model parameters of OSMM</i>	81
4.4.	<i>Processing of the experimental data of fatigue test of laminate panel</i>	84
4.5.	<i>Model of accumulation of fatigue damages based on the Markov chain theory taking into account matrix plasticity</i>	85
4.5.1.	Mathematical description of the model.....	85
4.5.2.	Application to the program loading. Residual fatigue life in two-stage fatigue loading.....	88
4.5.3.	Processing of residual fatigue life data set in two-stage fatigue loading.....	89
4.5.4.	Residual strength in two-stage fatigue loading.....	92
4.5.5.	Processing of residual strength data set in two-stage fatigue loading.....	95
4.6.	<i>Conclusions and areas for further research</i>	96
4.7.	<i>References</i>	98
5.	APPENDICES.....	99
5.1.	<i>Aircraft fatigue. History and current trends</i>	99
5.1.1.	Introduction.....	99
5.1.2.	The de Havilland crashes. Safe-life principle.....	99
5.1.3.	Fail-safe concept.....	104
5.1.4.	Structural Damage Tolerance. MSG-3.....	111
5.1.5.	References.....	113
5.2.	<i>Extensions and techniques</i>	113
5.2.1.	A connection of the c.d.f. of the strength of the specimens and the c.d.f. of the strength of a single LI in series system ($n_C=1$).....	113
5.2.2.	Connection of the c.d.f. of the strength of the specimens and the c.d.f. of the strength of a single LI using the MC theory ($n_C=1$).....	115
5.2.3.	Hypothesis testing.....	116
5.2.4.	Four main versions (hypotheses) of the structure of matrix P	121