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Studying the rate of corrosion of the bottom of a jet loop reactor using digital close-range photogrammetric techniques

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ABSTRACT

The current task intends to research the impact of various operating and geometrical parameters on the corrosion rate of a jet loop reactor bottom. Photogrammetry is a recent surveying method that has been used to picture and measure the corrosion rate. Henceforth, the three dimensional model of the affected regions of the reactor which are under investigation have been formed by one of the photogrammetric methods. The physical properties of the solution (viscosity and density), the nozzle height, the nozzle diameter and the flow rate of circulation are the variable that are being studied.

A dimensionless equation was developed from the experimental data, which will be a useful tool for prediction of the corrosion rate at the jet loop reactor bottom within the present range of operating conditions.

1. Introduction

The extremely crucial conditions in industrial stirred chemical reactors are power consumption and mixing time. Jet loop reactor (JLR) is among the reactors that can offer minimum power consumption with a little mixing time; it also plays a slight role in the process industry regardless of its easy applicability and great effectiveness [1]. A jet vessel comprises; as the term by now suggests; of a jet and a loop reactor [2]. Generally, recycle or loop reactors recycle a portion of the through passing reaction and reinstate it on top of the feed at the reactor's entrance. Recirculation of the portion of the vessel's content in a JLR is done through sucking it through a pump and giving it back speedily through a nozzle. The consequential high speed jet entrains a few of the nearby liquid and produces a circulation pattern inside the vessel with greater mixing rates. The jet loop reactor compromises an exceptional mixing performance at moderately slight consumption of energy, making it specifically interesting for implementation on the process industry as a substitute to stirred tank reactors especially in reaction systems managed by mass transfer stage [3–5]. Further merits of JLR, as likened to Continuous Stirred Tanks Reactors (CSTR), consist of the moving parts that are not present, which then removes the sealing difficulties and permitting process that is easier [6,7].

The aim of the current research is to examine the impact of hydrodynamic situation and geometrical parameters in a JRL on the corrosion rate at the reactor bottom. Geometrical parameters consist of nozzle diameter and nozzle height which possess a huge impact on the circulation patterns within the reactor. There are numerous measuring methods that can measure the corrosion at the reactor bottom. Photogrammetry is among these methods.

Photogrammetric measurement processes tries to fulfil, in an ideal way, numerous purposes for instance economy, reliability and precision. Determination of triangulated object point coordinates together with precision approximations is the ultimate objective of photogrammetric measurements [8]. 3D models of physical objects are increasingly becoming reasonably priced in several sectors like animation, navigations, visualization, object identification and inspection [9]. Photogrammetric methods offer a huge prospective for the solution for an extensive range of measurement tasks in various sectors. Photogrammetric methods have been temporarily approved as standard measurement methods, for particular applications [10]. Numerous merits are being offered by photogrammetry compared to conventional and other renowned measuring techniques. First, it is likely to map objects that are too precarious to touch or unreachable using photogrammetry. Secondly, photogrammetry offers a framework that is flexible since the entire data required to carry out the measurements can be found perpetually, instantaneously and at a static price with a single photographic achievement [11]. Afterward the measuring procedure can then be applied at whatever time. Last but not least, is that photogrammetry is cost-effective compared to conventional measuring method. Lastly, photogrammetry offers numerous types of digital

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products for instance ortho-images, digital elevation, 3D models and digital maps. Digital close-range photogrammetry is suitable for diverse implementations stretching from archaeology to industry; this is because of the above stated abilities [12]. A crucial branch in digital photogrammetry is digital close range photogrammetry. It possess an extensive range of implementations that snapped from a close distance. In this type of photogrammetry, the photographing requires high caution since the quality of the pictures could be affected by numerous causes. Attaining 3D measurement of photographed objects is the main purpose of digital close-range photography. It obtains measurements from digital images instead of measuring the object itself.

The procedures of producing 3D models comprises of many renowned stages which include: visualization, points recovering, text mapping, capturing and surface reconstruction. Range-based technique (3D laser scanner), photo-based-scanner and image based technique can be implemented at the points recovering and capturing stage.

The image-based technique comprises of the following stages:

(i) Taking pictures of no less than two images.
(ii) Determining the exterior and interior orientations of the taken image.
(iii) Measuring the interesting structures points in the images and working out the spatial coordinates of digital photogrammetry.

A new method known as “photo-based scanning” was offered in the digital photogrammetry sector many decades ago. This method related two photographs on a patch through the patch basis so as to obtain the ideal counterparts. As soon as these ideal counterparts are obtained, the orientation that is already computed and location information for the photos is used to work out the patch’s position in the three-dimensional space. A dense cloud of 3D points is resulted, as soon as a frequent grid of patches is sampled in the first image and matched to the ideal position in other one.

The range-based method is cantered majorly on measuring distance by means of a laser ray. In the laser technology, a laser beam is being swept by a type of laser scanner over the object and measure the period it takes to come back. This gives the distance from the scanner to all points that are sampled [13]. It has been described by numerous articles and textbooks that accuracy is a crucial element in the measurement world. Precision is described as the measurement’s degree of conformity or nearness to the actual value. Accuracy comprises not only the impacts of unsystematic faults, but also any preconception caused by inaccurate systematic faults. If there is no preconception, the precision can be measured by means of the standard deviation [14]. Similarly, it is described as the amount of conformism with a standard (“The Truth”). Accuracy can be assessed by means of check measurements and/or accuracy predictor techniques [15]. In the check measurements technique, the photogrammetric outcomes are compared with the outcomes acquired from a better precise measuring process. The accuracy predictor is depending on theoretical model of assessing a system using its major parameters. For precision determination of photogrammetrically target point coordinates, root-mean-square error (RMS) can be used [15–16]. Photogrammetry regularly approximates the precision of technique using controlled trials, whereby the coordinates that are determined photogrammetrically are related with the specified coordinates that have a precision that is significantly greater than the technique to be tested [17].

The process of assessing precision in digital close-range photogrammetry are renowned and are common. We are required to have field dimensions that can be matched with those dimensions acquired for the photogrammetric implementation so as to assess the precision in the digital close range photogrammetry. The field measurements are commonly precise (up to a particular limit). This precision is influenced by the used apparatuses and the mathematical model used to determine the 3D or 2D coordinates. Ebrahim [18] has talked about brief descriptions of the precision and how it can be attained in the works of photogrammetric. Generally, precision can be achieved from the field observations as follows:

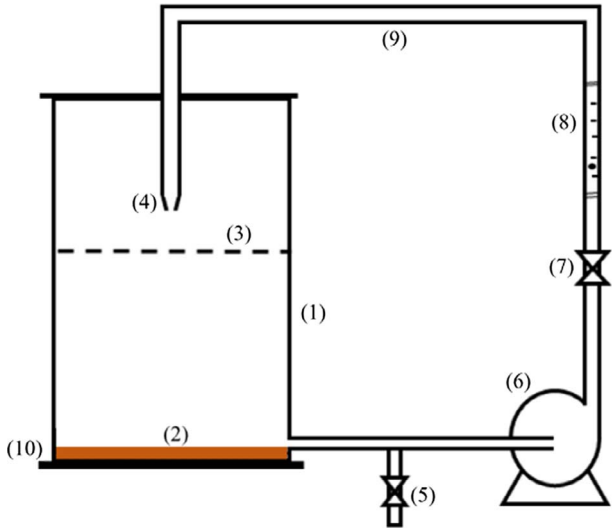

Fig. 1. The experimental model apparatus. (1) Plexiglas tank. (2) Copper disc. (3) Liquid level. (4) Nozzle. (5) Drain valve. (6) Plastic centrifugal pump. (7). Flow control valve. (8) Rotameter. (9) PVC pipe. (10) Tank base.

(i) Pick an appropriate test field to be used in the investigation (artificial or natural).
(ii) Record a few field measurements for the object so as to acquire 3D or 2D coordinates for particular selected points (targets).
(iii) Select camera configurations based on the aspects under investigation.
(iv) Pick an appropriate camera to use.
(v) Take the snapshots.
(vi) Be able to select whether to use the traditional or digital method.
(vii) Measuring targets photo coordinates.
(viii) Determine the targets space coordinates based on the photogrammetric answer.
(ix) Relate the surveying coordinates with that acquired from the photogrammetric answer and make the statistics needed.

2. Research hypothesis

A huge challenge in the industry sector is corrosion of metallic parts in chemical reactors and it has brought about large financial losses. The usage of corrosive may result in contaminating the contents of the reactor with corrosion products and reduce the quality of the product. The corrosion difficulty arises strongly due to great degree of turbulence in the reactor for instance the jet loop reactor (JLR) a portion of the content in this sort of reactors is re-circulated by sucking this part of fluid using a pump and taking it back at high velocity through a nozzle so as to entrain a few of the surrounding which will generate turbulence within the vessel. The great degree of turbulence might result in erosion-corrosion in the vessel. This current task purposes to study the impact of various parameters (operational and geometric) on the corrosion rate at the bottom of the vessel. In order to simulate the operating condition, a pilot scale reactor will be developed. The parameters will be enhanced so as to attain the operating and design conditions equivalent to the least corrosion rate. A 3D measurements of the tested regions, group of pictures are formed by various digital photogrammetric methods. Measurement of the quantity of erosion will be done by the 3D photogrammetric measurements. The measurements will be used to determine the impact of the parameters under investigation on the metal parts as well as analysing various scenarios.