Investigation of Sigma Level at the Stage of Testing Cement after Packing and Improving it using FMEA Approach

Md. Enamul Kabir[1] and Md. Golam Kibria[2]

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Abstract

Sophisticated customer demands and advanced technology have changed the way of conducting business. Financial condition of a manufacturing company largely depends on the defect rate of a product. Understanding the key features, obstacles, and shortcomings of the six sigma method allows organizations to better support their strategic directions, and increasing needs for coaching, mentoring, and training. The objectives of this paper are to study and evaluate processes of the case organization, to find out the current sigma level and finally to improve the existing Sigma level through decreasing defects. According to objectives, current sigma level has been calculated, manufacturing process analyzed and suggestions given for improvement. Especially in analyzing phase different analysis tools like Production Layout, Process Block Diagram, Cause and Effect Diagram, Cheek Sheet, Process control chart are used. FMEA is used as improvement tool. By using this it has been possible to improve productivity by reducing defects rate. This research work has been carried out in a cement manufacturing company to show how to implement Six- Sigma in this type of industry. This research related work does not only apply to cement manufacturing company but also in any other types of organizations. By implementing Six-Sigma a perfect synchronization among cost, quality, production time and control time can be achieved.

Index terms — six-sigma, improvement, process control chart, sigma level, FMEA.

1 Introduction

ix-Sigma is a statistical measurement of only 3.4 defects per million. Six-Sigma is a management philosophy focused on eliminating mistakes, waste and rework. It establishes a measurable status to achieve and embodies a strategic problem-solving method to increase customer. Satisfaction and dramatically reduce cost and increase profits. Six-Sigma gives discipline, structure, and a foundation for solid decision making based on simple statistics. The real power of Six Sigma is simple because it combines people power with process power.

The Six Sigma is a financial improvement strategy for an organization and now a day it is being used in many industries. Basically it is a quality improving process of final product by reducing the defects; minimize the variation and improve capability in the manufacturing process. The objective of Six Sigma is to increase the profit margin, improve financial condition through minimizing the defects rate of product. It increases the customer satisfaction, retention and produces the best class product from the best process performance. If an organization is focused on customer satisfaction, then Six Sigma will offer a method and some tools for the identification and improvement of both internal and external process problems to better meet customer needs by identifying the variations in organization's processes that might influence the customer's point of view, negatively.

2 II.

3 Literature Review

Though Fredrick Taylor, Walter Shewhart and Henry Ford played a great role in the evolution of sixsigma in the early twentieth century, it is Bill Smith, Vice President of Motorola Corporation, who is considered as the Father of Six-sigma. Fredrick Taylor came up with the methodology of breaking systems into subsystems in order to increase the efficiency of manufacturing process. Henry Ford followed his four principles, namely continuous flow, interchangeable parts, division of labor and reduction of wasted effort, in order to end up in an affordable priced automobile. The development of control charts by Walter Shewhart laid the base for statistical methods to measure the variability and quality of various processes.

Later during the 1950s, the Japanese Manufacturing sector revolutionized their quality and competitiveness in the world based on the works of Dr. W. Edwards Deming, Dr. Armand Feigenbaum, and Dr. Joseph M Juran. Dr. W. Edwards Deming developed the improvementcycle of 'Plan-Do-Check-Act', better known as the PDCA cycle. Dr. Joseph M Juran gave to the world his 'Quality Trilogy' and it was Dr. Armand Feigenbaum who initiated the concepts of 'Total Quality Control' (TQC). Between 1960 and 1980, the Japanese understood that everyone in an organization is important to maintain quality and so training programs were conducted for almost all employees not considering the department they belong to. Any organization that is dynamically working to build the theme of six-sigma and to put into practice, the concepts of six-sigma, in its daily management activities, with noteworthy improvements in the process performance and customer satisfaction is considered as a six -sigma organization [3].

M. Sokovi?et al. undertook papers to identify areas in the process where extra expenses exist, identify the biggest impact on production expenses, introduce appropriate measurement system, improve process and reduce expenses on production times, and implement improvements [4]. Gustav Nyren represented the variables influencing the chosen characteristics variable and then optimized the process in a robust and repeatable way [5].John Racine focuses on what sixsigma is today and what its roots are both in Japan and in the west and what six-sigma offers the world today [6]. Zenon Chaczkoet al. introduced a process for the module level integration of computer based systems which is based on the Six-sigma Process Improvement Model, where the goal of the process is to improve the overall quality of the system under development [7]. Philip Stephen highlighted a distinct methodology for integrating lean manufacturing and six-sigma philosophies in manufacturing facilities [8]. Thomas Pyzdek focuses that helps the user identify worthy papers and move them steadily to successful completion, the user identify poorly conceived papers before devoting any time or resources to them, the user identify stalled papers and provide them with the attention they need to move forward again, the user decide when it's time to pull the plug on dead papers before they consume too much time and resources and provide a record for the user that helps improve the paper selection, management and results tracking process.

4 III.

5 Methodology

The preface of implementing Six-sigma is very complicated job with several steps, which relates to observe carefully, and concentrating deeply in all of the processes. Data was collected through interviews, discussions and questionnaire. All data were useful here for better understanding the production system. The collected data then interpreted into suitable format for the concerned study. The methodology, which is used in this study, enables to collect valid and reliable information and to analyze those data to conclude with a correct decision. Defects were observed and their root causes were investigated. After getting the existing scenario of the organization, the current sigma level was calculated and then the way to improve this level was analyzed.

IV.

6 Data Analysis and Results

7 a) Process Measurement

In this measurement stage, different variables are identified to measure. As it has been trying to improve the sigma level of the organization, initially the present sigma level has been measured by using an Excel based sigma calculator.

Sigma level is a procedure to know the existing condition of a production shop. The calculation of sigma level is based on the number of defects per million opportunities (DPMO).

In order to calculate DPMO, three distinct pieces of information are required:

i. The number of units produced.

ii. The number of defect opportunities per unit.

iii. The number of defects.

The actual formula is: For this purpose, the relevant data is collected. By using collected data, the defect rate of each process is calculated and converted into the total defects. Moreover, in order to observe the situation better Sigma level is calculated in the final stage of testing cement after packing. After packing that means the final product actually gives the Sigma level of the manufacturing company.

? Sigma level at the stage of testing cement after packing:

No Out of a million opportunities, the long term performance of the process would create 19906.323 defects.

After plotting the required information into sigma level calculator, the calculator shows that the Sigma level at the stage of testing cement after packing is 3.6. Hence, to improve this level, different quality improvement tools have to be employed and the organization has to be set a milestone to achieve.

8 b) Process Analysis

It is a very important stage to consider because lack of proper analysis may lead to the process to a wrong way, which will deviate, from the main function of improvement. In this stage, different basic tools of quality are preferably used to analyze the real condition of the processes.

9 i. Process Block Diagram

To find out the existing problem of a complete production process, it is more preferable to represent the operation sequence by process flow diagram. For this purpose, the operation sequence is analyzed and obtained a chart shown in following figure. A control chart is a graphical and analytic tool for monitoring process variation. The natural variation in a process can be quantified using a set of control limits. Control limits help distinguish common-cause variation from special-cause variation. Typically, action is taken to eliminate special-cause variation and bring the process back in control. Process has seven constraints In this stage, improvement strategies are developed for achieving the desired goal. According to the analysis, perfect measures should be taken to progress the current situation. As the major concern to improve sigma level here in the case organization to improve the productivity, it is highly needed to diagnose the critical issues. For this reason FMEA (Failure Mode and Effect Analysis is used to improve the current situation of the production shop.

10 i. FMEA (Failure Mode and Effect Analysis)

A failure modes and effects analysis (FMEA) is a procedure in product development and operations management for analysis of potential failure modes within a system for classification by the severity and likelihood of the failures. A successful FMEA activity helps a team to identify potential failure modes based on past experience with similar products or processes, enabling the team to design those failures out of the system with the minimum of effort and resource expenditure, thereby reducing development time and costs. In FMEA, failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. A FMEA also documents current knowledge and actions about the risks of failures for use in continuous improvement.

FMEA is used during the design stage with an aim to avoid future failures. Later it is used for process control, before and during ongoing operation of the process. Ideally, FMEA begins during the earliest conceptual stages of design and continues throughout the life of the product or service. And for the Case Organization FMEA chart (Table -8) is given below according to the following three tables-Table 5, 6 and 7. If the recommended actions are followed then the risk priority number will be decreased at desired level as a result defective product will be decreased and hence the sigma level will be improved.

V.

11 Discussions

There were some uncertainties in the validity and reliability of the sampled data that are used in previous to analyze and improving sigma level of the cement manufacturing process. During the study not all, the information has collected instantly, but some previous records have also used for better understanding. The Sigma Level calculated for the case organization at the final stage of finished product is 3.6. From the Six-Sigma value chart it can be concluded that the case organization is an average industry. Analyzing tools is used and it finds out where the maximum and serious defects were in different sections. Then the Cause and Effect diagram determine the root causes of the problems. The check sheet represents defects at daily basis, which helps to find out in which day there were defects. Seven control charts are drawn to specify the process in control or not. The main reason for defective cement is then Compressive Strength. In addition, according to defects then Fineness, Setting time, Residue, Limestone, Slag and Fly ash. By using FMEA (Failure Mode and Effect Analysis), Risk Priority Number (RPN) at different stages of the manufacturing process were determined. From this case study the highest RPN was 320 (Ball Mill) and the lowest RPN was 56 (Packing Machine) in out of 1000. As the RPN increases, it indicates more risks and defects.

12 VI.

13 Recommendations

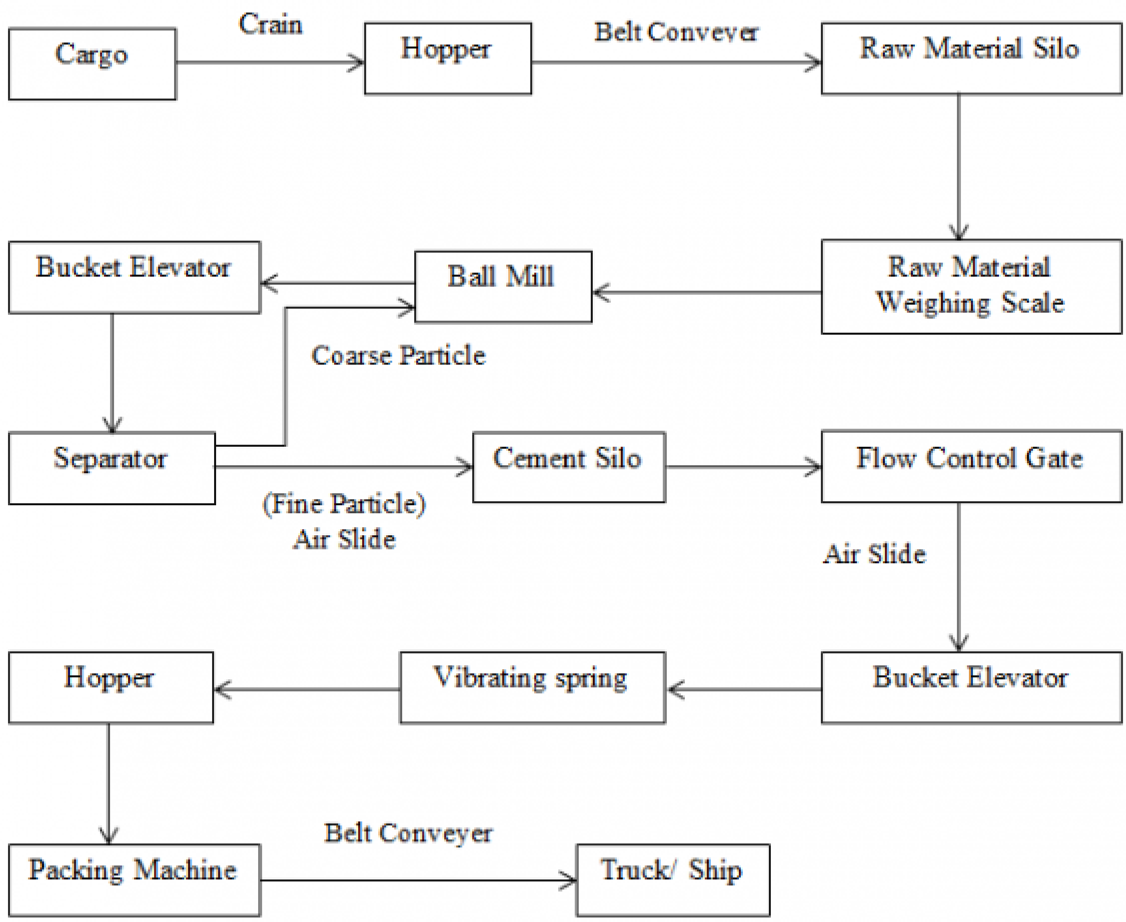
There are several approaches to choose from, when the goal is to increase the sigma level of a cement manufacturing company. The techniques used in this paper have been limited due to insufficient time and resources. In this paper only Process block diagram, Cause and Effect diagram, Cheek sheet, process control chart are used for process analysis. FMEA isused as process improvement neglecting other improvement tool like 5S, Kaizen and Supermarket. An important suggestion for future work is to test if the findings are applicable to other steps of manufacturing and machines within the factory. Moreover, to take customers opinion about the product, this will help to identify the problems and can be solved easily. [1]

Figure 1: DPMO=(

Defects	17
Opportunities	122
Defect Opportunities per unit	7

DPMO	19906.32
Sigma Level	3.6

Figure 2:



122

Figure 3: Figure 1 : 2 Figure 2 :

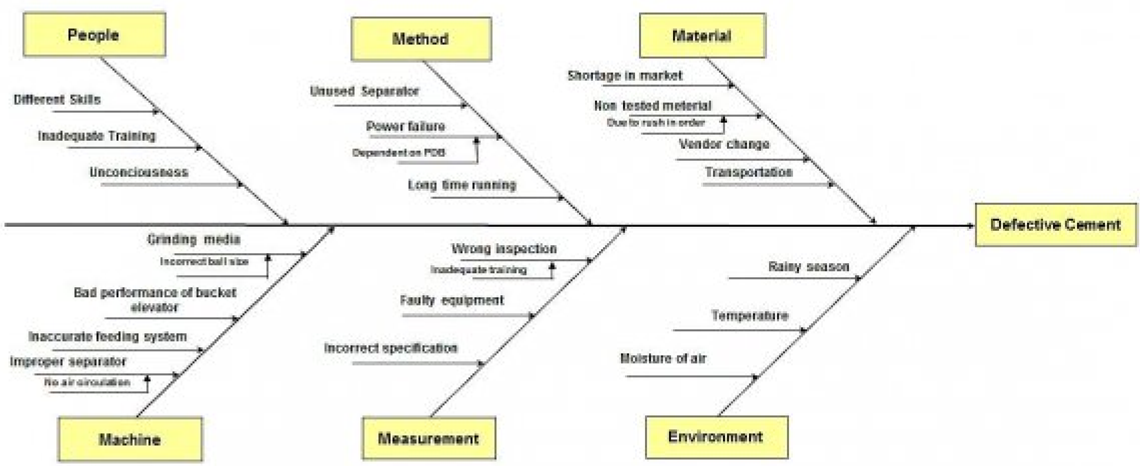


Figure 4: (

Defect	August																														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Fineness																										1						1
Residue			1																													1
Initial setting time																1																1
Final setting time																																
Compressive strength (3 days)																																
Compressive strength (7 days)																																
Compressive strength (28 days)			1																													1
Total			2													1									1							4

Defect	September																													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Fineness																															
Residue																		1							1						2
Initial setting time																															
Final setting time																						1									1
Compressive strength (3 days)							1																				1				2
Compressive strength (7 days)																															
Compressive strength (28 days)																															
3 Total							1											1				1			1		1				5

Figure 5: Figure 3 :

Defect	October																														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Fineness												1																				1
Residue																																
Initial setting time	1																															1
Final setting time								1																								1
Compressive strength (3 days)																																
Compressive strength (7 days)																																
Compressive strength (28 days)					1																											1
Total	1				1			1				1																				4

Defect	November																													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Fineness														1																	1
Residue																				1											1
Initial setting time																															
Final setting time								1																							1
Compressive strength (3 days)																															
Compressive strength (7 days)												1																			1
Compressive strength (28 days)																															
688 Total								1				1		1						1											4

Figure 6: Figure 6 Figure 8 :Figure 8 :

Score	Severity Guidelines	
	AIAG	Sig-Sigma
10	Hazardous without warming	Injure a customer or employee
9	Hazardous with warming	Be illegal
8	Very high	Render product or service unfit for use
7	High	Cause extreme customer dissatisfaction
6	Moderate	Result partial malfunction
5	Low	Cause a loss of performance which is likely to result in a complaint
4	Very low	Cause minor performance loss
3	Minor	Cause a minor nuisance but can be overcome with no performance loss
2	Very minor	Be unnoticed have only minor effect on performance
1	None	Be unnoticed and not affect the performance

Bad

Good

Figure 7:

Score	Occurrence guidelines		
	AIAG	Sig-Sigma	
10	Very high persistent loss Ppk < 0.55	More than one per day	>30%
9	Very high persistent loss Ppk >= 0.55	Once every 3-4 days	< 30%
8	High frequent failures Ppk>= 0.78	Once every week	< 5%
7	High frequent failures Ppk>= 0.86	Once per month	< 1%
6	Moderate occasional failures Ppk >= 0.94	Once every 3 months	< 0.03%
5	Moderate occasional failures Ppk >= 1.00	Once every 6 months	< 1 per 10,000
4	Moderate occasional failures Ppk >= 1.10	Once per year	< 6 per 100,000
3	Low relatively failures Ppk >= 1.20	Once every 1-3 years	< 6 per million
2	Low relatively failures Ppk >= 1.30	Once every 3-6 years	<3 per 10 million
1	Low relatively failures Ppk >= 1.67	Once every 6-9 years	< 2 per billion

Bad

Good

Figure 8:

Score	Detection guidelines	
	AIAG	Sig-Sigma
10	Almost impossible absolute certainty of non-detection	Defect caused by failure is no detectable
9	Very remote controls will probably not detect	Occasional units are checked for detect
8	Remote controls have poor chance detection	Units are systematically sampled and inspected
7	Very low controls have poor chance detection	All units are mutually inspected
6	Low controls may detect	Manual inspection with mistake-proofing modifications
5	moderate controls may detect	Process is monitored (SPC) and manually inspected
4	Moderately high controls have a good chance to detect	SPC is used with an immediate reaction to out of controls condition
3	High controls have a good chance to detect	SPC as above,.100% inspection surrounding out of control conditions
2	Very high controls almost certain to detect	All units are automatically inspected
1	Very high controls certain to detect	Defect is obvious and can be kept from affecting customers

Bad

Good

Figure 9:

Data after Packing for August-2013:

Date	Fineness m^2/Kg	Residue (%)	Setting Time (min)		Compressive Strength (MPa)		
			IST	FST	3 days	7 days	28 days
01-08-13	360	0.7	182	386	15.6	21.5	31.5
02-08-13	365	0.4	186	383	15.9	21.3	32.5
03-08-13	369	1.5	185	395	15.4	20.3	27.5
04-08-13	370	0.7	187	381	16.0	21.8	32.9
05-08-13	362	0.5	189	386	15.8	21.3	31.5
06-08-13	367	0.3	183	397	15.7	21.0	31.9
07-08-13	369	0.8	187	391	15.6	21.0	32.0
08-08-13	361	0.7	189	390	15.4	21.9	33.0
09-08-13	363	0.4	185	380	15.9	20.0	32.8
10-08-13	360	0.9	184	386	16.0	21.6	31.0
11-08-13	368	0.7	186	385	15.2	21.9	30.2
12-08-13	364	1.0	182	389	15.1	21.4	33.0
13-08-13	367	0.9	184	396	15.4	21.5	30.5
14-08-13	361	0.8	187	394	15.2	21.9	30.9
15-08-13	362	0.5	184	382	15.9	20.4	32.1
16-08-13	369	0.1	167	386	15.4	21.5	31.8
17-08-13	363	0.6	189	385	15.8	21.9	30.8
18-08-13	364	0.3	186	387	16.1	21.4	30.9
19-08-13	367	0.8	182	381	15.8	21.6	31.5
20-08-13	362	0.7	184	382	15.6	21.0	32.6
21-08-13	361	0.5	182	396	15.4	21.6	31.5
22-08-13	360	0.7	186	381	15.3	21.5	31.4
23-08-13	370	0.9	183	384	15.0	21.6	32.9
24-08-13	369	0.8	185	385	15.3	20.8	31.5
25-08-13	365	0.5	180	389	15.4	21.6	30.4
26-08-13	374	0.6	189	394	15.8	21.1	30.7
27-08-13	362	0.7	186	386	15.9	21.6	31.9
28-08-13	361	0.3	188	399	16.0	20.7	33.0
29-08-13	360	0.4	190	391	15.4	20.9	31.5
30-08-13	369	1.0	184	395	15.8	21.7	32.9
31-08-13	365	0.8	183	386	15.7	22.0	31.4

Figure 10:

Data after Packing for September-2013:

Date	Fineness m^2/Kg	Residue (%)	Setting Time (min)		Compressive Strength (MPa)		
			IST	FST	3 days	7 days	28 days
01-09-13	364	0.3	180	390	16.2	20.1	33.0
02-09-13	369	0.2	190	395	15.3	21.0	30.6
03-09-13	367	0.4	185	385	15.8	20.3	31.5
04-09-13	367	0.7	189	399	15.1	21.7	32.0
05-09-13	370	0.8	185	396	15.8	21.0	31.5
06-09-13	364	0.5	184	394	15.6	20.8	31.9
07-09-13	365	0.9	186	380	15.3	20.7	32.5
08-09-13	361	0.7	189	382	17.0	21.0	32.8
09-09-13	368	0.6	187	381	15.4	21.4	31.0
10-09-13	367	0.8	184	380	15.6	21.5	32.4
11-09-13	360	0.4	185	392	15.7	21.9	30.6
12-09-13	369	0.5	183	393	15.9	20.9	31.9
13-09-13	364	0.9	187	394	15.7	21.8	33.0
14-09-13	365	1.0	189	396	15.2	21.3	31.6
15-09-13	362	0.8	184	395	15.3	21.5	30.4
16-09-13	368	0.6	186	392	15.1	21.0	32.9
17-09-13	361	0.7	182	393	15.9	21.5	30.9
18-09-13	367	0.5	184	397	15.1	21.2	33.0
19-09-13	365	1.2	185	398	15.0	21.5	31.9
20-09-13	362	0.6	183	400	16.0	21.5	32.4
21-09-13	364	0.3	181	389	15.5	20.6	31.6
22-09-13	369	0.1	180	396	15.8	21.5	32.1
23-09-13	367	0.8	189	404	15.9	21.0	30.7
24-09-13	361	0.2	183	381	15.6	21.9	31.8
25-09-13	370	0.6	181	380	15.7	21.4	32.5
26-09-13	369	1.4	187	383	15.5	20.3	30.6
27-09-13	360	0.7	185	386	15.8	21.6	32.9
28-09-13	364	0.5	190	387	15.9	21.5	30.4
29-09-13	368	0.1	189	389	16.6	21.5	32.2
30-09-13	369	0.6	180	381	15.8	21.3	30.6

Figure 11:

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Check sheet for month August 2013

Figure 12: Table 1 ,

1

Figure 13: Table 1 :

2

Figure 14: Table 2 :

3

Figure 15: Table 3 :

4

Figure 16: Table 4 :

5

Figure 17: Table 5 :

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Figure 18: Table 6 :

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Figure 19: Table 7 :

8

Year 2014
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Figure 20: Table 8 :

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