

# **Influence of induction motorcycle in electricity generator which involved stated turbine protection reviewed by characteristic vibration and time domain**

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**Abstract.** Study of vibration characteristics of an induction motor that is not controlled and is not closely monitored and regularly adversely affects the vibration and the impact on comfort and engine life. This study aims to investigate the characteristics of vibration on electric-driven generator steam turbine at PT. Perkebunan Nusantara III (PTPN III) Rambutan Tebing Tinggi. The object of research is protected steam turbine engine palm oil processing factory company PTPN III Rambutan Tebing Tinggi. The results of this study show from both the point of measurement at engine speed rpm compared 4800, 4900, and 5000 obtain that the vibration velocity is highest at 120 seconds, 5000 rpm rotation vertical direction at the point G1. ISO 10816-3 standard for velocity on the highest vibration response measurements at two measurement points on the position of the engine cradle generator of  $0.650 \times 10^{-6}$  m/s Zone A is green, the vibration of the engine is very good and below the allowable vibration.

## **1. Introduction**

The development of technology in the present is very rapidly developed. Many methods are used to determine the feasibility of a tool to be used. One of them is a very noticeable vibration system to find out whether the machine is still good or comfortable to use. Vibration is one effect that occurs due to the motion caused by differences in pressure and frequency. Vibrations that occur in steam turbines have certain requirements / standards. Vibration engine or vibrating engine is the movement back and forth from a working machine or a machine component. Thus, any component that moves back and forth or oscillates is called vibrating. A machine component can vibrate strongly, small, sooner or later, or silently and heat. The use of steam turbine tools and machinery can prevent problems of comfort, health and safety [1, 2, 3].

Convenience of work can control the incidence of work fatigue (fatigue and saturation). This can be achieved through the suitability of the size of equipment and machines with the condition of the operator's body size, mechanical vibrations that can be muffled, flexibility of motion of tools and machines. Whereas occupational health is aimed at the employment of workers or the public to attain the highest level of health, physical or mental as well as social, by preventive and curative efforts, to disease/ disorder-health disorders caused by occupational factors and work environment [4].

Work safety is aimed at avoiding work accidents. According [4], accidents may occur due to the actions of a person who endangers or exposure to tools and machines in a state of danger. The provision of protective devices as a guard around the moving parts should be



carefully considered [5]. The issues of comfort, health, and safety on the use of agricultural machinery and equipment are a serious concern for human factors in the design of tools and machinery. It is learned in Ergonomics derived from Greek, i.e. *ergon* meaning work and *nomos* which means rule [6]. Ergonomics studies the design of a system in which humans are involved. All work systems consist of human components and machine components in a local environment. Ergonomics include mechanical noise and vibration problems.

In this study an induction motor from a steam protected steam turbine generator operating at 4800 rpm engine speed, 4900 rpm and 5000 rpm, at the PTPN III palm oil mill. Where the effect of the engine speed and mechanical vibrations occurring on the induction motor can be known based on the vibration that arises, whether it is still in accordance with the limits of the engine vibration which is good or still within the limits of tolerance allowed.

Vibration measurement is one way that can be done to monitor the comfort level within the company and further with the vibration analysis can be accurately known in case of interruption during the operation. Therefore, researchers want to analyze the induction motor rotation on electric generator driven steam turbine reviewed based on the characteristic of vibration based on time domain. From the background of the above situation then it is deemed necessary to do a research of induction motor rotation on electric generator driven steam turbine.

## 2. Research Methods

The subject of the research is an induction electric generator motor in a steam protected turbine. This research was conducted on June 27, 2016 in PKS PTPN III Rambutan - Tebing Tinggi, North Sumatera. The mechanical vibration measurement on the induction motor induction of electric generator on steam turbine is protected based on rotation and time domain using instrument, that is Portable Vibrometer Digital Handheld 908B. The measured mechanical vibration parameters are acceleration, velocity, and displacement. Measurements were made by installing the sensor device on the induction motor stand in two directions, then observed and recorded the figures shown and the data analyzed. In this research the subject of research is induction motor generator on protected steam turbine.

## 3. Result and discussion

Data retrieval system testing is done to measure how much the response of generator vibration that arises in the delivery of induction motor speed 4800 rpm and 4900 rpm, at the palm oil mill PTPN III. Data taken from this variation of engine speed is measured at four points of measurement at 2 points on the steam turbine generator stand as shown in figure 1.



**Figure 1.** Variation of engine speed is measured at four points of measurement that is at 2 points on the steam turbine generator stand.

Vibration frequency calculation results are presented at table 1. The measurement results at point G1 of the steam turbine generator vibration response  $n = 4800$  rpm, in the horizontal and vertical directions.

The price of vibration response in table 1 to table 5 is the average price obtained from direct measurement and calculation results using the deviation formula, velocity and acceleration

**Table 1.** Result of direct measurement

No	Time (s)	G1 Round Point 4800 rpm					
		Horizontal			Vertical		
		Dis ( $\mu m$ ) X	Vel (cm/s) $\dot{X}$	Acc (cm/s <sup>2</sup> ) $\ddot{X}$	Dis ( $\mu m$ ) X	Vel (cm/s) $\dot{X}$	Acc (cm/s <sup>2</sup> ) $\ddot{X}$
1	20	0.021	0.480	2.300	0.02	0.370	2.300
2	40	0.022	0.500	2.255	0.029	0.430	2.255
3	60	0.018	0.510	2.245	0.027	0.410	2.235
4	80	0.022	0.530	2.235	0.029	0.380	2.225
5	100	0.024	0.520	2.175	0.027	0.400	2.175
6	120	0.022	0.590	2.225	0.025	0.350	2.225
7	140	0.025	0.500	2.200	0.023	0.370	2.220
8	160	0.022	0.540	2.215	0.028	0.350	2.215
9	180	0.018	0.510	2.220	0.025	0.450	2.220
10	200	0.016	0.530	2.200	0.027	0.370	2.215
11	220	0.021	0.520	2.098	0.022	0.350	2.098
12	240	0.018	0.550	2.145	0.025	0.390	2.145
13	260	0.019	0.580	2.155	0.028	0.410	2.155
Average		0.020	0.528	2.205	0.025	0.387	2.206

Angular velocity for each direction can be calculated from table 1 namely:

1. Horizontal Direction

$$\text{The angle velocity : } \varpi = \sqrt{\frac{\ddot{x}}{x}} = \sqrt{\frac{2.205 \times 10^{-2} \text{ m/s}^2}{0.020 \times 10^{-6} \text{ m}}} = \sqrt{1102} = 1050 \text{ rad/s}$$

$$\varpi t = \arctan \frac{x \varpi}{\dot{x}} = \arctan \frac{0.020 \times 10^{-6} \text{ m} \times 1050}{0.528 \times 10^{-2} \text{ m/s}} = 0.227 \text{ rad}$$

$$\text{So obtained period : } t = \frac{\varpi t}{\varpi} = \frac{0.227}{1050} = 0.000216 \text{ s.}$$

$$\text{Amplitude: } A = \frac{x}{\sin \varpi t} \rightarrow A = \frac{0.020 \times 10^{-6} \text{ m}}{\sin 1050.0,000216 \text{ s}} = 5.052 \times 10^{-6} \text{ m}$$

**Tabel 2.** Angular Direction

	Direction	
	Horizontal	Vertical
$\omega$ (rad/s)	1050	939.36
$\omega t$ (rad)	0.227	0.346
t (s)	0.000216	0.000368
A (m)	$5.052 \times 10^{-6}$	$3.397 \times 10^{-6}$

**Table 3.** Amplitude point G2 at n = 4800 rpm

	Direction	
	Horizontal	Vertical
$\omega$ (rad/s)	1050	1359
$\omega t$ (rad)	0.397	1.306
t (s)	0.000378	0.000960
A (m)	$2.887 \times 10^{-6}$	$1.097 \times 10^{-6}$

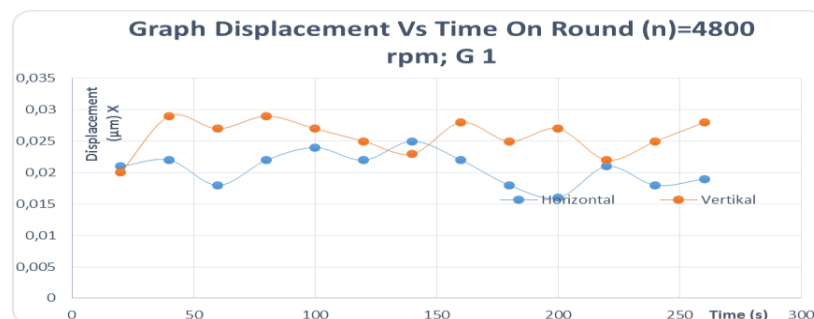
**Table 4.** Amplitude point G1 at n = 4900 rpm

	Direction	
	Horizontal	Vertical
$\omega$ (rad/s)	1059	847.053
$\omega t$ (rad)	0.270	0.243
t (s)	0.000254	0.000287
A (m)	$4.260 \times 10^{-6}$	$2.828 \times 10^{-6}$

**Table 5.** Amplitude point G2 at n = 4900 rpm

	Direction	
	Horizontal	Vertical
$\omega$ (rad/s)	1159	822.90
$\omega t$ (rad)	0.246	0.289
t (s)	0.000233	0.000352
A (m)	$3.819 \times 10^{-6}$	$4.75 \times 10^{-6}$

Vibration calculation results based on deviations, speed and acceleration can be presented in the graph below.

**Figure 2.** The deviation relationship with time at n = 4800 rpm: G1

From figure 2 it can be seen that the deviation in the vertical direction is the highest direction with the price of  $0.029 \times 10^{-6}$  m, whereas the deviation in the horizontal direction is  $0.025 \times 10^{-6}$ . The speed measurement for point G1 with  $n = 4800$  rpm can be in figure 3.

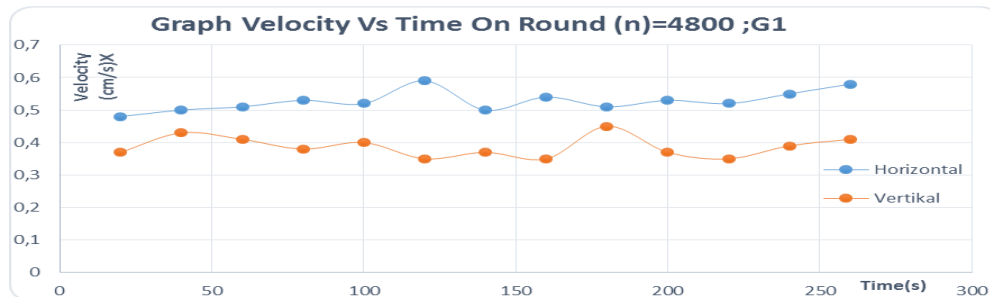


Figure 3. Speed relation with time at  $n = 4800$  rpm G1

From figure 3 we can see the velocity from horizontal direction is bigger with value  $0.590 \times 10^{-3}$  m/s while Vertical direction  $0.450 \times 10^{-3}$  m / s. At acceleration measurement for 4800 rpm rotation point G1 can be depicted in figure 4.

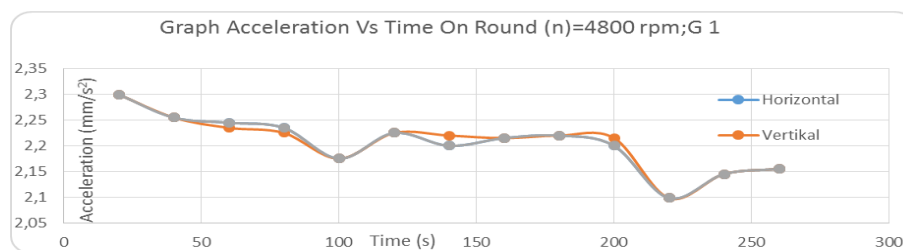


Figure 4. Acceleration Relation with Time at  $n = 4800$  rpm G1

From figure 4 can be seen acceleration of horizontal and vertical direction amount of acceleration almost same.

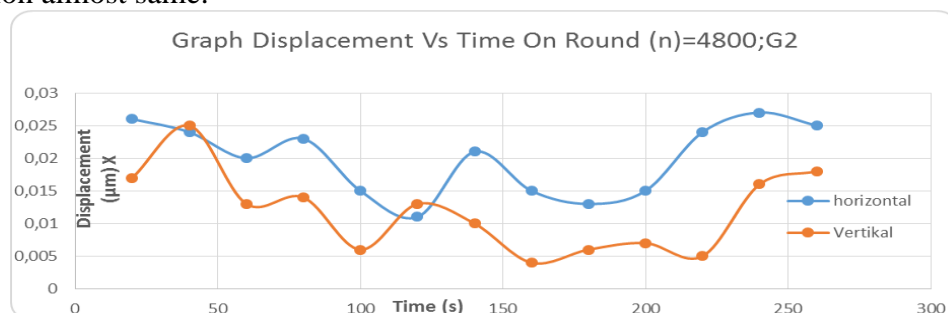


Figure 5. The time-drift relationship at  $n = 4800$  rpm: G2

From figure 5 can be seen that the deviation in the horizontal direction is the highest direction with the price  $0.027 \times 10^{-6}$  m, whereas the deviation in the vertical direction is  $0.025 \times 10^{-6}$ . Measurement speed for point G2 with  $n = 4800$  rpm can be seen in figure 6.

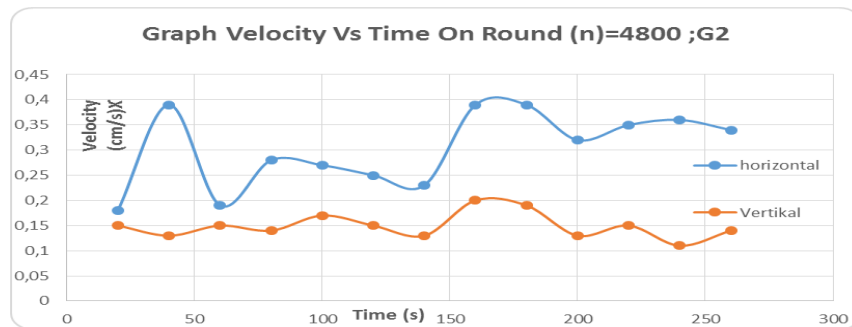


Figure 6. Speed with time relationship at  $n = 4800$  rpm, G2

From figure 6 we can see the velocity from horizontal direction is bigger with value  $0.390 \times 10^{-3} \text{ m/s}$  while Vertical direction  $0.200 \times 10^{-3} \text{ m/s}$ . At the acceleration measurement for G2 point the speed of 4800 rpm can be illustrated in figure 7.

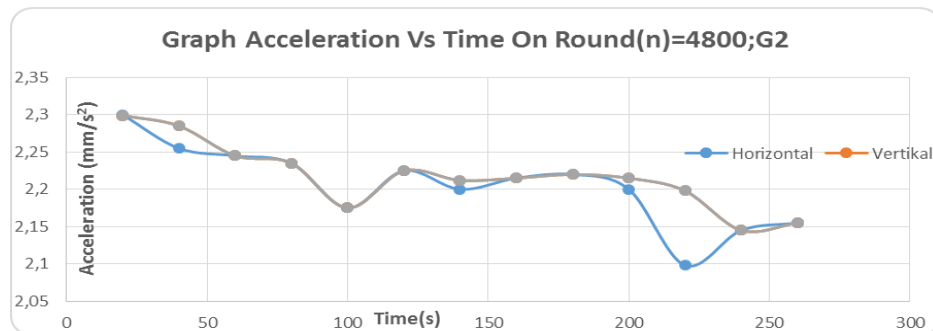


Figure 7. Acceleration relationship with time at  $n = 4800$  rpm G2

From figure 7 we can see the velocity from horizontal direction is bigger with value  $2.300 \times 10^{-3} \text{ m/s}$  while vertical direction  $2.100 \times 10^{-3} \text{ m/s}$

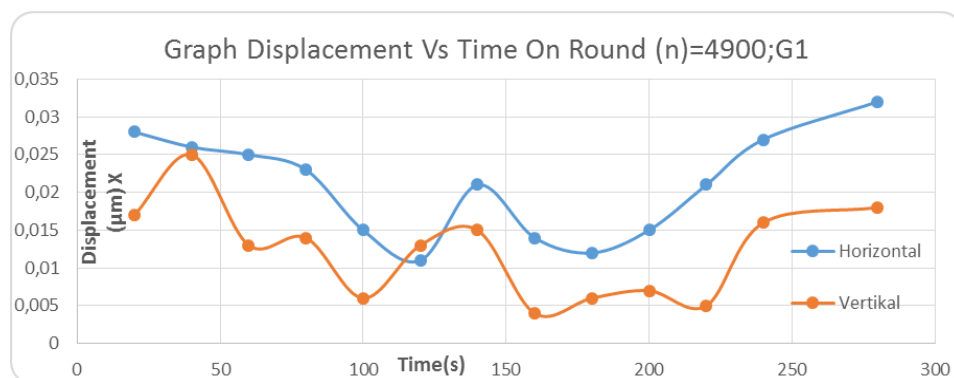
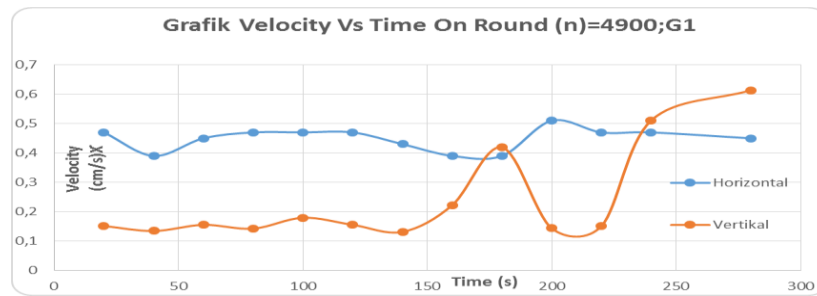


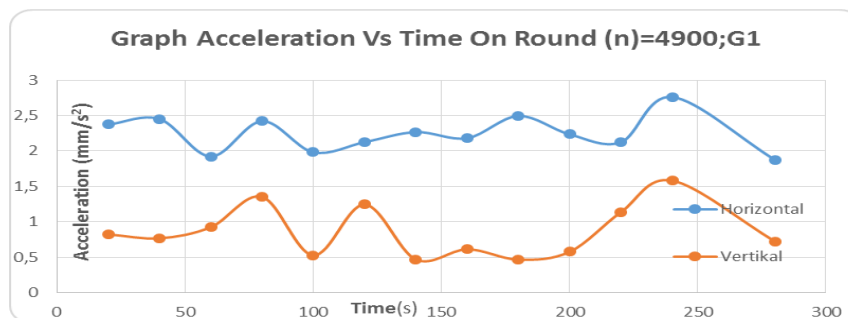
Figure 8. The time deviation relationship at  $n = 4900$  rpm G1

From figure 8 we can see the deviation from the horizontal direction is greater with the value  $0.032 \times 10^{-6} \text{ m/s}$  while the vertical direction is  $0.025 \times 10^{-6} \text{ m/s}$ . On the measurement of velocity for point G1 ( $n = 4900$  rpm) can be described in figure 9.



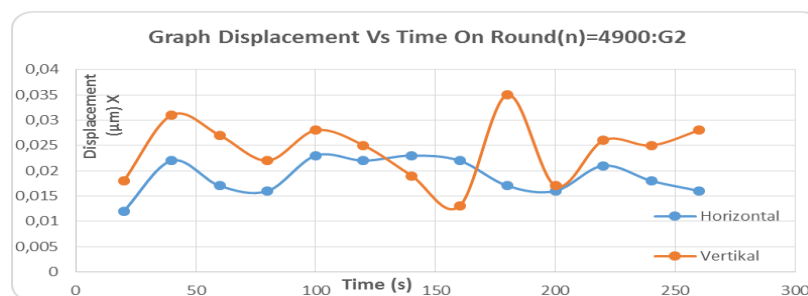
**Figure 9.** Rapid relation with time at  $n = 4900$  rpm G1

From figure 9 can be seen the velocity of the vertical direction is greater with the value of  $0.614 \times 10^{-3}$  m/s while the horizontal direction of  $0.510 \times 10^{-3}$  m/s. At the acceleration measurement for point G1 ( $n = 4900$  rpm) can be depicted in figure 10.



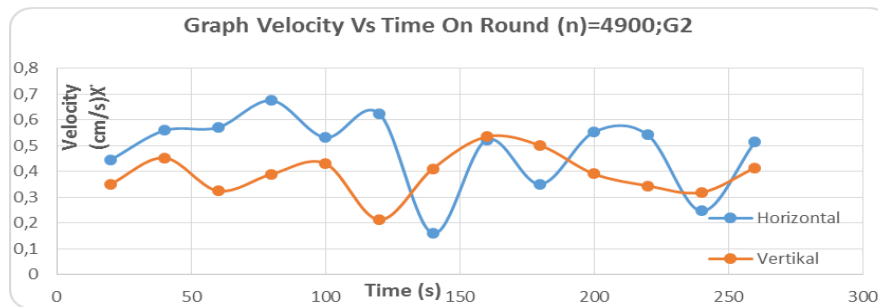
**Figure 10.** Acceleration relationship with time at  $n = 4900$  rpm G1

From figure 10 we can see the velocity of horizontal direction is bigger with value  $2.762 \times 10^{-3}$  m/s while vertical direction  $1.582 \times 10^{-3}$  m/s. At the acceleration measurement for point G2 ( $n = 4900$  rpm) can be illustrated in figure 11..



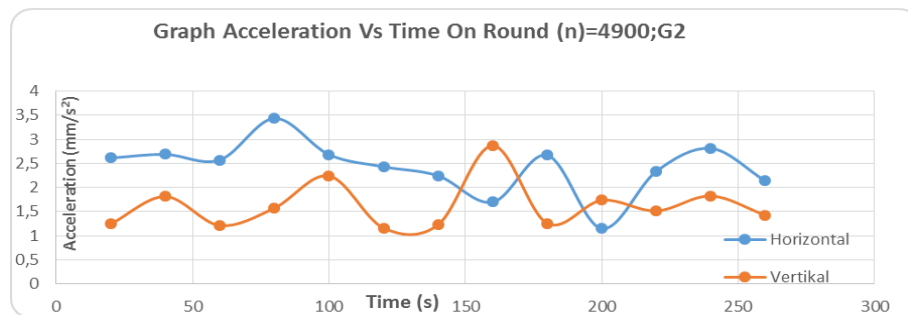
**Figure 11.** The time-drift relationship at  $n = 4900$  rpm G2

From figure 11 can be seen the deviation of the vertical direction is greater with the value  $0.035 \times 10^{-6}$  m / s while the horizontal direction  $0.023 \times 10^{-6}$  m / s. At the measurement of velocity for point G2 ( $n = 4900$  rpm) can be described in figure 12.



**Figure 12.** Rapid relation with time at  $n = 4900$  rpm G2

From figure 12 can be seen Speed of direction Horizontal bigger with value  $0.675 \times 10^{-3}$  m/s whereas vertical direction  $0.535 \times 10^{-3}$  m/s. At acceleration measurement for point G2 ( $n = 4900$  rpm) can be depicted in figure 13.



**Figure 13.** Acceleration relationship with time at  $n = 4900$  rpm G2

From figure 13 can be seen acceleration from horizontal direction is bigger with value  $3.435 \times 10^{-3}$  m/s while Vertical direction  $2.875 \times 10^{-3}$  m/s.

#### 4. Conclusions

The result of analysis based on vibration characteristic and time domain can be concluded as follows:

1. The lowest displacement is  $0.004x$  m at 160 seconds, 4800 rpm rotation vertical direction at point G2, Displacement highest is  $0.031x$  m at 40 seconds, 5000 rpm rotation horizontal direction at point G1
2. The lowest Velocity is 0.110 m/s at 240 seconds, 4800 rpm rotation of vertical direction at G2 point, velocity (highest speed) is 0.650 m/s at 120 seconds, 5000 rpm rotation horizontal direction.
3. Acceleration (acceleration) lowest is  $0.468 \text{ m/s}^2$  at 140 seconds, rotation 4900 rpm vertical direction at point G1.  
Acceleration (acceleration) highest is  $3.40 \text{ m/s}^2$  at 80 seconds round 5000 rpm horizontal direction at point G1.
4. From both measuring points at 4800, 4900, 5000 rpm comparable engine speed is obtained that the highest vibration speed is highest at 120 seconds, 5000 rpm rotation vertical direction at point G1.
5. From the ISO 10816-3 standard for velocity on the measurement of the highest vibration response at two points of measurement at the position of the generator engine holder of



$0.650 \times 10^{-6}$  m/s Zone A is green, the vibration of the machine is excellent and below the allowable vibration.

## 5. References

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