NGHRI
Namibia Green Hydroaen Research Institute

UNAM
UNIVERSITY OF NAMIBIA



CALL FOR APPLICATIONS

Joint Doctoral Scholarships

The Namibian Green Hydrogen Research Institute (NGHRI) at the University of Namibia and the Competence Center H_2Safety@BAM at Bundesanstalt für Materialforschung und -prüfung (BAM), Germany, are inviting applications for 5 scholarships to a joint-doctoral (PhD) studies.

Doctorate topics to choose from:

1. Innovative Steel Welds for GH_2 Transportation Pipelines
2. Evaluation of Hydrogen Absorption and Trapping in various Steels
3. Innovative Steels for High Pressure GH_2 Applications
4. Self-ignition processes during LH_2 releases
5. Hydrogen sensors: Detection limits, reliability, test set-ups, system monitoring sensors
6. Modelling and Simulation: Hydrogen Deflagration and Detonation Processes
7. Modelling for avoidance of hydrogen degradation and cracking in gaseous environments

Background

Safeguarding long-term energy supply and fulfilment of the ambitious climate protection goals, up to 80 % of the required amount of energy carriers like green hydrogen and its derivates need to be imported. Production of green hydrogen by electrolysis of water requires cheap green electricity, low-cost land and desalinated sea water, as resources. Worldwide, Namibia is one of the top countries with the widest abundance of such resources, and thus, has best preconditions for the delivery of green hydrogen to global markets, at extremely attractive prices. Regarding the African continent, Namibia can be regarded as to be far ahead of other countries with respect to the implementation goals for

green hydrogen production, transport, storage and usage.

Safety that builds trust has been addressed as extremely important topic in the puzzle of the GH2T horizontal and vertical value chains in Namibia. Capacity building has been highlighted as key factor for development, implementation and operation of GH2T in Namibia.

As governmental institutions working in the field of GH2T, BAM with its Competence Centre H2Safety@BAM and the Namibian Green Hydrogen Research Institute at UNAM have identified common doctoral topics, among several other initiatives.

This programme especially focuses on high-level capacity building with an emphasis on materials compatibility for components and on safety of GH2T systems.

Who may apply

Currently, the programme comprises up to seven 3-year doctoral terms exclusively for Namibian citizens or permanent residence holders to achieve high-level capacity building in that way that the acquired knowledge will be widely transferred into Namibia and significantly contributes to build research, laboratory and quality infrastructure.

Please take note:

- Selection of candidates will be based on joint interviews with the supervisors, preferentially in-presence at Main Campus or Eng. José Eduardo dos Santos (JEDS) Campus in November 2022.
- Successful candidates will be contracted by BAM in Germany and will be provided with a sufficient salary to cover living and partly travelling costs.
- To allow a very direct knowledge transfer on the scientific level, exchange terms between UNAM and BAM will be made possible, dependent on the topic and on suggestion by the supervisors.
- Dependent on the topic, the doctorate students will enrol at a German university cooperating with BAM at any time or at UNAM during the first half of 2023.
- Candidates will always be supervised jointly under close cooperation between colleagues from UNAM and BAM.
- Doctoral degrees will be granted by a German university or by UNAM and the leading supervisor from each institution will be on the granting committee.
- Doctoral candidates will be integrated in the doctoral programmes at BAM, in particular in those related to GH_2T within the Competence Centre H_2Safety@BAM, like the Joint European Summer School (JESS, together with other European universities) or the Graduate School "Trustworthy Hydrogen" to get additional insight beyond their thesis subjects into the wide scope of technical safety fields of GH_2T.
- Leadership staff at NGHRI at UNAM and H_2Safety at BAM will be available to support and assist you during your application and in Germany.

How to apply

- Interested candidates should submit sound applications for their doctoral term under selection of one of the topics above, including CV, letter of motivation and recommendation letter from a UNAM-supervisor.
- Submit application via email to: Dr Silas Hango at: shango@unam.na

Please get in touch with us immediately – the application deadline is ticking!

Application deadline: 15 November 2022

For any enquiries, please contact:

- Dr. Zivayi Chiguvare, NGHRI Director, at: zchiguvare@unam.na
- Dr. Natangue Shafudah, NGHRI Project Coordinator, at: nshafudah@unam.na
- Prof. Dr. -Ing. Thomas Böllinghaus, TF Energy Coordinator / HoD Component Safety – BAM, at: thomas.boellinghaus@bam.de
- Dr. -Ing. Kai Holtappels, H2Safety Chair – BAM at: Kai.Holtappels@bam.de

BAM

H_2 NGHRI
Namibia Green Hydrogen Research Institute

Doctorate Topic 1 (Materials Compatibility for GH_2T Components):

Innovative Steel Welds for GH_2 Transportation Pipelines

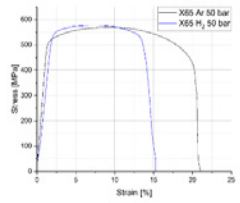
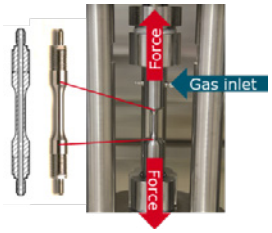
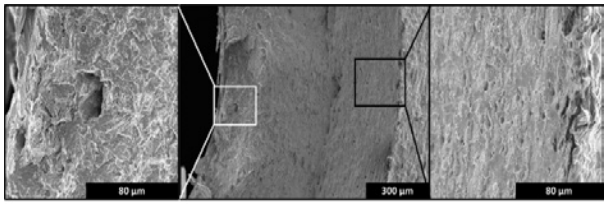
1. **Frame:** Pipelines provide the most effective and efficient means for energy transportation. During long-term service, there exist multiple threats affecting pipeline integrity. These include corrosion, fatigue, mechanical damage, materials and welding failures and external interference. Pipeline failures, once occurring, usually result in energy loss, impacts to environment, ecology and community, and, sometimes, death. In general, mechanical damage, corrosion and hydrogen-induced degradation are main reasons resulting in pipeline failures at welds. Most of the green hydrogen (GH_2) transportation pipelines in Namibia have still to be built, as there is not much pipeline infrastructure existing infrastructure that could be used. In contrast to quite soon declarations regarding H_2-readiness, it recently turned out that existing pipeline steel grades steels of the X65, X 70 type commonly applied for natural gas transportation in Europe and the Americas are not completely free from degradation, even at lower pressures (50 bar) and room temperature (20□C). This currently regards to some base materials. The long-term service behaviour of pipeline welds in pressurized hydrogen atmospheres has not even been investigated yet, especially not with respect to their complex microstructures. In contrast to European countries where the existing natural gas infrastructure needs to be largely converted to hydrogen usage, Namibia has greatest opportunities to build GH_2 systems with transportation lines using innovative structural steels and filler materials of the medium strength regime. Due to the open space, most of such transportation lines will be erected aboveground, in contrast to underground less-accessible pipeline systems in Europe, however, also at different climatic conditions.

2. **Task:** The opened three-year doctoral positions will exactly tackle these challenges. The doctoral theses should provide further insight into Metallurgical characteristics and Welding metallurgy of high-strength pipeline steels, Hydrogen permeation at pipeline welds, Hydrogen-induced degradation and control at pipeline welds, and which heats and grades of innovative pipeline steels as well as the welds and their treatment are more immune to hydrogen absorption and respective degradation. They also should provide a contribution, whether and how the warm climate and the day and night temperature cycles in Namibia might influence hydrogen uptake or not. For this, the doctoral theses will focus on two innovative fine-grained structural steels of the S 360 and S 500 regime and their respective, mainly MAG, welds.

Solution: The experimental work should mainly be carried out by slow strain rate tests (SSRT) with the newly developed hollow tensile specimen (HTS) technique at BAM. For comparison, also tensile tests of pre-charged specimens will be applied. Both experiment types will be accompanied by entailing hydrogen concentration determination and SEM fractography of the specimens. If a better resistance of innovative pipeline steels can be evidenced, this widens the pipeline design potentials. Due to decreasing wall thicknesses lower materials costs can be achieved. Beyond the new GH_2T, this would be one of a very innovative light weight design projects in Namibia.

3. Work: Literature overview, two steel types (S 360 and S 500), various weld microstructures (BM, CGHAZ, FGHAZ, WM), tensile testing of H-pre-charged specimens, SSRT, permeation experiments, TDA, transfer and application of results as well as suitable test technologies between BAM to UNAM

4. Ideal pre-requisites: MSc in a technical or natural sciences field, preferentially with a profound knowledge in mechanical, materials or welding engineering, fluent English.

		
Stress-strain diagrams of SSRT of a X65 pipe-line steel at a strain rate of $1 \cdot 10^{-6}$ 1/s	Principle of SSRT with hollow specimens	Fracture topographies investigation by SEM: Brittle fracture surface at the internal margins

Please contact Prof. Dr. O. T. Johnson, Dr. S. I. Hango

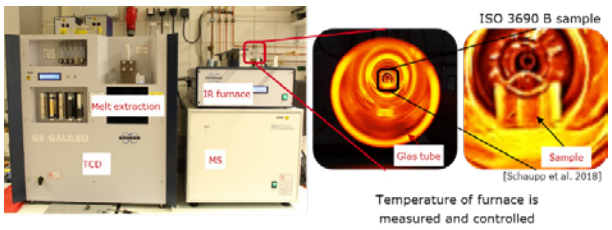
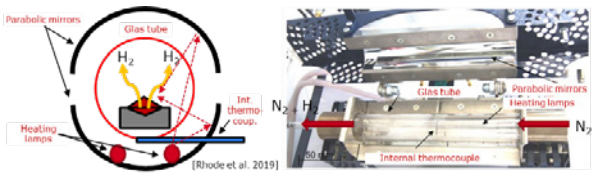
or Prof. Dr.-Ing. Th. Böllinghaus, Dr.-Ing. O. Sobol

BAM will accept up to two 3-year doctorates on this subject

Doctorate Topic 2:

Evaluation of Hydrogen Absorption and Trapping in Various Steels

1. **Frame:** It has been well proved that hydrogen represents a harmful element for steels because it leads to a serious decrease in mechanical properties, especially loss of ductility. Hydrogen diffusion and interactions with structural defects are fundamental for understanding and regulating the hydrogen embrittlement of steels. The processes of hydrogen uptake from gaseous and aqueous electrolytes are different and hydrogen is absorbed in quite different concentrations. The absorbed hydrogen is deeper bound at traps, if taken up from gaseous environments, however at much smaller concentrations. This opens potentials for regarding the GH_2T as much less harmless for the containment materials than originally anticipated. Hydrogen-induced degradation of high-strength steel pipeline has remained an essential threat to the integrity and safety of the pipeline system. There has been a big space in further investigations and understandings of the problem due to complicated metallurgical microstructure, stress, hydrogen distribution and their synergism on hydrogen-induced degradation behaviour. In the Namibian context, it would be important to evaluate different hydrogen absorption and trapping behaviours within our unique climatic conditions in order to make scientific-based recommendations on safety measures and maintenance plans of the pipeline system.
2. Task: The hydrogen uptake reactions from gaseous and electrochemical environments have to be revisited, as they are still not thoroughly understood. The successful candidate will work with two different steel types (preferentially with S 500 and 316L) to find the differences of hydrogen solubility for an innovative pipeline material and for a common material applied to high pressure tubing, as for instance in high-pressure hydrogen fuelling stations. Especially for the steel S 500, also hydrogen absorption and trapping in the different weld microstructures will be investigated. The program will be extended to higher temperatures and pressures for a comprehensive study. The results will be compared to new equations for calculating the absorbed hydrogen centration from gaseous environments. If the concentrations, at which hydrogen is absorbed from gaseous environments in comparison to aqueous environments are exactly known, then also avoidance measures/limits for the practical service operation can be drawn. In addition, a study will be carried out, if cathodic hydrogen charging in electrolytes under high pressure will reveal similar results than in gaseous environments at the same pressure.
3. Work: Literature overview, two steel types (S 500 and 316L), electrochemical charging with and without ambient pressure, gaseous H_2 charging, permeation experiments, TDA
4. Ideal pre-requisites: MSc in a technical or natural sciences field, preferentially with a profound knowledge in mechanical, materials or welding engineering, fluent English.
5. Knowledge gains: Innovative techniques for hydrogen absorption (successful candidates will be able to transfer these techniques into research labs in Namibia), hydrogen-metal interactions, conditions under which hydrogen absorption in metallic materials might be avoided, service behavior of GH_2T components, GMA welding processes, low alloyed ferritic-pearlitic and austenitic stainless steel and their weld microstructures, European networks in GH_2T

	
Thermal desorption analysis unit at BAM	Principle of thermal desorption hydrogen analysis

Please contact Dr. N. Shafudah, Prof. Dr. O. T. Johnson or

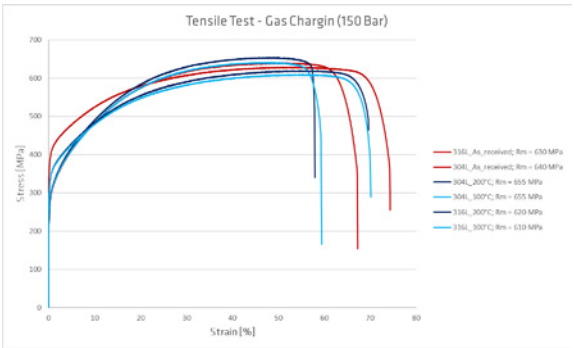
Prof. Dr.-Ing. Th. Boellinghaus

BAM (Department 9 – Component Safety) will accept one 3-year doctorate on this subject

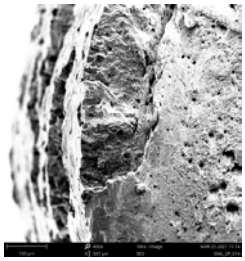
Doctorate Topic 3:

Innovative Steels for High Pressure GH_2 Applications

1. Frame: Austenitic stainless steels are commonly regarded to show a better resistance against hydrogen uptake, degradation and cracking and are thus, potential materials for high hydrogen pressure and elevated temperature applications, like in hydrogen fuel stations. However, in the past five years, it turned out that high hydrogen concentrations might be absorbed in those materials that might transform the microstructure from a fcc austentite into a hdp, bcc martensite which is much less ductile than the original one. Additionally, the deformation-induced martensitic transformation is enhanced by hydrogen.
2. Task: The hydrogen enhanced transformation of the austenitic into a martensitic microstructure is a relatively new materials engineering phenomenon not sufficiently yet considered, especially in high pressure gaseous GH_2T environments. Alternative stainless steels with improved resistance against such microstructural transformations have been identified. Stable austenitic steels with higher Ni and Mo contents do not (as easily) transform into martensite and thus appear more suitable for GH_2 applications. The successful applicant will investigate new alternative stable steels by slow strain rate tests (SSRT) with hollow specimens. Hydrogen degassing experiments will also be conducted and also respective fractography.
3. Work: Literature overview, several high alloyed stainless-steel types (1.4404 and 1.3964), tensile testing of H-precharged specimens, SSRT, permeation experiments, TDA
4. Ideal pre-requisites: MSc in a technical or natural sciences field, preferentially with a profound knowledge in mechanical, materials or welding engineering, fluent English.
5. Knowledge gains: The successful applicants will carefully be guided into this topic, will get tuition directly by the supervisors about this class of materials and their interaction with hydrogen absorbed from different environments. Innovative HTS-SSRT (successful candidates will be able to transfer these techniques into research labs in Namibia), hydrogen-metal interactions, service behaviour of GH_2T components, GMA welding processes, austenitic stainless-steel microstructures, European networks in GH_2T



Stress-strain diagrams of hydrogen pre-charged tensile test specimens of 304 and 316 L steel.





Fracture topographies investigation by SEM: Brittle fracture surface at the margins and in the centre of pre-charged tensile test specimens.

Please contact Prof. O. T. Johnson or Prof. Dr.-Ing. Th. Böllinghaus

BAM (Department 9 – Component Safety) will accept one 3-year doctorate on this subject

Doctorate Topic 4:

Self-ignition processes during LH_2 releases

1. **Frame:** The need to store hydrogen in its liquid state means that releases at cryogenic temperatures are possible. An understanding of the implication and consequences of any likely ignition is therefore required. In order to facilitate the use of liquid hydrogen (LH_2) outside of typical industrial applications, for example as a fuel for road vehicles, the understanding of certain high-risk scenarios needs development. Sudden release of LH_2 due to leakages of pipelines and storage tanks entails a rapid phase transition (liquid to gaseous) that in turn might cause self-ignition and even explosion accidents. Sudden release of gaseous hydrogen from a long-distance transportation pipeline might cause also sudden ignition and perhaps jet-fires, or even explosions. Therefore, it would be important to gather information such as the behaviour of LH_2 spills and identified common hydrogen mixtures that would be present in the event of an accidental spillage; ignition mechanisms, combustion properties and so on, in preparation for the adoption of GH_2T in Namibia.
2. **Task:** The processes and conditions under which such self-ignition is caused are not yet completely understood. Conditions for >safe< gas release into the ambient air need to be defined to avoid accident scenarios. The candidate will learn about this topic and will conduct experiments with the BAM experts to gain a closer insight in such processes, but a better measurement and observation of such gas releases, especially by thermo-grafic inspection. Especially, the gas distribution into the ambient air and the spreading of such scenarios in width have to be evaluated to find values for critical public distances from hydrogen pipelines, for instance. It is expected that specific conditions of such self-ignition are first investigated under a limited spectrum of operation parameters and that such phenomena are then investigated in detail then also theoretically.
3. **Work:** Literature overview (the influence of low temperature on the flammability limits of hydrogen gas; minimum ignition energy and ignition energies of cryogenic H_2/air mixtures), experiments on the BAM Test Site Technical Safety, identification of conditions under for LH_2 release which self-ignition can be avoided.
4. **Ideal pre-requisites:** MSc in chemical, mechanical or materials engineering.
5. **Knowledge gains:** The successful applicant will carefully be guided into this topic, will get tuition directly by the supervisors and will experience large scale testing on the BAM Technical Safety Test Site, avoidance of accident scenarios, understanding of liquid hydrogen transportation systems, safety of liquid hydrogen transportation and storage systems



Experiment of liquid hydrogen release into an aqueous environment on the BAM Test Site Technical Safety to simulate leakages of connection pipelines for transfer and transport of LH_2 at port sites.



Release of gaseous hydrogen from a pipeline section and respective explosion scenarios.

Please contact Dr. Mutiu Erinosho or Dr. K. Holtappels

BAM (Department 2 – Chemical Safety Engineering) will accept one 3-year doctorate on this subject

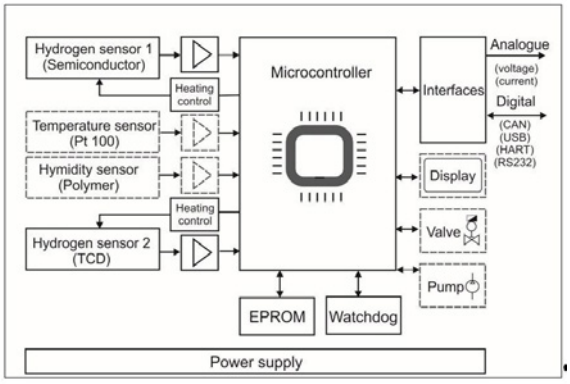
Doctorate Topic 5:

Hydrogen sensors: Detection limits, reliability, test set-ups, system monitoring sensors

1. **Frame:** Hydrogen sensors are of increasing importance in connection with the development and expanded use of hydrogen gas as an energy carrier. Even though, the detection and concentration measurement of hydrogen has been discussed over the years, there is a continued need for faster, more accurate and more selective detection of hydrogen gas in various areas of industry for monitoring and controlling hydrogen concentration. Hydrogen detection in air with gas sensors and time series analysis, determination of characteristics of gas sensors (sensitivity, selectivity as well as response behaviour), determination of causes of uncertainty of the gas mixing procedures. Hydrogen also needs to be stored at high pressure which means high risk and safety issues during storage and transport.
2. **Task:** The testing of hydrogen sensors has to be improved to gain more knowledge regarding their reliability and potentials to monitor complete systems. For this, the successful candidate will set up and apply of gas mixing system to test hydrogen detection apparatuses (hydrogen sensing element as well as hydrogen sensors) with respect to ISO 26142:2010. Gaps will have to be explored in hydrogen detection with respect to safety, process control and environmental issues. In addition, communication systems for hydrogen sensors will have to be designed and to be developed. Hydrogen detection devices will be validated the by time-series analysis methods with respect to certified reference materials. Numerical models by real experiments of the gas mixing system will be developed. Deployment and application of low-cost acoustic sensors attached to hydrogen containment systems for leakage detection.
3. **Work:** Literature overview sensor design, assembling and testing, development and adaption of calculation procedures and numerical models, experimental validation, transfer to the use case, control systems
4. **Ideal pre-requisites:** MSc in chemical, mechanical or materials engineering.
5. **Knowledge gains:** Hydrogen sensors and their technology, testing and evaluation of the reliability of sensors, numerical models for assessment of sensors, acquaintance to gas mixtures and respective systems, communication systems of sensors



Various sensor types



Principle of a hydrogen sensor

Please contact Dr. N. Shafudah, Dr. T. Wanjekeche,

or Dr. rer. nat. Carlo Tiebe

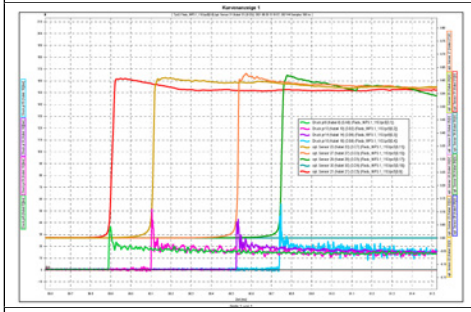
BAM (Departments 2 and 8 – Chemical Safety Engineering and Non-Destructive Testing)

will accept one 3-year doctorate on this subject

Doctorate Topic 6:

Modelling and Simulation: Hydrogen Deflagration and Detonation Processes

1. **Frame:** The transition processes between deflagration and detonation in gaseous hydrogen containing environments are not yet completely understood. For correct assessment of the hydrogen release and detonation damage in case of accidents, such models have to be improved.
2. **Task:** Models have to be developed further to fully simulate deflagration and detonation processes. The respective experimental data acquisition has to be carried out and such data have to transferred to the respective simulations. Existing models for other explosive geseous phases have to be adapted and to be optimized with respect to hydrogen. Such models also have to be validated experimentally. Several simulations have to be carried out to approve such models. The MSc covers the adaption of one model and to sufficiently operate such simulations with first results. Later, within the doctorate various models are used and the results will be compared to each other as well as validated by large scale experiments on the BAM Test Site Technical Safety. If applicable models are identified, the accident scenarios and in particular their avoidance can be evaluated and the GH_2T can be made even safer than are already.
3. **Work:** Literature overview, development and adaption of numerical models, experimental validation, transfer to the use case
4. **Ideal pre-requisites:** MSc in a technical or natural sciences field, preferentially with some course specification (not mandatory) in mechanical or materials engineering for the master course/thesis at BAM. MSc in mechanical or materials engineering for the doctorate.
5. **Knowledge gains:** The successful applicants will carefully be guided into this topic, will get tuition directly by the supervisors about metallic materials and their interaction with hydrogen absorbed from different environments. The successful candidates will also be introduced into innovative test procedures to prove the resistance of materials and components against absorbed hydrogen. In particular, successful candidates will be introduced into modern simulation and modelling procedures for hydrogen cracking avoidance.



Pressure-time-histories of a gas explosion in a pipe



Test set-up for large scale gas explosions in pipes

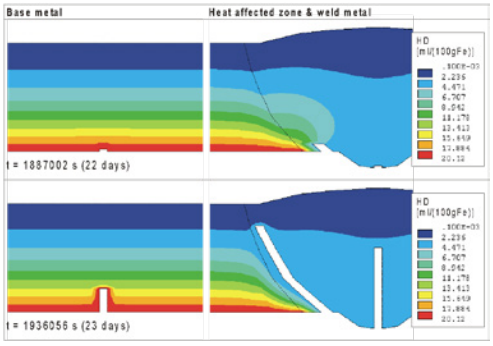
Please contact Dr. Mutiu Erinosho or Dr. K. Holtappels

BAM (Department 2 – Chemical Safety Engineering) will accept one 3-year doctorate on this subject

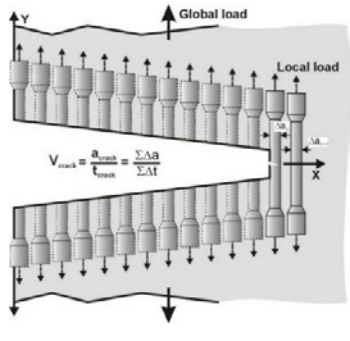
Doctorate Topic 7:

Modelling for avoidance of hydrogen degradation and cracking in gaseous environments

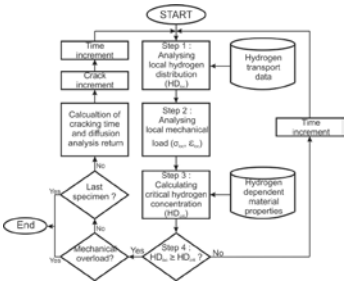
1. **Frame:** The modelling and simulation procedures for hydrogen uptake, degradation and cracking processes in steels can become suitable tools to access the long-term service behaviour of all sort of components subjected to GH_2T. Such models and simulation techniques have been developed for processes of hydrogen uptake from aqueous electrolytes. However, they have not yet been applied to gaseous environments with conditions for hydrogen absorption and permeation which are quite different.
2. **Task:** The developed hydrogen uptake and diffusion equations for gaseous and electrochemical environments will be applied to various models and compared with respective experimental results. The successful candidate will work in the MSc thesis with two different steel types (X65 and 316L) to look into the differences of respective hydrogen degradation and crack propagation. The program of the MSc thesis will later be extended to other materials and welds for a comprehensive doctorate. If the candidate succeeds to modify sufficiently the existing models and simulation techniques, these can be applied to gaseous hydrogen environments, then they can immensely help to make to increase the sustainability of such new GH_2T.
3. **Work:** Literature overview, learning and working with finite element modelling, investigating two steel types (X 65and 316L), application and adjustment of existing models
4. **Ideal pre-requisites:** MSc in a technical or natural sciences field, preferentially with some course specification (not mandatory) in mechanical or materials engineering for the master course/thesis at BAM. MSc in mechanical or materials engineering for the doctorate.
5. **Knowledge gains:** The successful applicants will carefully be guided into this topic, will get tuition directly by the supervisors about metallic materials and their interaction with hydrogen absorbed from different environments. The successful candidates will also be introduced into innovative test procedures to prove the resistance of materials and components against absorbed hydrogen. In particular, successful candidates will be introduced into modern simulation and modelling procedures for hydrogen cracking avoidance.



Finite element simulation of hydrogen assisted crack propagation in a welded pipeline



Principle of hydrogen crack propagation modelling



Flow chart of hydrogen cracking modelling

Please contact Prof. O. T. Johnson or Prof. Dr.-Ing. Th. Böllinghaus

BAM (Department 9 – Component Safety) will accept one 3-year doctorate on this subject