Project report 2020

BENTO

Nonlinear and dynamic micromagnetic Behavior modeling and characterization for Non-Destructive Testing techniques optimization

MAIN PARTICIPANTS

			
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OVERVIEW *(keep within this page)*

Starting year: 2016 **Current researchers** (permanent/non-permanent): 6 person-month/year

Positioning *(Multiple selection allowed – total 100%)*	**Transportation**	**Energy**	**Eng. for Health**
Materials and structure design	25%	25%	
Surfaces and interfaces			
Simulation and modeling	25%	25%	

Other:

Include partner from ☐ Outside ELyT ☐ Industry

Main funding source(s)
☒ Public project(s) ☒ Industrial ☐ Own resources

IFS CRP/LyC project? ☒ Yes ☐ No

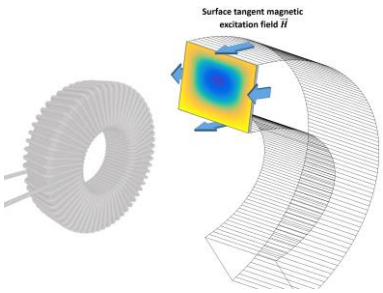
For main projects: Agency / year / name of project *(up to 3, past projects in gray)*
- JSPS Grant-in-aid for scientific research (B) (2018 – 2020)
- Estimated budget: 17 000 000 ¥
- Lyc project (2017 – 2020)

Estimated annual budget: 20 k€E

Highlights & Outstanding achievements *(3-5 bullet points)*

- B. Gupta received the best Ph.D. award of 2019 by INSA under the category "Transports: Structures, infrastructures et mobilité".
- A simulation tool has been developed.
- More than 10 scientific papers have been published and more than 30 conference participations.

Illustration *(5x5 cm² max)*



PROJECT DESCRIPTION

Background (10 lines max; Calibri 11)

In the framework of Non-Destructive Testing of metallic parts used in the field of electrical power plants or in transportation, a fine modeling of tested materials is developed, including particular frequency dependencies of the signals and ferromagnetic behavior. The collaboration focuses on the modeling and testing of innovative electromagnetic Non-Destructive Testing (NDT) techniques, based on micromagnetic properties of tested materials. Both the modelling of the materials itself (including magnetic major and minor hysteresis loops and their frequency dependence), as well as the modelling of the NDT techniques (such as Barkhausen noise and Magnetic Incremental Permeability) are investigated in order to go further in the sensitivity of the techniques and their ability to differentiate different kind of defects or structural material degradations, in addition to also finding a co-relation between mechanical and magnetic properties of the materials.

Key scientific question (2 lines max; Calibri 11)

Identification of structural defects or degradation through electromagnetic signatures.

Research method (8 lines max; Calibri 11)

The magnetic state of a ferromagnetic material is sensitive to multiple parameters including the temperature, the mechanical state, the microstructural content … Under stable conditions, magnetism can be used as an indirect way to identify and characterize one of these parameters. Electromagnetic non-destructive testing (MNDT) is the concept of using an electromagnetic signature to anticipate a level of integrity. Electromagnetic methods exist already but the simulation tool we developed allow to improve their performances by a deeper understanding and interpretation of the resulting signals.

Research students involved *(gray color for previous years)*

Ph.D. candidates (years, institution):

- Bhaawan Gupta (2016-2019)
- Shurui Zhang (2020-2023)

Master/Bachelor students (years):

Visits and stays *(gray color for previous years)*

FR to JP (date, duration):

- *B. Ducharne, Jan 2019, 10 Days*
- *B. Ducharne, Jul 2019, 10 Days*
- *B. Ducharne, Mar 2019, 10 Days*
- *B. Ducharne, Oct 2018, 10 Days*
- *B. Ducharne, Jan 2018, 10 Days*

JP to FR (date, duration):

- *T. Uchimoto, 2019, 61 Days total*
- *Kita, Sep 2019, 2 months*
- *S. Zhang, Sep 2019, 3 months*
- *T. Matsumoto, May 2018, 3 months*
- *T. Uchimoto, Jul 2019, 2 weeks*
- *T. Uchimoto, Nov 2019, 1 week*

COMMUNICATIONS AND VALORIZATION

Journal publications *(gray color for previous years)*

	Authors	Title	Journal	Vol.	pp. / ID	Year	DOI
1	B. Gupta, B. Ducharne, T. Uchimoto, G. Sebald, T. Miyazaki, T. Takagi	Comparison of electromagnetic inspection methods for creep-degraded high chromium ferritic steels	NDT & E International			2020	
2	S. Zhang, B. Ducharne, T. Uchimoto, A. Kita, Y.A. Tene Deffo	Simulation tool for Eddy Current Magnetic Signature (EC-MS) non-destructive method	Journal of magnetism and magnetic materials	513	167221	2020	https://doi.org/10.1016/j.jmmm.2020.167221
3	B. Gupta, B. Ducharne, T. Uchimoto, G. Sebald, T. Miyazaki, T. Takagi	Non-destructive testing on creep degraded 12% Cr-Mo-WV ferritic test samples using Barkhausen noise	Journal of magnetism and magnetic materials	498	166102	2020	https://doi.org/10.1016/j.jmmm.2019.166102
4	B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto, T. Miyazaki, T. Takagi	Physical interpretation of the microsctructure for aged 12 Cr-Mo-VW steel creep test samples based on simulation of magnetic incremental permeability	Journal of magnetism and magnetic materials	486	165250	2019	https://doi.org/10.1016/j.jmmm.2019.165250
5	B. Gupta, T. Uchimoto, B. Ducharne, G. Sebald, T Miyazaki, T. Takagi	Magnetic incremental permeability non-destructive evaluation of 12 Cr-Mo-VW steep creep test samples with varied ageing levels and thermal treatments	NDT & E International	104	42-50	2019	https://doi.org/10.1016/j.ndteint.2019.03.006
6	T. Matsumoto, T. Uchimoto, T. Takagi, G. Dobmann, B. Ducharne, S. Oozono, H. Yuya	Investigation of electromagnetic nondestructive evaluation of residual strain in low carbon steels using the eddy current magnetic signature (EC-MS)	Journal of magnetism and magnetic materials	479	212-221	2019	https://doi.org/10.1016/j.jmmm.2019.01.103

7	T. Matsumoto, B. Ducharne, T. Uchimoto	Numerical model of the Eddy current magnetic signature (EC-MS) non-destructive micro-magnetic technique	AIP advances	9	035045	2019	https://doi.org/10.1063/1.5079995
8	B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto	A space discretized ferromagnetic model for non-destructive eddy current evaluation	IEEE Transactions on magnetics	54	1-4	2018	https://doi.org/10/1109/TMAG.2017.2773517
9	B. Ducharne, B. Gupta, Y. Hebrard, J.B. Coudert	Phenomenological model of Barkhausen noise under mechanical and magnetic excitation	IEEE Transactions on magnetics	54	6202606	2018	https://doi.org/10/1109/TMAG.2018.2833419
10	B. Zhang, B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto	Dynamic magnetic scalar hysteresis lump model, based on Jiles-Atherton quasi-static hysteresis model extended with dynamic fractional derivatives	IEEE Transactions on magnetics	54	6200204	2017	https://doi.org/10/1109/TMAG.2018.2773517
11	B. Zhang, B. Gupta, B. Ducharne, G. Sebald, T. Uchimoto	Preisach's model extended with dynamic fractional derivative contribution	IEEE Transactions on magnetics	54	6100204	2017	https://doi.org/10/1109/TMAG.2018.2759421