CONFERENCE INFORMATION

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CONFERENCE INFORMATION

Numerical analysis utilizing the advantage of the development of computer hardware and software has had an immerse impact in many fields of engineering in recent years as it can provide not only fast but also comprehensive solutions in engineering problems.

The 10th International Conference on Numerical Analysis in Engineering (NAE) 2017 offers a place and opportunities for researchers and engineers from academic, industries and other sectors to exchange their scientific and technological information. NAE 2017 is also provided for students to present their research papers.

The conferece is organized by University of Sumatera Utara, in cooperation with Toyohashi University of Technology (TUT), Toyohashi – Japan; JSME – ICTS (International Chapter for Indonesian Section); Universiti Kebangsaan Malaysia (UKM), Bangi, Kuala Lumpur – Malaysia; Badan Kejuruan Mesin - Persatuan Insinyur Indonesia (BKM-PII); Universitas Syiah Kuala (UNSYIAH); IKATM USU (Mechanical Engineering Alumni Association of USU), and other academic institutions in Japan.

Background: Materials, Science, and Engineering

The conference covers the following topics approached by the numerical or the experimental method (but not limited to):

- Stress, strain and deformation analysis (linear, nonlinear, viscoelastic, viscoplastic, foams, seismic,etc)
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- Damage analysis
- Engineering dynamics (vibration, rotation of shaft, noise, multibody dynamics, etc)
- Mechanical elements (gear, screw, welding, joint, bearing, etc)
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- Fluid dynamics (laminar flow, turbulent flow, fluid machines, drain, dam, irrigation, etc)
- Material forming (metal, plastics, composite, etc)
- Tribology (friction, lubrication, etc)
- New algorithms for numerical analysis (Neural network, Genetic algorithm, Evolutionary algorithm, etc)
- Computational method in engineering and science
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Reliability enumeration model for the gear in a multi-functional machine

M. K. M. Nasution[1,*] **and H. Ambarita**[2]

[1]Teknologi Informasi, Fasilkom-TI, Universitas Sumatera Utara, Padang Bulan 20155 USU, Medan, Indonesia

[2]Sustainable Energy Research Centre, Faculty of Engineering, Universitas Sumatera Utara, Padang Bulan 20155 USU, Medan, Indonesia

E-mail: mahyuddin@usu.ac.id

Abstract. The angle and direction of motion play an important role in the ability of a multi-functional machine to be able to perform the task to be charged. The movement can be a rotational action that appears to perform a round, by which the rotation can be done by connecting the generator by hand through the help of a hinge formed from two rounded surfaces. The rotation of the entire arm can be carried out by the interconnection between two surfaces having a jagged ring. This link will change according to the angle of motion, and any yeast of the serration will have a share in the success of this process, therefore a robust hand measurement model is established based on canonical provisions.

1. Introduction

The arm or wrists in multi-functional machine play an important role in replacing dangerous human tasks like lever and lifting heavy loads, or resolve welding at a car manufacturer, defusing bombs, chemicals management, paint spraying and assembling. To perform such a task, the robotic arm or wrist must be capable of rotating within a range the same as that of a human, as a gear mechanism [1].

Most of the gear are modelled round with a serrated gaze transmitted in such a way that the spherical shape facilitates movement within the specified range. The canonical lever has been designed and known to be a discrete gear distributed on a round surface so that the gear direction is not continuous. In order for the serrations to be produced, the spindle-shaped teeth are designed by distributing serrations around the ring in a continuous manner [2]. Therefore, the gear movement has a probability, but the encounter of two jagged surfaces is interdependent and thus requires an enumeration model. This paper intend to reveal a model associated with the enumeration of the gear on the hand.

2. A Concept of Model

The arm and wrists of the lever of machine are connected to two rounded surfaces, and the wrists will rotate when the arm is also spinning or vice versa. The rotation due to the mechanism on the arm is transformed to the wrist through the relationship between two round surfaces, which

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have several rings with the gears attached in such a way, there are some rings that are not connected between two unrelated surfaces, depending on the angle of motion formed by the arm and wrist. Space created by a rounded ringed surface of the serration causes a lever to move his hand in a straight or crooked state without losing its power.

Each ring on a round surface, depending on the presence of its teeth, performs the performance of the lever [3]. A performance can be measured based on the interaction results of the teeth of two related surfaces, and loss of capture power of one gear from a surface against the gears on the other surface will cause the gear not to operate properly. Performance measurement of reliability refers to the probability that a system will carry out a stated mission that is based on the odds caused by the number of teeth [4, 5]. A mission is expressed in term of quantity, quality, time and others, whose operations can be assessed. Assuming that the extent to which expansions are expressed from this mission can be described with the Boolean function with all of the assumptions that have been widely described about a lever, the multi-functional machine performance measurement model is established and the enumeration.

3. An Approach

As already disclosed, a round-shaped gear is formed by producing a ring around the ring on a round surface. The rounded gear mechanism can be used to order two degrees of freedom, based on the direction of the rounded gear motion [6]. A rack-cutting vector function in the $S_1(o_1, x_1, y_1)$ reference system can be represented by $\mathcal{R}_1(\beta)$, β representing the shelf-cutting curve parameter. The rack-cutting set can be expressed by a vector function

$$\mathcal{R}_2 = \mathcal{R}_2(\beta, \phi_2) \tag{1}$$

ϕ_2 is a motion direction parameter. Thus, the point on the rack-cutting set wrapper simultaneously satisfies the above equation and the following equation

$$\frac{\partial \mathcal{R}_2}{\partial \beta} \times \frac{\partial \mathcal{R}_2}{\partial \phi_2} = 0 \tag{2}$$

Based on the gear theory, the design of the gear-shaped surface is rounded by a ring around the ring, which is a mechanism involving a spherical Σ^1, Σ^2 and a rack cutter for a multi-functional machine. Coordinate the system $S_1(o_1, x_1, y_1)$ is rigidly attached to the rack cutters. Coordinate system $S_2(o_2, x_2, y_2, z_2)$ is rigidly attached to the cross section of the Σ^1 gear. The coordinate system of $S_3(o_3, x_3, y_3, z_3$ and $S_4(o_4, x_4, y_4, z_4)$ is stacked rigidly against Σ^1 and Σ^2 as a lever. The S_3 coordinate system is introduced to rotate at the angle ϕ_1 and ϕ_2 each axis: y_3 and x_3. In the same way, ϕ_4 and ϕ_5 are rotating angles of the rounded gear Σ^2 which each rotates around the axis y_4 and axis z_4 in a lever. For a round-shaped gear Σ^1 has a ring around gear Σ^1 has a ring around the ring, the angle of ϕ_1 and ϕ_2 are the same. So, it is stated that $\phi_1 = \phi_2 = \phi$. In the same way the ϕ_4 and ϕ_5 annotations are equal to θ_1. The relationship between ϕ and θ_1 is $r_{p1}\phi = r_{p2}\theta_1$ [5]. The relationship between ϕ and θ_1 is $r_{p1}\phi = r_{p2}\theta_1$, with which r_{p1} and r_{p2} are the radius of relations of each gear Σ^1 and Σ^2. Therefore, the coordinate transformation matrix from S_1 to S_2 can be parsed as

$$\mathcal{M} = \begin{pmatrix} \cot\phi_2 & -\tan\phi_2 & r_{p1}\cot\phi_2 + S\tan\phi_2 \\ \tan\phi_2 & \cot\phi_2 & r_{p1}\tan\phi_2 - S\cot\phi_2 \\ 0 & 0 & 1 \end{pmatrix} \tag{3}$$

System reliability is the probability of system success, expressed as an assessment. The success of a system depends on the success of its building components, in this case a ring with a round-shaped gear of the arm and wrist at lever. Success is expressed for each teeth as the performance

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of a given set of specifications for a period of time. So, it is a probability of success applied directly to where the A event (total sample space) is the total number of experiments. Therefore, reliability A, $\mathcal{R}(A)$, expressed by

$$\mathcal{R}(A) = \frac{N(A)}{N(S)} = \frac{\text{success number}}{\text{total tried}} \tag{4}$$

Functional relationships should be established to express the reliability of the system as a function of component reliability by series and parallel terms. The series of relationships with each component must be successful in order for the system to succeed [8]. Failure of any one component causes failure in the system. For system with n series components, the Boolean function AND relationship is used to connect between system components [7], i.e.

$$T = A_1 A_2 \dots A_n \tag{5}$$

If the component fails freely, then the equation that can be applied to the reliability function is

$$\mathcal{R}(T) = \prod_{i=1}^{n} \mathcal{R}(A_i) \tag{6}$$

The parallel connection resulted in the system to be successful if one of the components of any component succeeded. Success in parallel for n component is represented by an operator OR in Boolean that can express the following truth value [7]

$$T = A_1 + A_2 + \dots + A_n \tag{7}$$

In order for the system to fail otherwise the whole component must fail. Hence $\overline{T}$ denotes system failure, and $\overline{A}_i$ signifies the failure of the i component, the following relation is derived from Eq. (5)

$$\overline{T} = \overline{A}_1 \overline{A}_2 \dots \overline{A}_i. \tag{8}$$

It can be transformed into probability function relationships $P(\overline{A}_1)P(\overline{A}_2)\dots P(\overline{A}_n)$, it may be expressed in the following parts of the system and component reliability

$$\mathcal{R}(T) = 1 - \prod_{i=1}^{n} [1 - \mathcal{R}(A_i)] \tag{9}$$

Determination of reliability as a general approach consist of two steps

(i) Write a Boolean expression for reliability configuration, by series, parallel or a mixture of both. This expression will relate the truth value of the system to the value of the success of the component.

(ii) Translate this phrase in algebraic form for the probability of system success as a function of the reliability of the components.

4. Enumeration

The motion direction of the gear mechanism by which assembly is used which describes the surface models of the Σ^1 and Σ^2. First (left-handed gear) can rotate around the y_3 and z_3 at the same time based on the frame. If the left-handed gear rotates around the y_3 when associated with the second (right-handed gear), the rotation of the z_3 is determined. Similarly, if the first part rotates around the x_3 with the right gear, the rotation of the y_3 is determined. Based on that it can be stated that if there are n rings from the center to the edge of two rounded surfaces, there will be m ringed rings, so $m < n$ corresponds to the established angle that is applicable for the transformation of the Eq. (3).

The relationship illustrates that for the angles formed and according to the spherical surface there are two rings that catch each other on the teeth, while the other rings will do the same in pairs according to the angle sequence constructed by two surfaces. Therefore, referring to the preceding part descriptions can be modeled that a series of Boolean functions will represent a link between the rings of two surfaces, whereas the parallel shaped Boolean function represents a sequence of m of meshed ring of two surfaces. Suppose there are n rings on a surface, written c_{S1i}, $i = 1, 2, \ldots, n$, on the other surface expressed by c_{S2i}, $i = 1, 2, \ldots, n$. If there are m interlocked rings of both surface then in general

$$T = \Sigma_{i=1}^{m} c_{S1i} c_{S2i} \tag{10}$$

From the middle ring of the surface to the edge rings, the m coupling of the linked pair can use the above equation. Based on the model formed, it can be stated that this pairing resulted in an incision on each pair of links, resulting in a series relationship between the sequences that are formulated into

$$T = \prod_{j=0}^{n-m} \Sigma_{i=1+j}^{m+j} c_{S1i} c_{S2i} \tag{11}$$

As example, $n = 5$ rings on each surface and there is a sequence of $m = 2$ interlocked rings, serial and parallel series can be modeled as follows

$$\begin{aligned} T &= \textstyle\prod_{j=0}^{3} \Sigma_{i=1+j}^{2+j} c_{S1i} c_{S2i} \\ &= (c_{S11}c_{S21} + c_{S12}c_{S22})(c_{S12}c_{S22} + c_{S13}c_{S23})(c_{S13}c_{S23} + c_{S14}c_{S24}) \\ &\quad (c_{S14}c_{S24} + c_{S15}c_{S25}) \\ &= T_0 T_1 T_2 T_3 \end{aligned} \tag{12}$$

i.e. it is $T_j = \Sigma_{i=1+j}^{2+j} c_{S1i} c_{S2i}$, $j = 0, 1, 2, 3$.

Enumeration of each T_j can be done by stating the configuration in progress, for example for T_1 as follows

(i) Write the success function for configuration, done by enumerating success path. Both c_{S11} and c_{S21} or c_{S12} and c_{S22} work, thus

$$T = (c_{S11}c_{S21} + c_{S12}c_{S22}) \tag{13}$$

or

$$T = vw + xy. \tag{14}$$

(ii) Map the success functions for the multi-functional machine.

(iii) Rearrange and merge the function of success into an event of mutual. It produces the function

$$T = vw + \overline{v}xy + v\overline{w}xy. \tag{15}$$

(iv) Determine the reliability functionality based on Eqs. (4), (6) and (10), i.e. the reliability function for the system

$$\mathcal{R}(T) = \mathcal{R}(vw) + \mathcal{R}(\overline{v}xy) + \mathcal{R}(v\overline{w}xy). \tag{16}$$

Then, this equation is changed by tribe depending on whether the component fails freely or is bound. Assume that the dependency and subsequently raised in the following facts

$$P_x = \mathcal{R}(x) \tag{17}$$

and

$$Q_x = 1 - \mathcal{R}(x) \tag{18}$$

Thus the reliability function of (13) can be rewritten as

$$\mathcal{R}(T) = p_v p_w + q_v p_x p_y + p_v q_w p_x p_y. \tag{19}$$

Reliability values can be expressed as the opportunity of each yeast to successfully perform the interconnection between the two rings in the same direction of movement, and all the values with the rings with the rings can be substituted into the above equation. To obtain the overall system reliability from the same application robot hand from Eq. (13) to Eq. (15) can be repeated as much as T_j, $j = 0, 1, 2, \ldots, nm$.

5. Conclusion

The lever's reliability model of the multi-functional engine is formulated on the basis of the interface between the rings of two surfaces, the direction of motion, and the angle formed between two rounded surfaces. A freely two-degree canonical form represents the interconnection between rings occurring on two rings on each surface, resulting in series and parallel relationships, thus formulations can be expressed in terms of truth values and then can be amenable after determining their combinations based on mapping.

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