

IN-SITU OFFSHORE PIPELINE MONITORING: A SYSTEMATIC REVIEW

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Abstract. In-situ monitoring of submerged pipelines is an extremely important procedure since the continuous monitoring of this system helps to avoid possible errors and allows better visualization of a necessary solution. In this sense, the retro-analysis also shows a very fundamental method, which consists in the observation and analysis of a real situation, already occurred. In this way, mistakes or poorly adjusted parameters that prevent the success of the work, are more easily adjusted. This work consists of a systematic review of free spanning pipelines in-situ monitoring. A systematic review of the literature consists of investigating the state of the art of a subject or area, however against a common literature review, systematic reviews have the purpose of being replicable, accurate and methodical. Therefore, they are accomplished through the definition of a research question, a search strategy, the establishment of inclusion and exclusion criteria and the careful analysis of the material. In this sense, a whole study on the chosen theme, as well as the definition of a search string is being elaborated to reach a final amount of Works that represent the subject of this article. Thus, the careful analysis of the keywords, abstracts, and introductions has been of great relevance in this phase of the research. Finally, through the application of systematic review techniques, the most relevant works of the area were identified and the construction of a bibliographic review was made possible. Hence, as a final result of this project, it is intended to build a systematic review article that serves both to exercise this tool and to base other studies that need a precise and in-depth knowledge regarding the subject in question.

Keywords: Systematic Review, in-situ Monitoring, Pipelines, Free-spans

1 Introduction

The purpose of the subsea pipeline is to transport fluids between the well and the platform, between platforms, or between the platform and a land location. The section of the pipeline that is suspended is called riser and the section that is in contact with the marine soil is called the subsea pipeline [1].

The main phenomena that affect this type of structure are Vortex-Induced Vibrations (VIV), since these arise due to the occurrence of free spans, especially when the pipe is very long. Free spanning may induce vibration due to vortex shedding, which generates alternating forces in the structure in both in-line and cross-flow directions. Resonance may occur if this frequency induced by VIV approaches the natural frequency of the structure. Then, it is possible that the structure, subjected to cyclic loading, fails [2].

Since in-situ monitoring is very important to ensure the successful design of these structures, it is also relevant to know which latest and most developed techniques and methods are being used for this purpose. In this case, a very useful resource can be employed to facilitate this task: the Systematic Review (SR). This process is widely used in medical fields and by software engineers. However, for researchers in many fields, including engineering, this process - despite its potential - is still very little known and used.

For more experienced researchers working on very specific topics, the SR process does not make much sense as they are already knowledgeable about the work in their field and their peers. However, when the proposal is to survey the state of the art of multidisciplinary, comprehensive and unknown topics, the Systematic Review plays a very important role.

Hence, SR consists of a secondary study, aiming to gather similar works and critically and methodically evaluate them, so that the analysis can be systematic and reproducible. Data selection and analysis methods are established before the review is initiated, in a rigorous and well-defined process. Therefore, following the following steps: the establishment of a research question, i.e. the central idea of study, literature search, analysis of the works found, establishment the inclusion and exclusion criteria and, finally, the deeper reading of the remaining studies.

2 Systematic Review process

2.1 Systematic Review protocol

Given the data selection, an analysis criteria must be established before the review process begins. It is critical that these steps are well planned, studied and defined very carefully, as one of the objectives of a systematic review is to be reproducible. In this sense, anyone who follows the same steps as a review already done should achieve the same results as before.

Therefore, the construction of a systematic review protocol is very useful in this regard, since it makes the author reflect on every minimal step of his review, not missing something that would compromise the reproduction of this work. In general terms, this tool consists of establishing a step-by-step review, determining, among other things, the theme, the general and specific objectives, the search places and the inclusion and exclusion criteria.

The protocol of this paper, for example, begins by defining the general and specific objectives of this study, i.e., establishing which activities and skills should be performed and acquired through this work. In this context, the initiation to scientific work and contribution to the knowledge of the VIV phenomenon are configured as a general objective, as well as the learning of StArt (the tool used to build a SR protocol), Latex, among others, can be treated as specific objectives.

However, many other steps, beyond the purpose of a paper, need to be added to a protocol and clearly defined, since, by setting the purpose of the study alone, different people may have unequal opinions about the relevance of an article, for example, about the same study. Thus, the literature review may follow very discrepant paths, culminating in very different results, which is definitely not intended for a systematic review.

2.2 Protocol phases

Besides the general and specific objectives, for this work protocol, other steps of the systematic review were studied and well defined. The goal is to ensure the reproducibility of this review.

Search places and Research bases

Search basis were chosen based on ease of access and amount of studies available. In this work the CAPES, the Brazilian research funding agency, and Google Scholar basis were chosen for that reason, both have free access and a lot of papers and good journals accessible. Besides that, knowledge of these search places is fundamental to a research beginner, since they are widely used in scientific research. Hence, students must know how to look for studies in good spaces.

Regarding to the research basis, their choice was made taking into consideration, among other factors, the scope of studies of each one. The connection with the research theme was also taken into account. In this context, IEEE Xplore, Scopus, OnePetro and Web of science were chosen.

Research question and keywords

According to [3] it's important to establish the core objective or intent of your qualitative research from the outset. A single sentence purpose statement should guide the entire study. The importance of establishing a research question is to define what referral your study will take. Hence, it is guaranteed that your work will permeate the areas covered by the theme, without deviating from it.

A good research question must be refined to avoid being easily answered with yes and no or with a statistic, for example. For that, some words like how, what, identify and describe can help to build a good question. In this case, considering the factors mentioned, the following research question was formulated: "What is the state of the art of in-situ monitoring of submerged free span pipelines?". Therefore, it opens space to discussions and subareas that can be explored in this research.

Regarding keywords, they must be chosen carefully as they can give good visibility or not. They should be representative, i.e., they should be a good summary of a study so that anyone who reads them will know what this study is intended to show. However, at the same time, keywords must be general to ensure that the study has a good reach. So, for this context, In-situ, Monitoring, Pipelines, and Offshore were chosen as keywords for this review.

Search string

The huge range of information that has appeared on the web requires extra care from those who use it, since searching for specific information can be a complex activity. Thus, the search must be done concisely and specifically, using keywords and their combinations to find the desired result [4].

In this context, the search string is a very efficient mechanism, since it allows a specific and effective search. It consists of the combination between words, connectors, and signals that help to specify the search and return a satisfactory result[4].

These connectors are called Boolean operators. They are used to make a search more specific and restricted, as well as to broaden it. "VIV AND PIPELINES OR DUCTS AND MONITORING", "VIV AND PIPELINES NOT RISERS" or "VIV AND FREE *SPAN*" are examples of using these connectors. Thus, after analyzing which keywords would work better and which combinations between them and connectors would make the search more effective, the search string built for this study was d.

Inclusion and Exclusion criteria

Establishing inclusion and exclusion criteria is one of the most crucial phases of a Systematic Review. The given criteria, as the name implies, will establish which studies will be absorbed and which will be discarded. Hence, it is very important to ensure that no work relevant to the study is left out of this selection.

The purpose of this paper is to explore the systematic review process. Therefore, a less comprehensive review with more restrictive inclusion and exclusion criteria is more interesting. Thus, focusing more on the review process ensures a good domain of this tool at the end of the work.

The table below shows the inclusion and exclusion criteria for this review:

Table 1. Inclusion and Exclusion criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
Journals	Not journals
English or portuguese studies	Studies in others languages
Studies between 2010 and 2019	Studies not between 2010 and 2019
Contain at least 1 keyword in the title	Not contain at least 1 keyword in the title
Contain 3 of 4 keywords in abstract	Not contain 3 of 4 keywords in abstract
	Studies that deal with risers

For the inclusion criteria, it was determined to read-only articles and these articles must be just in English or Portuguese to optimize the process. As the present study deals with the state of the art of in-situ monitoring of submerged pipelines, the period from 2010 to 2019 was established to exclude works that were already outdated in this context. As it was chosen to specify the search theme, as was done with the search string, it was chosen to restrict the studies already by the title and by the abstract. Thus, studies that do not have at least 1 keyword in the title and studies that do not have at least 3 of 4 keywords in the abstract are considered very comprehensive for this study.

Exclusion criteria complement the inclusion criteria. However, regarding the last one, the exclusion of studies that deal with risers is due to the fact that the phenomenon that happens in these structures is not exactly what is interesting for this study.

2.3 Tool used: StArt

State of the Art through Systematic Review (StArt) is a computational tool developed at the Software Engineering Research Laboratory (LaPES) at the Federal University of São Carlos (UFSCar). As the Systematic Review is a repetitive process and comprised of several steps, StArt was created to provide more quality to this procedure and provide greater support to researchers. More information is provided on the LaPES website. [5]

This tool helps to make the systematic review protocol and three phases of study analysis: execution, selection, and extraction. Besides, it also has a visualization section, which provides graphs and statistics of each of these phases.

3 Results and Discussions

3.1 Discussion of Systematic Review phases

The execution phase consisted of exporting the search base articles to StArt. In this sense, articles were divided into sections corresponding to their bases of origin.

The next phase of selection had a lot of work. Thus, the criterion of containing at least one of the keywords in the title was used to make fast and effective filtering of the studies. Also, criteria such as papers that are articles only, papers in English and Portuguese only, and papers between 2010 and 2019 were analyzed, even if they were already filtered in the search bases.

Finally, the extraction phase used the criterion of having at least 3 of the 4 keywords in the abstract. In this sense, articles that passed this phase would have a greater guarantee of dealing with the theme in

question.

3.2 Numbers of studies in each phase of Systematic Review

In this work, 806 articles were exported to the execution phase, 2 from IEE Xplore, 734 from OnePetro, 14 from Scopus and 56 from Web of Science. Regarding the selection stage, the criteria adopted was the existence of at least one of the keywords in the title of the paper. In this sense, 95 articles were accepted and sent to the extraction phase, while the remaining 710 were rejected by these criteria and 1 article was duplicated. Thus, 25 articles were accepted by the criteria of containing keywords in the abstract and the other 70 were rejected by the same criteria.

3.3 Presentation of final numbers of representative studies

At the end of the process of this systematic review, the 25 articles found were not fully representative. In this sense, some of them, despite meeting all inclusion criteria, deal with themes that are not so pertinent to this study. However, we also came up with works that are relevant to the theme.

In this sense, factors such as the process of elaborating the inclusion and exclusion criteria or the search string may have been decisive. If these criteria were readjusted, analyzing the literature better and trying to better study the way keywords are presented in the works, the results would possibly be more representative. Taking as an example, by changing the inclusion criteria "contain at least 3 of the 4 keywords in the abstract" to "contain all keywords in the abstract", the 25 articles would be reduced to just 2. However, these 2 papers would be quite representative indeed. One of the goals of this study is to show how many papers on this topic there are and specifically recent ones. Thus, as technologies evolve so fast, changing the date range is not consistent.

However, the fact that there are not many studies on this topic, culminates in the low number of articles found at the end of the review. Thus, one of the intentions of this article is to show that there is a deficit regarding studies in this area. And, as this is such an important area for the offshore industry, it is increasingly necessary to better understand these phenomena involving subsea pipelines. Being in-situ monitoring an important ally in this process.

Acknowledgements

I would like to thank the Laboratório de Computação Científica e Visualização (Scientific Computing and Visualization Lab - LCCV -) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (National Council for Scientific and Technological Development - CNPq -) for all the support. I would also like to thank Programa de Educação Tutorial (Tutorial Education Program - PET -) for the teachings.

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