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Implementation of Value Engineering for Production Process Efficiency in Metal Stamping Industry

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ABSTRACT: Productivity can be increased by modifying the production process to achieve the best cycle time, but the quality of product doesn't decrease. This research aimed to increase the efficiency of the metal stamping process in an automotive company by considering the value engineering aspects. Value engineering (VE) is a systematic analysis of the functions of various components and materials to lower the cost of goods, products and services with a tolerable loss performance or functionality. Before the progressive die design changes were made, this automotive company required an additional process machining to produce one of their products, because the result of the progressive dies have not reached the specified quality standards, where the specified product height is 8.5mm ± 0.5 with ironing 7% of the material thickness, while the actual product height achieved 11mm with ironing of 0-10% at a height of 0-9mm and 40% at a height of 9-11mm. In response to this situation, this company attempted to increase the drawing height by 2.5mm and then cut it with a turret machine, but this process was inefficient. Therefore, researchers made changes to the design of progressive dies to produce products without using the turret machine. In the design of progressive dies, researchers considered several aspects, such as the process sequence within the progressive dies, the material tension during each drawing process, and the ironing of the material. After the design changes, the target ironing 7% of the material thickness was achieved without changing any other dimensions, and it has an impact on reducing the production cost by 10.87%.

KEYWORDS: cycle time; metal stamping; dies progressive; turret machine; value engineering; ironing

1. INTRODUCTION

The automotive industry is one of the main pillars of the world economy, with fierce competition between countries to dominate the market. Indonesia has successfully entered the list of the top 15 vehicle manufacturers in the world, occupy a competitive position with countries that have long been major players in this sector.

Based on data from *Organisation Internationale des Constructeurs d'Automobiles* (OICA), Indonesia is in 14th position as the largest vehicle industry in the world, with car production of 1.196.664 units throughout 2024. Here are the 15 countries with the largest automotive industries in the world as of 2024.

Tabel 1. Countries with the Largest Automotive Industries

Country	Number of Cars	Number of Commercial Vehicles	Total
China	27.476.886	3.804.706	31.281.592
USA	1.432.615	9.129.573	10.562.188
Japan	7.139.188	1.095.493	8.234.681
India	4.991.413	1.023.278	6.014.691
Mexico	947.726	3.254.916	4.202.642
South Korea	3.849.326	277.926	4.127.252
Germany	4.069.222		4.069.222
Brazil	1.895.020	654.575	2.549.595
Spain	1.918.244	458.260	2.376.504
Thailand	549.752	919.245	1.468.997
Czech Republik	1.452.881	6.011	1.458.892
Turkey	904.513	460.783	1.365.296
Canada	217.344	1.125.303	1.342.647

Indonesia	1.026.976	169.688	1.196.664
Slovakia	993.000		993.000

Source: OICA (Organisation Internationale des Constructeurs d'Automobiles)

Meanwhile in the two-wheeled sector, *Completely Built Up (CBU)* motorcycle exports in ASEAN from January to October 2025 based on data from Association Industri Sepeda Motor Indonesia (AISI), Indonesia's position is in first place with a total of 458.101 units and part by part of 113.292.768 units. To survive industrial competition, the manufacturing industry in the metal stamping sector is required to increase efficiency in the production process, so it can produce competitive product prices with guaranteed quality, even though there are various obstacles such as press machines, dies, materials, labor and even industry regulations.

In the case study that has been conducted, there is one process that is the object of research, namely the production process of a motorcycle component called the Collar T/L Set in an automotive company. The production process of Collar T/L Set generally requires 3 processes, namely progressive stamping, machining with a turret machine and electro plating.

Given these conditions, researchers simplified the production process from three processes to two processes. This research aims to obtain an effective production process by maximizing it in the metal stamping process. Therefore, researchers changed the existing progressive die design by paying attention to several important aspects including the sequence of processes in progressive dies, material tension in each drawing process and material ironing. The simplification of the production process carried out by researchers aims to obtain effective production time and lower production costs.

2. LITERATURE REVIEW

Value engineering was first introduced by Lawrence D. Miles, an engineer from General Electric Company in 1947. Miles combined various ideas and techniques in developing a methodological approach to ensure the value of a product has an optimum cost and is called value analysis which later after its widespread use became known as Value Engineering (VE). Value engineering is an organized effort directed at analyzing the functions of systems, equipment, facilities, services, and provision of services to achieve significant objectives at the lowest life cycle cost, consistent with performance, reliability, quality, and safety requirements. Value engineering distinguishes and separates the necessary from the unnecessary, where alternatives are developed that meet the needs and eliminate the unnecessary at the lowest cost.

Value engineering is the systematic application of a few techniques to identify the functions of an object or service by assigning a value to each existing function and developing several alternatives that allow the achievement of these functions at minimal total cost [8].

Value engineering is an organized, directed, function-oriented team approach to analyzing the functions of a product, system, or delivery process, for the purpose of increasing its value by identifying unnecessary costs and achieving required performance at the lowest project life cycle cost [13].

Value engineering is an evaluation method that analyzes the techniques and value of a project or product involving owners, planners and experts who are experienced in their respective fields with a systematic and creative approach that aims to produce consistent quality at the lowest possible cost, namely with functional limitations and task plan stages that can identify and eliminate unnecessary/unsupportive costs and efforts[5].

Value engineering is a systematic and structured multidisciplinary decision-making process. It involves analyzing functions to achieve the best value for a project by defining the functions required to achieve the desired value and providing these functions at an optimal cost, consistent with the required quality and performance [3].

Value engineering is a systematic evaluation to examine and consider various activity components such as procurement, fabrication, and construction as well as other activities in relation to their costs and functions, with the aim of reducing overall project costs [10].

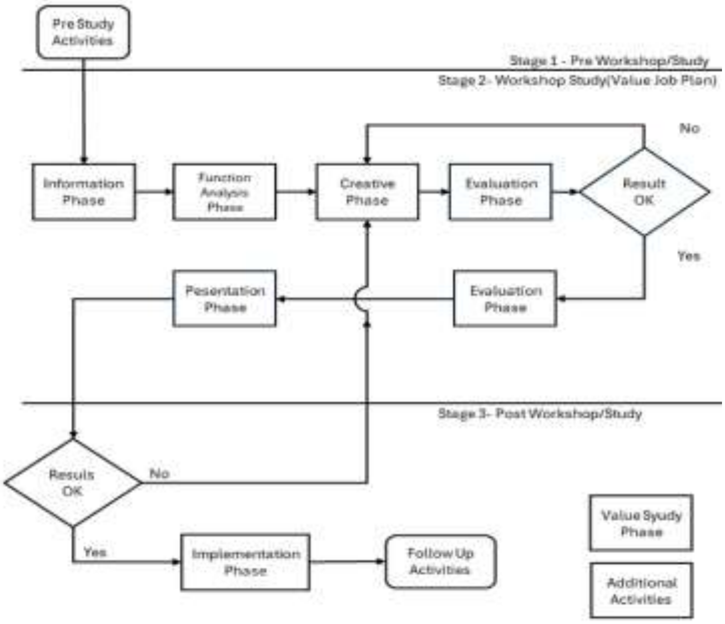
Value engineering is a method of cost savings using a systematic approach to achieve the best balance of functions between cost, strength, and appearance of a project. The characteristics of value engineering are as follows [16]:

a) System oriented
b) Multidisciplinary team approach
c) Life cycle oriented
d) A proven management technique
e) Function oriented

Value engineering is a low-cost, systematic approach to assessing a project. Value engineering can be used to obtain the following benefits [15].

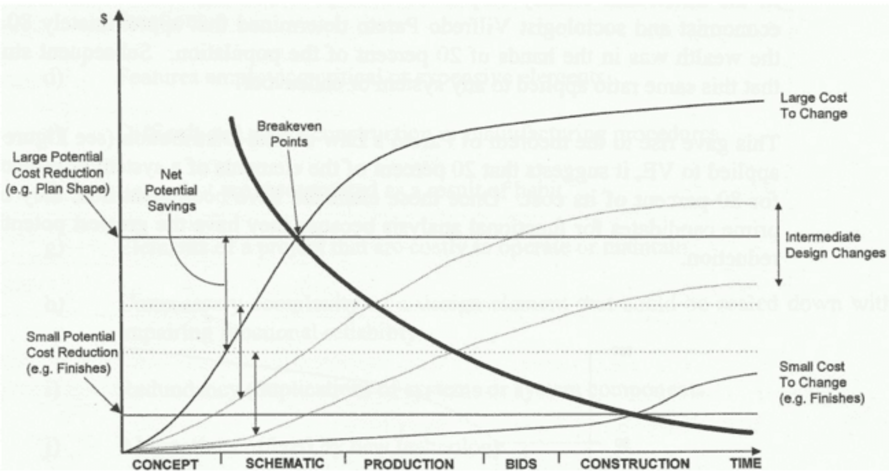
- Cost reduction
- Time saving
- Quality improvement
- Fix design flaws

Three key stages in the design of the offline quality control process, namely System Design (primary design), Parameter Design (secondary design), and Tolerance design (tertiary design) [11].



Ref: SAVE International, 2007

Figure 1. Work Plan



Ref: *Bechtel's Value Engineering Handbook, 2000.*

Figure 2. Potential reduction in production costs from the implementation of VE

3. RESEARCH METODOLOGY

To achieve the required function according to the value obtained, value engineering consists of three aspects, namely value, function and cost [16].

a) Value

Value can be divided into two: use value and esteem value. Use value reflects the extent to which a product is useful due to its function, depending on the product's nature and quality. Esteem value indicates the product's ability to satisfy its consumers.

b) Function

Function is the main benefit of a product that is designed to meet practical needs or provide solutions for users. Functions can be divided into three, namely basic functions, secondary functions, and unnecessary functions. The basic function is the main reason the system exists, because if the basic function is lost, the selling value attached to that function will also be lost. Secondary functions are complementary to basic functions, which are needed to fulfill and support basic functions. If the secondary function is removed, it will not interfere with the capabilities of the primary function. Meanwhile, unnecessary functions are anything that is given and does not have any utility value, added value, exchange value or aesthetic value.

c) Cost

Cost is the sum of all efforts and expenses made in developing, producing, and applying a product. Manufacturers always think about the impact of costs on quality, durability and maintenance because it will affect costs for users. Life Cycle Cost (LCC) is the total cost starting from the initial planning stage until the end of use of a facility. The elements of Life Cycle Cost (LCC) are investment costs, financing costs, operational costs, maintenance costs, change costs, taxes and salvage value. The largest costs that often contain unnecessary costs include materials, labor and overhead. The relationship between value, cost and function can be formulated as follows:

$$\boxed{Value = \frac{\text{Function}}{\text{Cost}}}$$

So, value can be increased by increasing/improving function without increasing the cost of the product/service, reducing costs by maintaining function and reducing the cost of producing it, and a combination of both.

Factors that need to be considered in implementing value engineering are as follows:

a) Availability of planning data
b) Initial cost
c) Operational and maintenance requirements
d) Availability of materials
e) Adjustment to standards
f) Impact on users

The implementation of value engineering is divided into several stages, namely as follows:

a) Information

The information stage is an initial stage in the value engineering work plan which aims to obtain a comprehensive understanding of the system, structure, or parts being studied and aims to collect data related to the work items being analyzed, to obtain the work items for which value engineering will be carried out. Some basic principles carried out at the information stage are cost models, cost breakdown and functional analysis.

b) Creative

Stages to produce various alternatives that can fulfill or carry out the main function.

c) Analysis

The stage for evaluating the alternatives generated in the creative stage. The evaluation results are used to determine which alternatives are beneficial, allowing for further studies that will offer the greatest potential for cost savings.

d) Development

At this stage, what is done is to prepare all ideas or opinions to be examined into the initial design (preliminary), create a solution outline, estimated into the life cycle cost of the initial design and with the newly proposed design, then the present value (PV).

e) Presentation

At this stage, a written or verbal report is made in the form of a percentage, presented to all parties involved in the project. This describes the alternatives that will be selected.

f) Implementation

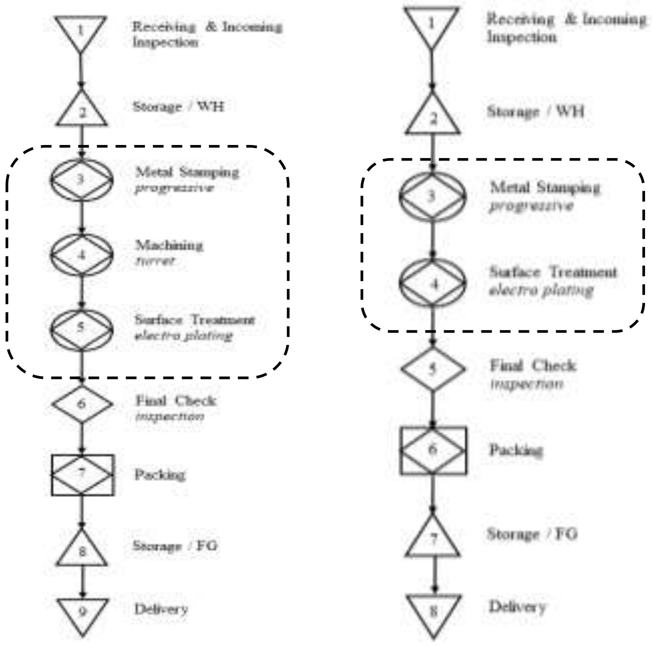
When the change is declared successful in terms of function and quality, the change is socialized to the relevant lines to be implemented comprehensively.

g) Monitoring

Periodic monitoring of the results of changes is carried out, including the quality and smoothness of the process.

4. DATA PROCESSING

The flowchart of the Collar T/L Set production process (before improvement) is shown in scheme 1. Then, scheme 2 represents the target improvement, where the turret machining process is no longer used in scheme 2, because this process will be maximized within the progressive metal stamping process. In this condition, there is a simplification of the production process flow with the aim of reducing production costs without lowering the quality of the products produced.



Scheme 1 *Scheme 2*

Figure 3. Flow process metal stamping

Ref: *Document PQCS metal stamping company*

By using JSC270C material, thickness 1.0 mm, width 29.5mm, pitch 28mm and 110T machine press, the existing die layout is obtained as shown in the following image,

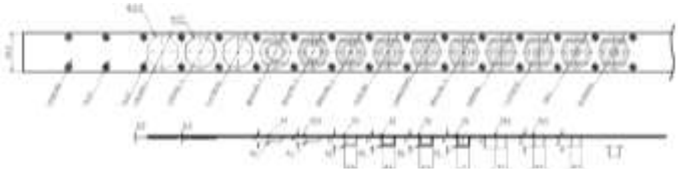
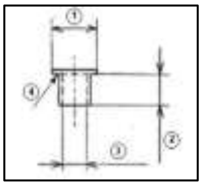


Figure 4. Design layout Collar T/L Set *(existing)*
Ref: *Metal stamping company*

Figure 5. Actual Layout Collar T/L Set *(existing)*
Ref: *Metal stamping company*

Figure 6. Actual product *(existing)*
Ref: *Metal stamping company*



No.	Point Check	Standard (mm)
1	Diameter	Ø12 +0/-0.5
2	Distance	7.5 ± 0.5
3	Diameter	Ø 6.5 +0,5/-0
4	Radius	R 0.5 +0.5/-0

Figure 7. Standard Dimension by QIS
Ref: *Metal stamping company*

As seen in Figure 6, there is ironing of the material at the end of the product, so the metal stamping company make this dimension product higher than standard drawing. To achieve the height and eliminate the ironing area, machining with turret is performed, but this methode make the cycle time decrease and potentially creating many part defects, because the turret process is manually.

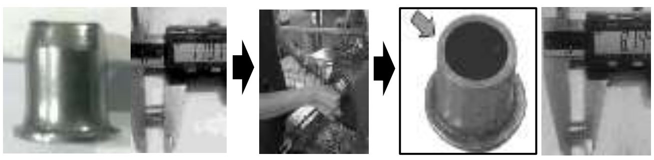


Figure 8. Illustration of existing production process
Ref: *Metal stamping company*

The defect ratio in the turret process from January to June 2025 was 560 pieces, with a loss value of IDR 600 / piece.

Table 2. Reject Collar T/L Set (January – June 2025)

Part No.	Part Name	Process	M/C	Data Reject 2025 (pcs)						Total
				Jan	Feb	Mar	Apr	May	Jun	(pcs)
33715-GBO-9003	Collar T/L Set	Machining	Turret 1	233	10	20	117	145	35	560

Table 3. Output Production Collar T/L Set (January – June 2025)

M/C	Target /hour (pcs)	Output 2025 (pcs)						Total
		Jan	Feb	Mar	Apr	May	Jun	(pcs)
Turret 1	600	163,151	175,770	281,550	931,30	159,680	176,970	1,391,595
Turret 2		126,960	192,624	0	0	0	21,160	

Meanwhile, the cost of using a turret machine is IDR 65/ piece. Therefore, the production costs incurred using the turret process (6 months) are as follows,

- *defective products = 560 x 600 = IDR 336.000*
- *machine cost = 1.391.595 x Rp 65 =IDR 90.453.675*
- *total =IDR 90.789.675*

From these calculations, an average of IDR 15.131.612/ month must be paid for production costs using a turret machine, with the following details of the production time required:

Table 4. Machine turret usage (January – June 2025)

Time required in using the turret machine		Target /hour	2025						Total (hours)
			January (hours)	February (hours)	March (hours)	April (hours)	May (hours)	June (hours)	
Turret 1	T25B	600	272	293	489	156	268	295	2,318
Turret 2	T15A		212	321	0	0	0	35	

5. ANALYSIS

After researchers collect data over a certain period and understand the data, the next step is to analyze the conditions that occur. The next step is to implement countermeasures to address the root causes found in the fishbone diagram by developing a plan based on the 5W + 1H concept.

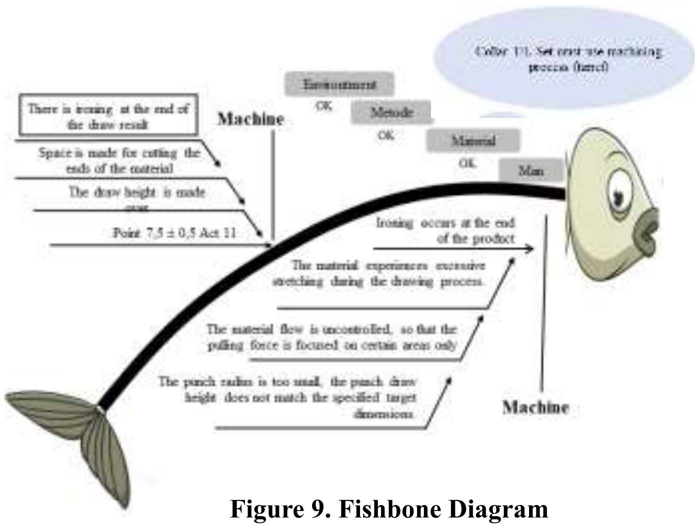


Figure 9. Fishbone Diagram

Table 5. Problem Analysis

No	Root Cause	Solusi Alternatif	Risiko	Keputusan	Alasan	Solusi terbaik
1	The punch draw radius is too small, the punch draw height does not match the specified target dimensions, resulting in thinning of the material at the end of the draw result.	Process repair (without modify dies) By resetting parameters, lubrication process, blank holder, stroke height, material thickness control, or press settings	Does not guarantee that the product will be OK	NO	Repairs have been made, the results are still NG	Create new dies / redesign tooling
		Repair existing dies by changing the punch radius to be larger and correct the punch height according to the initial design.	The improvement may be temporary, the results may not be OK	NO	Repairs cannot guarantee that the parts are OK	
2		replace die components according to design	Need spare part stock, repairs take a relatively long time, and there is	NO	Replacement of components with the old concept, still has the potential for	
		Create new dies / redesign tooling	It takes time to design & build, validation trial is required	**YES**	**Does not interfere with production planning**	

Table 6. 5W+1H

Why	When	Where	Who	How	How much	
					Breakdown	Total
Does not interfere with production planning	28-Aug-25	Metal Stamping Company	R&D Department	Design	IDR 3,000,000	IDR 29,926,367
			Dies Shop Department	Preparation Material	IDR 12,105,367	
			Dies Shop Department	Machining Process	IDR 10,321,000	
			Dies Shop Department	Assembling	IDR 1,500,000	
			Dies Shop Department	Trial	IDR 1,500,000	
			QC Engineering	Inspection	IDR 1,500,000	

Redesigning progressive dies using different calculations for each drawing process in the previous design. Drawing is the process of forming metal from sheet metal into a tube shape. In this case, there are changes in the target achievement of radius, inner and outer diameter and product height in each step to achieve the specified dimensional standards. The limitations in the tooling redesign are the same material type JSC270C thickness 1.0 mm, width 29.5 mm, pitch 28 mm and a 110T press machine. This is implemented so as not to change the gross weight and rate of the machine used.

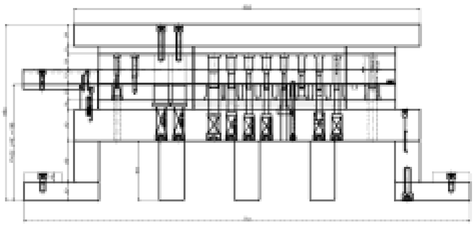


Figure 10. New Collar T/L Set progressive dies construction (front view)

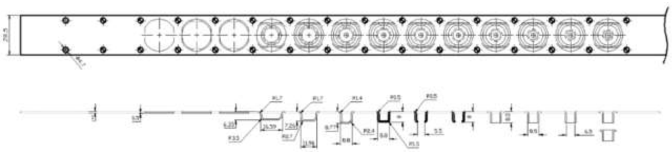


Figure 11. New Die Layout Collar T/L Set

Significant changes to the design occurred in the drawing 1, drawing 2, drawing 3, drawing 4, piercing and burring processes as shown in Figure 12.

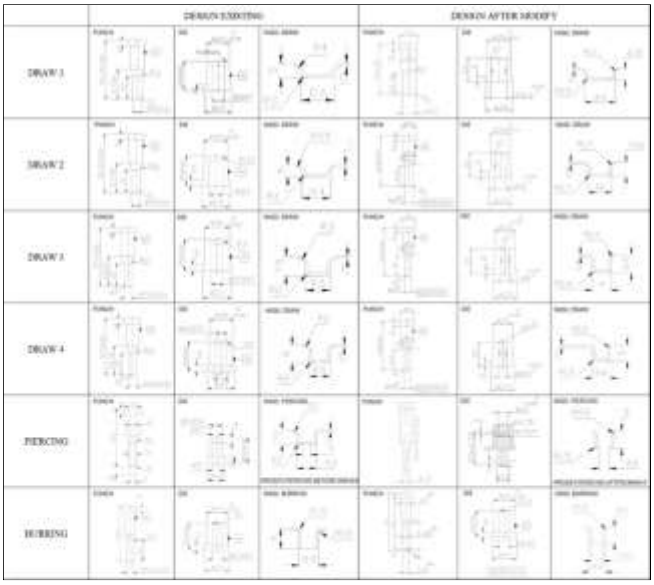


Figure 12. Collar T/L Set design changes

After the design and machining process are completed, the assembly process is carried out and then trial and error is continued to obtain the appropriate setting parameters, so that the resulting product does not experience changes in quality and the production process runs stably. Samples from the trial results are checked to determine whether the resulting dimensions are in accordance with the repair target or not. The measurement method for the samples is the same as the measurement method used for existing products. From the inspection results, the material thinning results were obtained by 0.03 ~ 0.05 mm, where within good limits is ± 0.07 mm.

6. CONCLUSION

Based on research conducted on the production process of Collar T/L Set, researchers can conclude:

1) Radius punch in the tooling design determine the product results, because a sharp punch will increase the bending force required for the drawing process.
2) Radius die in the tooling design affect the forming force. If the die radius is close to the material thickness, the bending force that occurs will be smaller. Conversely, if the die radius increases, the bending force that occurs will be greater.
3) To facilitate the movement of material during the drawing process, a gap is required between the punch and the die, this gap is called clearance. The clearance is 7% to 20% of the material thickness. If the clearance is too small, the material can experience thinning (ironing), and if the clearance exceeds the tolerance of 20%, it can cause wrinkles.

4) After making changes to the tooling design, the targeted material thinning (ironing) of 0.07 mm can be achieved, without changing the other dimensional conditions that are the checking points.
5) Simplification of the production process can be done by changing the tooling design without reducing product quality.
6) With a shorter production process, the production costs incurred are lower. The research obtained a calculation of the reduction in production costs for the Collar T/L Set of IDR 181.579.344 / year with a cost reduction (CR) value of 10.87%.

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