

Nomenclature.....I

1 Introduction.....1

1.1 Motivation: Power generation and vibration reduction in a rotational vibrating system... 1

1.2 State of the art..... 2

1.2.1 Energy harvesting function..... 2

1.2.2 Vibration absorption function..... 11

1.2.3 Vibration control and energy harvesting..... 12

1.3 Vibration-to-electricity conversion..... 14

1.4 Outline of the thesis..... 17

2 Model of the rotating structure.....21

2.1 Torsional vibration theory..... 21

2.2 Test rig modelling..... 24

2.2.1 Description of the drive train..... 24

2.2.2 Numerical model..... 25

2.2.3 Results and validation 30

2.3 Concepts of structural dynamics of the rotating system 35

2.3.1 Mode shapes analysis 35

2.3.2 Definition of the interesting frequency 38

3 Design of torsional vibration absorber..... 39

3.1 Dynamic vibration absorber theory 39

3.2 Mechanical parameters definition of the tuned TVA..... 42

3.3 Realisation of torsional TVA..... 48

3.3.1 From pendulum concept to continuous flywheel..... 48

3.3.2 FE-model of the SDOF absorber 53

3.3.3 Validation of the SDOF model 55

3.4 Operational results of TVA on the drive train 59

4 Implementation of the energy harvesting system.....63

4.1 Fundamentals of piezoelectricity..... 63

4.1.1 History and general information..... 63

4.1.2 Electromechanical constitutive equations 65

4.2 Integration of piezoelectric patches in TVA 67

4.2.1 Modelling of the active piezo beam 67

4.2.2 Shape optimisation of the electromechanical device 69

4.3 Experimental analysis of EHTVA 73

4.3.1 Mechanical validation 74

4.3.2 Electrical validation..... 78

5 Rotational energy harvesting vibration absorber (R-EHTVA)..... 85

5.1 Implementation of switched storage circuit..... 85

5.2 Experimental evaluation of EHTVA 88

5.3 Operational evaluation of the R-EHTVA..... 94

5.3.1 Evaluation of the dissipated energy 94

5.3.2 Evaluation of the generated power96

5.4 Real application scenario of a sensor network for condition monitoring99

6 Summary and Conclusion.....101

7 Outlook.....103

Appendix A: Piezoelectric material characteristics (PIC151 and PIC252)..... i

Appendix B: A study of the electric circuit for a vibration energy harvesting absorber.....iii

Appendix C: Electrodynamic rotational vibration energy harvesting.....xi

Bibliography.....xix

Own publications.....xxvii

List of figures.....xxix

List of tables.....xxxv