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Research paper

Isolation of Vibration Induced in Drive Type Voith Schneider Propeller due to Rotation of Cycloidal Drive

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Abstract

In this paper experimental modal testing was present for propulsion drive type Voith Schneider Propeller, deconvolution used to decrease the effect of vibration stresses generated by the rotation of cycloidal drive (Voith Schneider Propeller) especially the sing phenomenon also reduce the effect of vibrational critical speeds and to avoiding matching between the frequencies of ship hull and equipment and propeller frequencies with frequency of rotational torque. Reach the reason zone over the maximum velocity by controlling the variables with high accuracy. Experimental testing of Voith Schneider Propeller without structural damping shows a rise in vibration more than in the case of structural damping. When comparing the angles of the blades propeller 90° and 120°, it was concluded that when the blades propeller 90° is the highest vibration of 120°. The reason for this is because angle 120° forces are analyzed into two vertical and horizontal components. Predictive deconvolution which is a filtering process which removes a wavelet from the recorded seismic trace by reversing the process of convolution. Suppresses multiple reflections and optionally alters the spectrum of the input data to increase resolution. The commonest way to perform deconvolution is to design a Wiener filter to transform one wavelet into another wavelet in a least-squares sense. By far the most important application is predictive deconvolution in which a repeating signal
Good results lead for precise, safe and efficient maneuvering.

Keywords: *Deconvolution, Cycloidal Drive, Propellers, Spectrum*

Nomenclature

$x(t)$ Input
$h(t)$ Unit impulse response
$y(t)$ Output
τ Period
F Force N
t Time sec
Δ Nabla
δ Kroniker delta
g Impulse response
λ Lam´e parameters

1. Introduction

With the ascent of ship speed and size, vibration of shipboard turns into an expansive consideration in the development and plan of the boats. Ship of unreasonable vibration is to be maintain a strategic distance from for gathering compartments and team comfort. Other than bothersome impacts of clamor, ship of unnecessary vibration may do come about at the weakness disappointment from glitch or auxiliary individuals from harm and apparatus [1].

Today cycloidal drive are being used everywhere throughout the world wherever exact, wellbeing and productive moving. The propeller is made out of a progression of sharp edges with a streamlined aerofoil area syllable that slips vertically to the base of the body of the vessel and pivots around a vertical hub where the edges are focused on a round hub rotating around a focal focus hub. The cutting edges associate with it by methods for which it sways around its hub to give the essential push bearing.
With a specific end goal to meet the required wellbeing necessities specifically and moving prerequisites are utilized for vessels containing Voith Schneider Propellers (VSP) and Variable Pitch Propeller. The Voith Schneider Propeller is Unique in the vertical pivot of turn. To Generating the impetus compel is done through the propeller sharp edges adjusted and oscillator. The Voith Schneider Propeller (VSP) consolidates directing and impetus in unit of one [2].
Despite the many advantages of VSP, but because of the movement of blades with water and other parts causes interference waves and produces a high sound that harms the staff and crew and affects the comfort of passengers this phenomenon is known as convolution. Noise and vibration levels are dictated by the attributes of source, transmission and receptor. Low recurrence commotion and vibration (say, up to a couple of hundred Hz) are famously difficult to sodden and expansion of mass and firmness in the 'therapeutic' outline organize is exorbitant and bulky, if at all conceivable. Accordingly, commotion and vibration issues must be maintained a strategic distance from through ID and treatment of the significant sources amid early outline phases of the vessel. The treatment is done by placing a filter of type wiener,

where it will clean the waves and take out a clean signal and thus reduce the vibration this phenomenon is known as deconvolution [3].

1.2 Voith Schneider Propeller

The Voith Schneider Propeller (VSP) additionally called a cycloidal drive (CD) moves push toward every path. It is constantly factor, a quick and precise ship drive framework additionally joining directing and impetus in unit of a solitary. VSP supplier vessels needn't bother with rudders. Controlling powers and push amongst most extreme and zero can be made toward any path [4].
The marine cycloidal propeller comprises of a solitary consolidated drive and directing unit. A round circle with various sharp edges opposite to the plate pivots at the base of the vessel. Every last one of the cutting edge can exclusively controlled. The size and heading of push is dictated by the rotational speed of the circle, the edge point, ship's speed and so on. The marine cycloidal propeller cutting edges are settled at one edge by a pole with the goal that it can be pivoted about the pole hub [5].

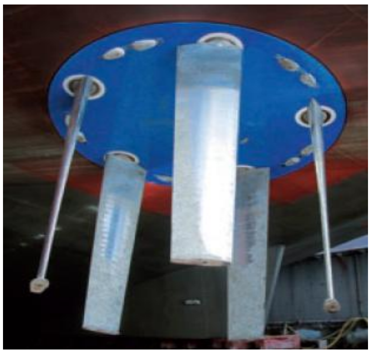


Fig. 1: Voith Schneier Propeller

2. Convolution Excitation

Ships in the seas are exposed to waves of convolution that affect safety and security and increase the vibration that harms crew and passengers. The convolution basic considered as the best scientific to express of the physical procedure this procedure can happen by embedding contribution on a straight framework to deliver yield. On the off chance that $x(t)$ is the info, $h(t)$ is the unit drive reaction of the framework and, $y(t)$ is the yield, at that point persistent time convolution is uncovered by the accompanying vital:

$$y(t) = x(t) * h(t) = \int_{-\infty}^{+\infty} x(\tau)h(t-\tau)d\tau \qquad (1)$$

Think about a discretionary excitation $F(t)$ for example, that delineated in **Fig.5**, and concentrate on the commitment to the reaction of a motivation relating to the time interim $\tau < t < \tau + \Delta\tau$. Accepting that the time increase Δτ is adequately little

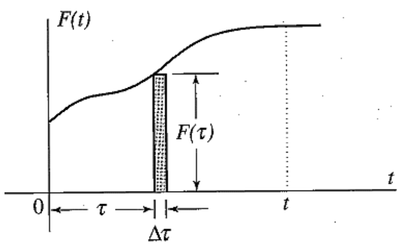


Fig. 5: Arbitrary excitation

Impulsive force having the form

$$\hat{F}(\tau)\delta(t-\tau) = F(\tau)\Delta\tau\delta(t-\tau) \qquad (2)$$

Yet, as appeared in **Fig. (6)**, the reaction of a straight time-invariant framework to the imprudent power given by Equation (2) is just

$$\Delta x(t.\tau) = F(\tau)\Delta\tau\delta(t-\tau) \qquad (3)$$

$g(-\tau)$ is the drive reaction deferred when interim τ. At that point, in regards to the excitation $F(t)$ as a superposition of rash powers, one can estimated the reaction by composing

$$x(t) = \sum_{\tau} F(\tau)\Delta\tau g(t-\tau) \qquad (4)$$

In the breaking point, as $\Delta\tau \to 0$, first type of convolution vital supplant the summation by reconciliation and acquire the correct reaction

$$x(t) = \int_0^t F(\tau)g(t-\tau)d\tau \qquad (5)$$

Condition (5) is known as the convolution fundamental, and communicates the reaction as a superposition of motivation reactions. Therefore, Equation (5) is likewise alluded to now and again as the superposition indispensable.

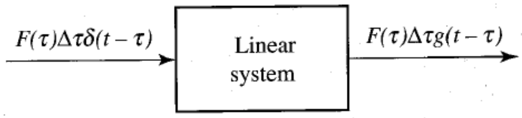


Fig. 6: Block diagram relating the response to an excitation in the form of an impulse of magnitude $F(\tau)\,\Delta\tau$

To determine the second form of the convolution basic, we present a change of factors from τ to λ, as takes after:

$$t-\tau=\lambda.\ \tau=t-\lambda.\ d\tau=-d\lambda \qquad (6)$$

Which requires the adjustment in as far as possible

$$\tau=0 \to \lambda = t \text{ and } \tau = t \text{ if } \lambda = 0 \qquad (7)$$

Presenting Equations. (6) and (7) in Equation (5), get

$$x(t) = \int_t^0 F(t-\lambda)g(\lambda)(-d\lambda) = \int_0^t F(t-\lambda)g(\lambda)\,d\lambda \qquad (8)$$

Which is the second type of the convolution indispensable. Perceiving that τ in Equation (5) and λ in Equation (8) are minor sham factors of joining, one can consolidate Equations. (5) and (8) into [6]

$$x(t) = \int_0^t F(\tau)g(t-\tau)d\tau = \int_0^t F(t-\tau)g(\tau)\,d\tau \qquad (9)$$

2.1 Deconvolution

Deconvolution is a separating procedure which expels a wavelet from the chronicled seismic follow by switching the procedure of convolution. The commonest approach to perform deconvolution is to outline a wiener channel to change one wavelet into another wavelet in a slightest squares sense. By a long shot the most vital application is prescient deconvolution in which a rehashing signal (e.g. primaries and products) is formed to one which doesn't rehash (primaries just). Prescient deconvolution smothers different reflections and alternatively adjusts the range of the information to expand determination.

It is quite often connected at any rate once to marine seismic information. Deterministic deconvolution can be utilized to expel the impacts of the account framework, if the framework qualities are known. This compose additionally can be utilized to expel the ringing that outcomes from waves experiencing different bobs in the water layer, if the movement time in the water layer and the reflectivity of the ocean bottom are known .

Deconvolution used to diminish the impact of vibration stresses created by the revolution of cycloidal drive (Voith Schneider Propeller) particularly the sing phenomenon likewise lessen the impact of vibrational basic speeds and to abstaining from coordinating between the frequencies of ship frame and hardware and propeller frequencies with recurrence of rotational torque. Achieve the reason zone over the most extreme speed by controlling the factors with high accuracy [7].

3. Experimental Work

Albeit high devotion PC reproductions can incorporate numerous subtle elements and give exact evaluations, it is important to perform analyses to tune a model and in addition to confirm numerical models. The model was manufactured in the engineering workshops of the University of Thi-Qar College of Engineering after drawing in the Sold work program 2014. The material used was aluminum as shown Table 1 shows the properties of aluminum. Where a six blades propeller was manufactured as shown in Fig. 2, which was designed and manufactured for vessels that needed safe maneuvering and orientation without the need for rudder. The first series of tests was carried out on propeller, which contains six blades with an angle of 90° with horizontal. The second series of tests is carried out on propeller, which has six blades at angle 120° with horizontal.

Fig. 2: Manufacturing model

Table 1: Characteristic properties of aluminum

3.1 Perform the Test on the Propeller

The tests were carried out to measure vibration in the College of Engineering University of Babylon for lack of equipment in the University of Thi-Qar, then measuring the vibration in the case without any wiener filter without insulation to reduce the vibration and with wiener filter as shown in Fig.3, at a speed of rotation 150RPM and the effect of sea water on the blades of the propeller. Three sensors were connected to angles $0^\circ.90^\circ$ and 180° on the base, where the signal is received by a NI 9234 Module with 1-slot NI Compact DAQ Chassis device in which the sensors are connected and then connected to the computer to save the information and subsequently analyzed. The number of blades used was 6 with an angle of 90° with the horizontal direction. The test was repeated on six blades but at 120° angle with the horizontal direction as shown in Fig.4.

Fig. 3: Place a damping between the propeller and the base

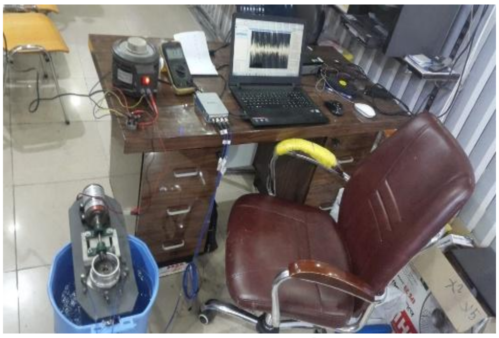


Fig. 4: Test procedure

4. Results and discussion

The propeller will face the vibrations of the water waves (convolution) during work.These vibrations will cause noise, weakness and stresses in the metal propeller over time because of the movement of the blades of the propeller with water, this causes high vibration and may cause damage, particularly in the axes of small diameters.The results are divided into two parts:

4.1 Angle of Propeller Blade 90°

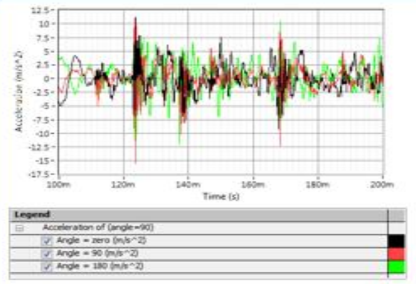
The response was measured by acceleration and amplitude over time.

Table 2: damping ratio and natural frequency at angle of propeller blade 90° without wiener filter

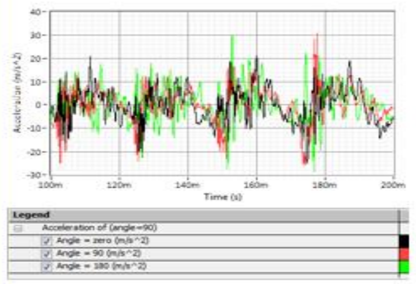
Angle	Damping ratio	Natural frequency
0°	0.3489	8.126
90°	0.1725	6.314
180°	0.0982	6.004

Table 3: damping ratio and natural frequency at angle of propeller blade 90° withwiener filter

Angle	Damping ratio	Natural frequency
0°	0.3616	8.986
90°	0.1987	6.579
180°	0.144	6.034



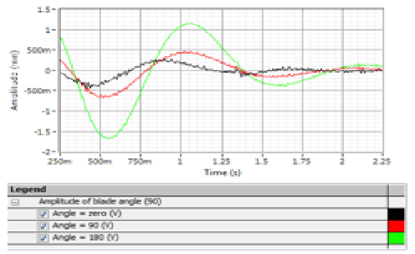
(a) With wiener filter



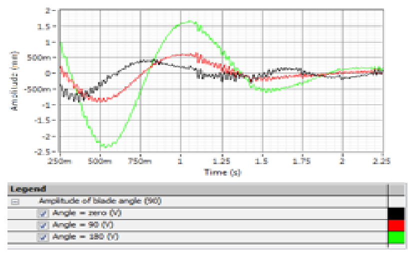
(b) Without wiener filter

Fig. 7: Relation between acceleration and time of VSP with 150 RPM by angels $0^\circ . 90^\circ . 180^\circ$

Fig.7 Shows the response angles $0^\circ . 90^\circ$ and 180° representing the sensors that have been connected to the system to measure acceleration where it was observed that the highest response at angle 90° reaches (30 m/s^2) at time (175ms. While the wiener filter mode is observed, the acceleration will decrease significantly at all angles. Where the position of the filter, which is similar to damping, leads to the success of equilibrium at all speeds. This does not result in a frequency match



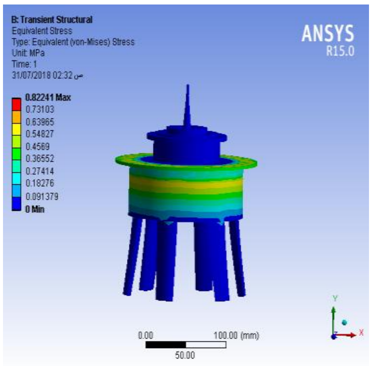
(a) With wiener filter



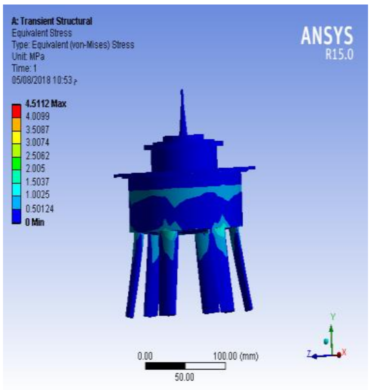
(b) Without wiener filter

Fig. 8: Relation between amplitude and time of VSP with 150 RPM by angels $0^\circ . 90^\circ . 180^\circ$

Fig.8 Illustrations the relationship between time and amplitude where observe in the absence of wiener filter the response is irregular and the highest amplitude at angle 180° is (1.7mm) at time (1.1sec)while the angle 0° and 90° are less vibration. In the event of a wiener filter, the vibration will decrease at all angles and become more regular. If the frequency of the external forces coincides with one of the natural frequencies of the system, the resonance phenomenon is liable to lead to a high amplitude vibration. Then it is possible to break the blades of propeller.



(a)



(b)

Fig. 9: Equivalent (von-Mises) stress at 150 RPM (a) with structural damping. (b) without structural damping.

Fig.9 shows Equivalent (von-Mises) stress that occurs in the propeller where it is in a state without structural damping higher than it is in the case of structural damping. The reason for this is that the propeller is exposed to several stresses, including torsion vibration due to fatigue, axial vibration, lateral vibration and longitudinal vibration. These vibrations arise from several forces, including torque during rotation or because of axial forces generated in the axisor due to the deviation of the axis of rotation in the spin-off direction of the axis of rotation, it is possible have number the critical velocity and others. The rotary axis when accompanied by a side resonance when the vibration is in the case of critical swirling frequencies. The number of swirling frequencies can be based on the forces and the generated power

4.2 Angle of propeller blade 120°

Table 4: damping ratio and natural frequency at angle of propeller blade 120° without wiener filter

Angle	Damping ratio	Natural frequency
0°	0.1754	9.117
90°	0.1065	7.706
180°	0.0455	7.314

Table 5: damping ratio and natural frequency at angle of propeller blade 120° with wiener filter

Angle	Damping ratio	Natural frequency
0°	0.6805	10.629
90°	0.5356	9.320
180°	0.4099	7.569

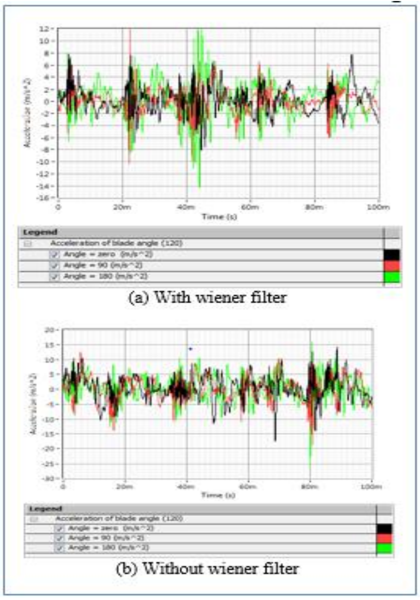


Fig. 10: Relation between acceleration and time of VSP with 150 RPM by angels $0^\circ.90^\circ.180^\circ$

Fig. (10) shows the response angles when the angle of the blades propeller of 120° where notice a significant reduction in acceleration than when it is the angle the blades propeller 90°. The response angle 180° highest acceleration is ($16m/s^2$) at time (81ms).While when setting the wiener filter notice a decrease in acceleration at all angles.

Table 6: Damping levels and their associated frequency ranges

Frequency (Hz)	Damping (Percentage Of Critical)
0-5	1
5-20	1 – 3 by linear interpolation
20 and above	3

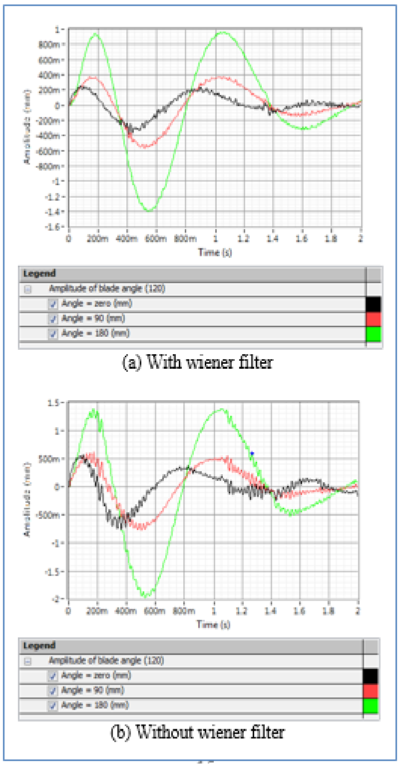
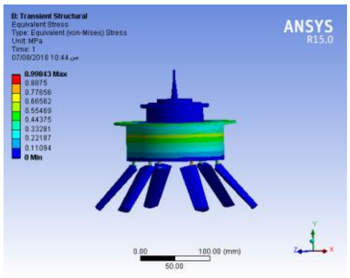
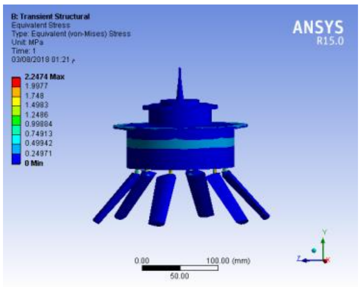


Fig. 11: Relation between amplitude and time of VSP with 150 RPM by angels $0^\circ.90^\circ.180^\circ$

In Fig. (11) above the response at angle 180°, the highest amplitude at time (1.1sec) is (1.4mm), The amplitude response decreases at angles 0° and 90° when non placing wiener filter.



(a)



(b)

Fig. 12: Equivalent (von-Mises) stress at 150 RPM (a) with structural damping. (b) without structural damping.

Fig.12 shows Equivalent (von-Mises) stress where the results showed that the distortion at the angle 90° higher than the angle 120°, because the concentration of stresses increases at the angle 90°.In addition to the previous factors mentioned in the case inclination angle of propeller blade 90°.

5. Conclusions

In this paper experimental modal testing is carried out for Voith Schneider Propeller, the aim of the work was to dampen the vibrations clean the waves and show a clean signal to avoid overlapping waves that cause noise by placing a wiener filter between the propeller and the base. A filter is a device or process that removes some unwanted components or features from the signal. Experimental testing of Voith Schneider Propeller without wiener filter shows a rise in vibration more than in the case of wiener filter. The wave of convolution may lead to the phenomenon of cavitation, which means the rapid destruction of the walls and surfaces of the areas located in the area of influence of this phenomenon. This leads to the generation of unbalanced forces in the blades of the propeller and the natural frequency of the propeller with the frequency of torque occurs, leading to the entry of propeller to the critical speed zone as a result, vibrations occur and may be transmitted to the hull in full and noticeable form. The occurrence of the critical velocity of the entire rails will result in a fracture of the blades from a region close to the navel. Or that the vibration of the propeller is unacceptable because it is a source of noise, the turbulent flow also raises the blades of the propeller, causing a sing. This vibration may generate a range of audible frequency which produces a sound capable of harassing the ship's crew by fully vibrating the body. The state of sing can be attributed to the phenomenon of cavitation or increase the movement of circulating water near the propeller troubled and these reasons can be avoided by making the edge and end of the feather with a small thickness or increase the depth of propeller or reduce the speed of propeller. When comparing the angles of the blades propeller 90° and 120°, it was concluded that when the blades propeller 90° is the highest vibration of 120°.The reason for this is because angle 120° forces are analyzed into two vertical and horizontal components. This reduces vibration but cannot be eliminated permanently.

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