

# CONTENTS

| <b><u>Description</u></b>                                                   | <b><u>Page</u></b> |
|-----------------------------------------------------------------------------|--------------------|
| PREFACE.....                                                                | i                  |
| ACKNOWLEDGEMENTS.....                                                       | ii                 |
| ABSTRACT.....                                                               | iv                 |
| NOMENCLATURE.....                                                           | vi                 |
| CONTENTS.....                                                               | vii                |
| <b>CHAPTER ONE - INTRODUCTION.....</b>                                      | <b>1</b>           |
| 1. General.....                                                             | 1                  |
| 1.2 Pool Boiling Applications in Nuclear Power Reactors.....                | 6                  |
| 1.2.1 Boiling Water Reactor (BWR).....                                      | 6                  |
| 1.2.2 Pressurized Water Reactor (PWR).....                                  | 6                  |
| 1.2.3 Liquid-Metal Fast-Breeder Reactor (LMFBR).....                        | 8                  |
| 1.3 Surfactants.....                                                        | 9                  |
| <b>CHAPTER TWO - REVIEW OF PREVIOUS WORK.....</b>                           | <b>12</b>          |
| 2.1 General.....                                                            | 12                 |
| 2.2 Surfactants as pitting corrosion inhibitors for industrial materials... | 26                 |
| <b>CHAPTER THREE - DESCRIPTION OF THE TEST APPARATUS</b>                    | <b>32</b>          |
| 3.1 Introduction. ....                                                      | 32                 |
| 3.2 Description of the experimental test rig.....                           | 33                 |
| 3.2.1 Boiling and condensation vessel.....                                  | 36                 |
| 3.2.2 Test tubes.....                                                       | 38                 |
| 3.2.3 Condenser cooling water circuit.....                                  | 42                 |
| 3.2.4 Instrumentation.....                                                  | 43                 |
| <b>CHAPTER FOUR - EXPERIMENTAL WORK.....</b>                                | <b>44</b>          |
| 4.1 Introduction.....                                                       | 44                 |

|                                                                                                                            |           |
|----------------------------------------------------------------------------------------------------------------------------|-----------|
| 4.1.1 Thermocouple calibration.....                                                                                        | 44        |
| 4.1.2 Pressure gauge calibration.....                                                                                      | 45        |
| 4.2 Preparation of test tubes.....                                                                                         | 47        |
| 4.3 Preparation of the aqueous surfactant solutions.....                                                                   | 51        |
| 4.3.1 Effect of surfactants on the physical properties of the aqueous<br>surfactant solutions.....                         | 52        |
| 4.4 Temperature measurements.....                                                                                          | 56        |
| 4.5 Experimental Procedure.....                                                                                            | 57        |
| 4.6 Data reduction.....                                                                                                    | 59        |
| 4.7 Determination of the size distribution function $N(r)$ .....                                                           | 60        |
| 4.8 Experimental result.....                                                                                               | 63        |
| 4.8.1 Photographic visualization.....                                                                                      | 63        |
| 4.8.2 Nucleate pool boiling data.....                                                                                      | 64        |
| <b>CHAPTER FIVE - RESULTS AND DISCUSSION.....</b>                                                                          | <b>74</b> |
| 5.1 Effect of aqueous surfactant solution on pool boiling data.....                                                        | 74        |
| 5.2 Comparison between the three test aqueous surfactant solutions....                                                     | 90        |
| 5.3 Effect of the wall heat flux on the enhancement of heat transfer<br>coefficient, $h^*$ .....                           | 91        |
| 5.4 Effect of surfactant type on heat transfer enhancement factor $h^*$ ...                                                | 99        |
| 5.5 Size distribution function, $N(r)$ data.....                                                                           | 103       |
| 5.6 Effect of aqueous surfactant solution type and its concentration on<br>the size distribution function's constants..... | 110       |
| 5.7 Effect of the concentrations of the aqueous surfactant solutions on the<br>variation of $N/A$ with $q$ .....           | 115       |
| 5.8 Effect of test tube material on the pool boiling data.....                                                             | 119       |
| 5.9 Effect of test tube material on the size distribution function's<br>constants.....                                     | 123       |
| 5.10 Correlation of the wall heat flux with $\Delta T$ and $N/A$ .....                                                     | 126       |

|                                                                                                   |     |
|---------------------------------------------------------------------------------------------------|-----|
| 5.10.1 Correlation for brass test tube with the three aqueous surfactant solutions.....           | 129 |
| 5.10.2 Correlation for aluminum test tube with the three aqueous surfactant solutions.....        | 129 |
| 5.10.3 Correlation for stainless steel test tube with the three aqueous surfactant solutions..... | 130 |
| 5.11 Verification of the new correlation (Eq.5.2) with the present experimental data.....         | 131 |
| 5.12 Comparison between the present experimental data and the available published data.....       | 137 |
| <br><b>CHAPTER SIX - CONCLUSIONS AND RECOMMENDATIONS....</b>                                      | 139 |
| 6.1 Conclusions.....                                                                              | 139 |
| 6.2 Proposal for future work.....                                                                 | 141 |
| <b>REFERENCES.....</b>                                                                            | 142 |
| <b>APPENDICES.....</b>                                                                            | 152 |
| APPENDIX A.....                                                                                   | 152 |
| APPENDIX B.....                                                                                   | 153 |
| APPENDIX C.....                                                                                   | 154 |
| APPENDIX D.....                                                                                   | 160 |