DESIGN DEVELOPMENT OF FIXTURE MODEL IN MANUFACTURING SPRING SHACKLE

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Abstrak: *Spring shackle merupakan komponen penting dalam sistem suspensi pegas daun karena memungkinkan pegas tersebut meregang ketika kendaraan mengalami lonjakan atau sedang mengangkut beban berat. Desain fixture-komponen yang berfungsi untuk mencengkeram benda kerja selama proses manufaktur berlangsung-menentukan efisiensi proses manufaktur spring shackle. Dalam penelitian ini, akan dibahas pengembangan desain fixture spring shackle dengan metode Design for Manufacture and Assembly (DFMA). Pemodelan fixture secara 3D dengan menggunakan CAD terbukti membantu dalam memvisualisasikan dan mengkomunikasikan pengembangan desain fixture spring shackle tersebut. Hasil yang diperoleh dari pengembangan desain fixture terjadi penghematan waktu sebesar sebesar 82,22% ditinjau dari aspek Design for Assembly (DFA) dan 19,25 % ditinjau dari aspek Design for Machining (DFM).*

Kata kunci*: fixture, DFMA, CAD, manufaktur*

Introduction

Spring shackle is an important component in leaf spring suspension system, mostly used for heavy duty vehicles, such buses and trucks. Manufacturing process of spring shackle is divided into two processes, which are casting (primary) and machining (secondary).

In the machining process, fixture has an important role to hold the workpiece. Fixture design determines the efficiency of spring shackle's manufacture because it affects the time of manufacture, which are loading and unloading time.

A fixture design, developed by Mechanical Engineering Department Universitas Tarumanagara, is based on a design which has been planned to be manufactured by PT X.

Research Aim

To develop a fixture design of spring shackle, using Design for Manufacture and Assembly (DFMA) methodology, so it can be obtained a new design which is able to save manufacturing time.

Methodology

Firstly, PT X's fixture design is analyzed. From the analysis, weaknesses of this design are identified. And then, the weaknesses, such as the number of fixtures and bolts, fixture position, separated operation, and tool acquire time, are overcome by developing the fixture design [1].

Developed fixture design replaces some features to overcome the weaknesses. It uses clamping system, snap fit system, and also some modifications, such as the ease of alignment and geometry of cutting tool. This developed fixture design then is also analyzed with the same method as the PT X's one.

After both former and latter analysis are fulfilled, the time for assembling and manufacturing spring shackle, using the developed fixture design, is compared to the time, using the PT X's one. If the time consumed is shorter than the PT X's one, it means the developed fixture design is available to use then the design detail is received, followed by conclusions of the development has been made.

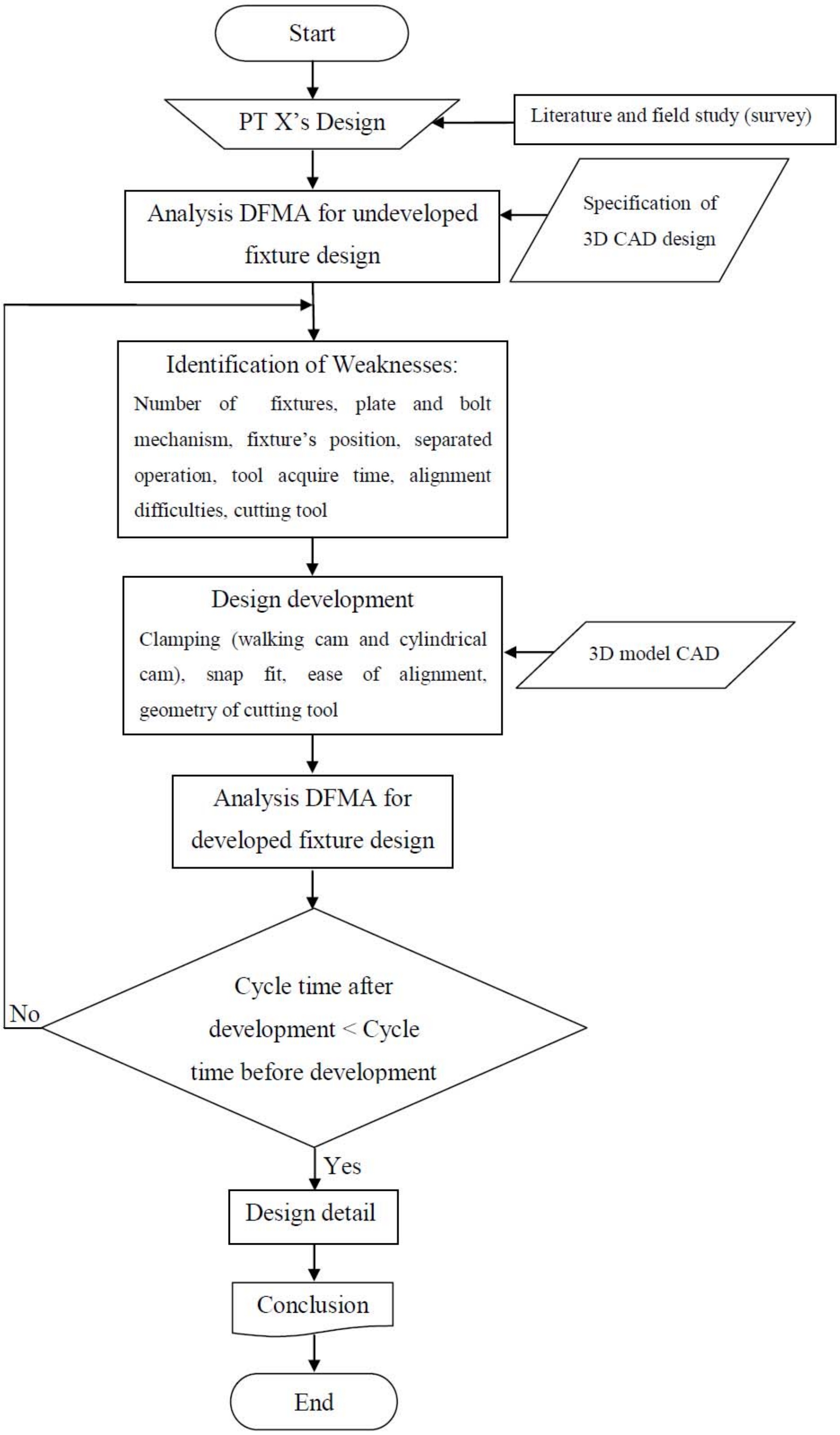

Figure 1. Flow Chart

Discussion and Result

Based on DFA analysis, the result of total assembly time for fixture PT X is illustrated in Table 1.

Table 1. DFA Analysis for Fixture PT X

	No. of items RP	Tool acquire time TA (s)	Handling Code	Handling time TH (s)	Insertion Code	Insertion time TI (s)	Tool time TA + RP* (TH + TI) (s)	Minimum part count	Explaination
1. Spring Shackle A	1	-	30	1,95	02	2,60	4,55	1	Place in the first fixture and hold down
2. Plate	1	-	20	1,80	02	2,60	4,40	0	Add and hold down
3. Bolt	1	3,60	10	1,50	02	2,60	7,70	-	Add and screw fasten
4. Spring Shackle B	1	-	30	1,95	02	2,60	4,55	1	Place in the second fixture and hold down
5. Plate	1	-	20	1,80	13	7,40	9,20	0	Add and hold down
6. Bolt	1	6,40	10	1,50	13	7,40	15,30	0	Add and screw fasten
7. Spring Shackle C	1	-	30	1,95	12	4,80	6,75	1	Place in the third fixture and hold down
8. Plate	3	-	-	-	12	4,80	14,40	0	Rotate and hold down
9. Screw fastening	3	3,60	-	-	61	4,50	17,10	-	Standard operation
10. Spring Shackle D	1	-	30	1,95	02	2,60	4,55	1	Place in the fourth fixture and hold down
11. Plate	1	-	20	1,80	13	7,40	9,20	0	Add and hold down
12. Bolt	1	6,40	10	1,50	13	7,40	15,30	0	Add and screw fasten
							113,00	4	

DFA index = $E_{ma} = N_{min} \times (t_a/t_{ma}) = 4 \times (3\ s/113,00\ s) = 0,106 = 10,60\ \%$

Based on DFM analysis, the result of total machining time for fixture PT X is illustrated in Table 2.

Table 2. DFM Analysis for Fixture PT X [2]

No.	Process	Time (s)
1	Boring	70,8
2	Boring	39
3	Face mill	33
4	Milling	18,6
5	Milling	18,6
6	Face mill	33
7	Drilling	3,36
8	Face mill	27
9	Slitting	27,6
10	Face mill	27
Total		297,96

The development embraces an integrated machining process, saving the machining time, and a cam system used for clamping mechanism [3]. The type of cam is direct clamping, using walking cam and indirect clamping, using finger driven by cylindrical cam [4].

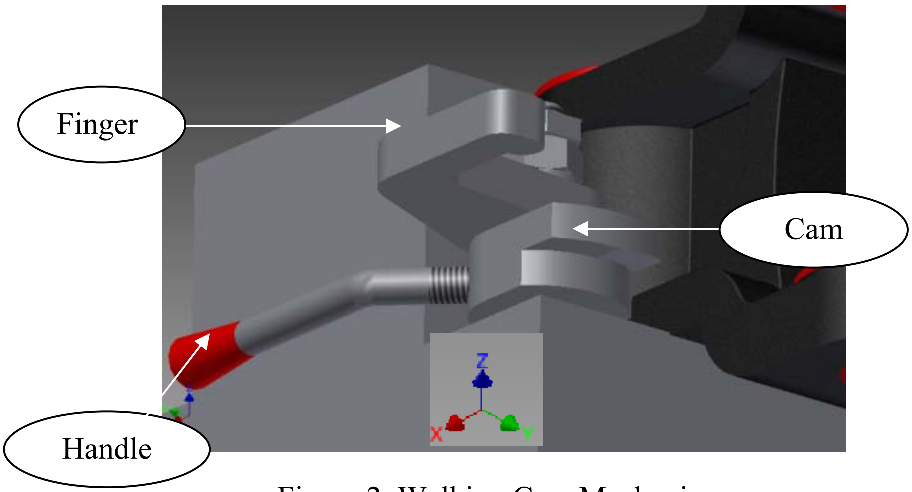

Figure 2. Walking Cam Mechanism

Walking cam has three surface contacts as shown in Figure 2. A side beneath the upper one of cam clamps spring shackle along Z axis, lower side of cam clamps spring shackle along X axis, and the finger clamps spring shackle along Y axis. The setting of bolt upon the cam affects the strength of clamping.

Cylindrical cam utilizes its unique elliptical-shaped profil to generate a force on follower when the handle revolves. Thus, the follower will drive a clamping mechanism. A spring is used to reposition the follower to initial position after clamping.

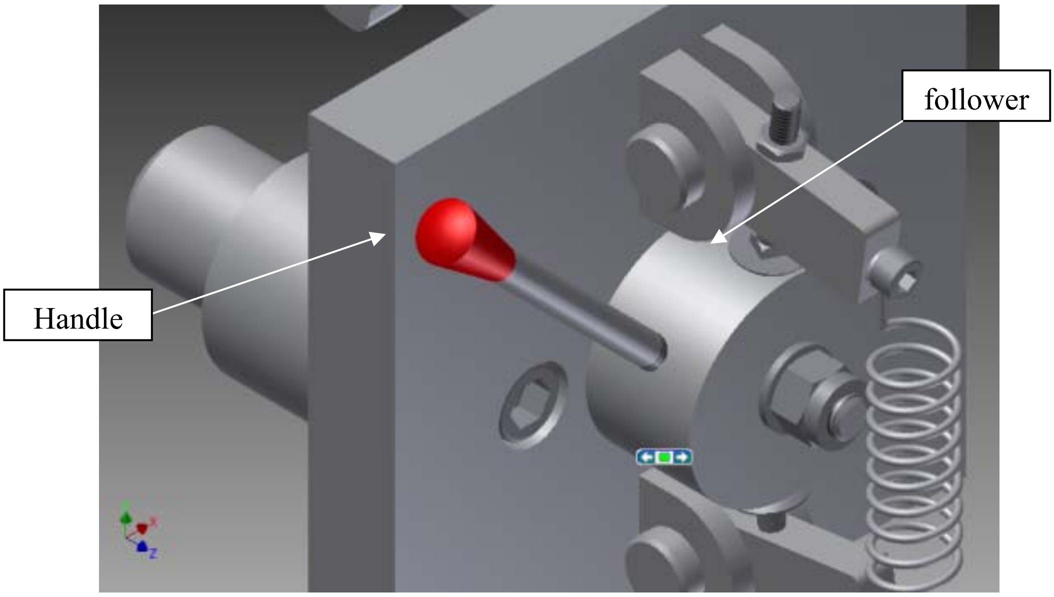

Figure 3. Cylindrical Cam Mechanism

Based on the same DFA analysis as the former one, the result of total assembly time for fixture after development is illustrated in Table 3.

Table 3. DFA Analysis for Fixture After Development

	No. of items RP	Tool acquire time TA (s)	Handling Code	Handling time TH (s)	Insertion Code	Insertion time TI (s)	Tool time TA + RP* (TH + TI) (s)	Minimum part count	Explaination
1. Spring Shackle A'	1	-	30	1,95	02	2,60	4,55	1	Place on the left side of the first fixture and hold down
2. Clamping	1	-	-	-	04	1,80	1,80	-	Tighten the spring shackle A'
3. Spring Shackle B'	1	-	30	1,95	02	2,60	4,55	1	Place on the right side of the first fixture and hold down
4. Clamping	1	-	-	-	04	1,80	1,80	-	Tighten the spring shackle B'
5. Spring Shackle C'	1	-	30	1,95	02	2,60	4,55	1	Place in the second fixture and hold down
6. Clamping	1	-	-	-	04	1,80	1,80	-	Tighten the spring shackle C'
							19,05	3	

DFA index = $E_{ma} = N_{min} \times (t_a/t_{ma}) = 3 \times (3\ s/19{,}05\ s) = 0{,}472 = 47{,}20\ \%$

Based on the same DFM analysis as the former one, the result of total machining time for fixture after development is illustrated in Table 4.

Table 4. DFM Analysis for Fixture After Development [2]

No.	Process	Time (s)
1	Boring	70,8
2	Boring	39
3	Face mill	33
4	Face mill	15,6
5	Drilling	3,36
6	Face mill	27
7	Slitting	27,6
8	Face mill	27
Total		243,36

There is a significance difference in total time consumed for assembly and machining at both developed and PT X's fixture which can be seen in Table 5.

Table 5. Comparison of Both Fixture Designs' Results

No.	Design	Total Time DFA (s)	Total Time DFM (s)
1.	PT X's fixture	113.00	297.96
2.	Developed fixture	19.05	243.36

Acknowledgement

Thanks to Mechanical Engineering Department Universitas Tarumanagara which has donated and supported the research until its accomplishment. There's still a probability to do a further research to obtain more satisfying results of it, such as analyzing the strength and capability of the fixture to overcome the load, applied during the assembly and machining. This research has won the fifth place in "Lomba Nasional Tahunan Rancang Bangun Mesin 2011", held by Badan Kerja Sama Teknik Mesin–Indonesia on November, 2nd 2011.

Conclusion

The application of cam method in clamping system accelerates and simplifies the process of clamping itself so it reduces a cycle analytic time, whereas the cycle analytic one for a spring shackle, using PT X's fixture is 410.96 s and using developed fixture is 262.41 s. The analytical result indicates that cycle anlaytic time for developed fixture is shorter, compared to the PT X's fixture, which are 93.95 s or 83.14% from DFA aspect and 54.60 s or 19.25% from DFM aspect. The result can be achieved due to fixtures' adjacent layout in the developed fixture, shortening the uncut tool path, as well as the identification and elimination of obstructed access and restriction vision by using 3D model CAD [5].

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