ROLL FORMING SIMULATION FOR AUTOMOTIVE BUMPER FIXING

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We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

The bumper beam today is generally made of steel via stamping. The structural and Complexity potential of such parts is very high but investments and variable costs are significant. A process offering an economic and flexible alternative is roll forming. In this paper, a simulation has been done in order to compare between roll forming and stamping bumper beam. CAD softwares have been used for the simulation and analysis which are Solidwork 2005 and finite element analysis software Algor version 21. The bumper beams have been design in Solidwork and the Algor has been used to make stress analysis to the bumper beams. The static stress with linear material model has been applied to the both bumper beams that are from stamping and roll forming for comparison. The surface loads that have been applied to the bumper beams are calculated from the velocity of Gen-2 car at 80km/h to 120km/h. From the analysis the maximum stress for stamping bumper beam is 282.82MPa and 243.29MPa for roll forming bumper beam. After that, the analysis about costs to produce each bumper beam has been done. The costs that have been considered for this thesis are costs from man, machines and materials. From the calculation the production of stamping bumper beam need cost about RM 26 032 400 and for the roll forming bumper beam just need RM 3 010 600 for the production cost. As a conclusion, from this thesis roll forming bumper beam has more advantages compare to stamping bumper beam.

ABSTRAK

Galang bamper kereta biasanya diperbuat daripada besi melalui proses menekap. struktur dan kerumitan bahagian-bahagian adalah tinggi tetapi pelaburan-pelaburan dan kos-kos yang berubah adalah signifikan. Satu persembahan proses satu alternatif yang menguntungkan dan fleksibel adalah pembentukan gelekan. Dalam kertas ini, satu penyerupaan telah dibuat teratur membandingkan antara pembentukan gelekan dan pengecapan bamper alur. Perisian CAD telah digunakan untuk simulasi dan analisis yang wujud Solidwork 2005 dan perisian analisis elemen terhad versi Algor 21. Galang bamper telah direka dalam Solidwork dan Algor telah digunakan untuk membuat analisis tegasan untuk galang bamper. Tekanan statik dengan peragawati penting yang lurus telah digunakan ke atas galang bamper dan kedua-dua yang adalah daripada pengecapan dan senarai dibentuk untuk perbandingan. Muatan-muatan permukaan yang telah digunakan ke atas galang bamper dikira dari halaju Gen-2 kereta di 80km / h untuk 120km / h. Tekanan paling tinggi untuk galang bamper untuk proses menekap ialah 282.82 Mpa dan 243.29 Mpa untuk galang bamper dari proses pembentukan gelekan. Selepas itu, analisis mengenai kos-kos untuk mengeluarkan alur yang setiap satu bamper telah dibuat. Kos-kos yang telah dipertimbangkan untuk tesis ini adalah kos-kos daripada pekerja , mesin-mesin dan bahan-bahan. Daripada pengiraan kos pengeluaran untuk galang bamper dari proses menekap adalah sebanyak RM26 032 400 dan kos pengeluaran galang bamper dari proses pembentukan gelekan adalah sebanyak RM 3 010 600 .Sebagai satu keputusan, daripada senarai tesis ini membentuk bamper alur mempunyai lebih kelebihan berbandingan pengecapan bamper alur.

TABLE OF CONTENTS

CHAPTER 5 CONCLUSION

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOL

%	Percentage
$\sum$	Summation
C_i	Value of Item
X_i	Number of Item
m	Number Item

LIST OF ABBREVIATION

L	Length
W	Width
SWOT	Strength, Threaten, Opportunity, Weakness
QCD	Quality, Cost And Delivery

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The automotive industry has been developed rapidly in all country. Many car makers try to produce cars that can compete with other companies. Nowadays customers not only want the low cost cars but the cars that meet customers demand at low cost. As a result the car makers try to reduce cost in other car's part in order to produce cars at low cost with a better condition that can give more comfortable to customers.

Today, it is common to produce structural body parts via stamping or hydroforming. The structural and complexity potential of stamped and hydroformed steel parts is very high however, machine investment costs for these manufacturing processes are significant. In addition, the tools can be complicated and costly. A process offering an economic alternative to the above mentioned is roll forming.

In conventional bumper beam, to produce this bumper beam is using stamping process but it cost a lots of money due to in stamping process it involve a lots of process likes drawing, trimming, piercing and flanging. If many process involve the probability to make mistake is higher. It will make the cost of the bumper become higher when there a lots of mistake in each process.

1.2 PROBLEM STATEMENT

(i) Increasing demand to the comfortable cars in low cost make the car makers try to reduce cost for potential components in a car

(ii) Bumper beam has big potential to reduce the production cost by using roll forming method

1.3 PROJECT AIM AND OBJECTIVES

To use roll forming method as a replacement for stamping method in making automotive bumper beam. The objectives these studies are:

(i) To compare the stress analysis roll forming bumper beam and stamping bumper beam.

(ii) To reduce cost of bumper beam produce by using roll forming method

1.3 PROJECT SCOPES

This study will investigate the different of producing bumper beam using roll forming method compare to stamping method. The scopes of this project are:

(i) To analyze stress analysis in roll forming and stamping bumper beam.(front)

(ii) To reduce costs base on 3M method comparison that is man, machine and material

(iii) The bumper used is a Gen-2 car’s front bumper beam

CHAPTER 2

LITERATURE REVIEW

2.1 ROLL FORMING

Roll forming is a manufacturing technology to obtain long parts with constant cross-sections. Roll forming is a continuous bending operation in which flat sheet metal (from coils or pre-cut blanks) is plastically deformed along a linear axis. Tandem sets of rolls shape the metal stock in a series of progressive stages until the desired cross-section is obtained. The gap between upper and lower rolls changes from one roll forming station to the next, whereas the material thickness and the area covered by the cross-section remains almost constant (Kevin Sweeney*,Ulrich Grunewald,2002)

To form sheet metal strip along straight, longitudinal, parallel bend lines with multiple pairs of contoured rolls without changing the thickness of the material at room temperature. Roll forming is a flexible process, where both the fundamental rules and the exceptions can be utilized. It has been proven several times that even seemingly impossible roll forming tasks can be accomplished, although it may take a longer time and much more money. On the other hand, it has also seen shown that plans to roll form simple shapes can create disastrous results if the basic rules of roll forming are not followed.(George T.Halmos,2006)

A simplified profiling operation (U-profile) is shown in Fig. 1. Each forming step consists of two or four rolls which shape the material. The number of forming steps needed to produce the profile is mainly dependent not only on its geometry but also on its material, desired surface quality, lubrication and form of input material (coil or pre-cut blanks). (Kevin Sweeney*,Ulrich Grunewald,2002)

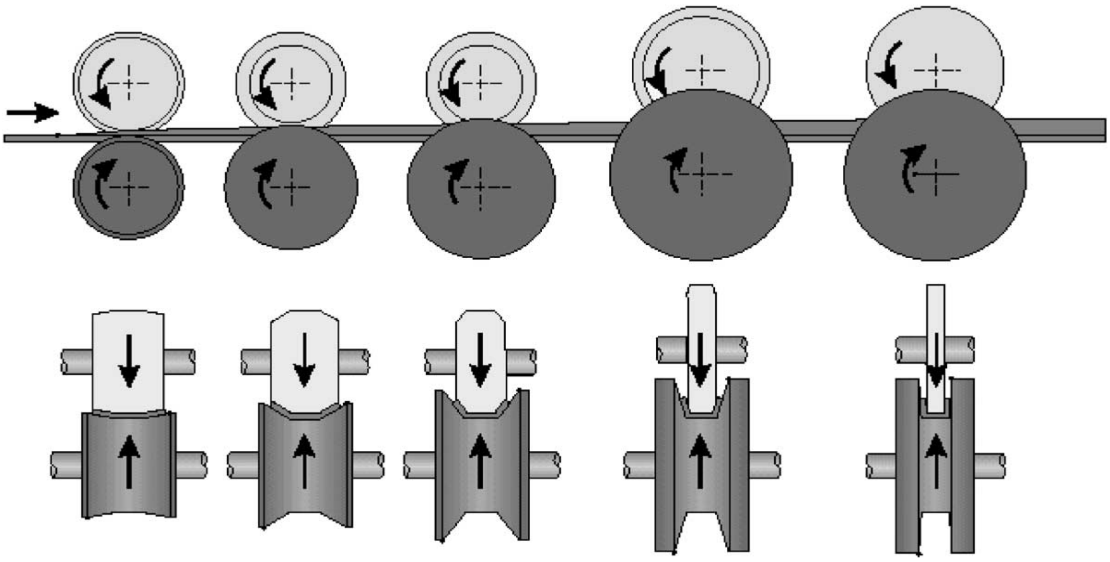


Fig. 1. Roll forming of a U-profile(Kevin Sweeney*, Ulrich Grunewald,2002)

2.1.1 CONTINUOUS BODY STRUCTURE MANUFACTURING TECHNOLOGIES

Roll forming and extrusion are continuous manufacturing processes. These manufacturing technologies are characterized by a continuous long part exiting the tooling and, consequently, by the necessity of an additional production step to cut the part to length. These processes enable the production of parts in different lengths without changing tooling, and thus without additional tooling costs. These processes are explained in the following section.

2.2 EXTRUSION

By means of extrusion, long profiles are manufactured by pressing a heated material bolt through a die determining the profile geometry. By changing the die, it is possible to produce profiles with different geometries on one machine.Typical materials used in this process are aluminium, magnesium, copper and zinc. The achievable extrusion speed depends on the applied metal, complexity of geometry and the desired surface quality. Advantages of extruded profiles include:

(i) high variety in profile geometries (design flexibility),
(ii) good physical properties,
(iii) low tooling/die costs,
(iv) design simplification,
(v) high surface quality

(Kevin Sweeney, Ulrich Grunewald, 2002)

2.3 RAPID COST ESTIMATION TOOL FOR ROLL FORMED PARTS

Beginnings with the input of part specific parameters (e.g. annual production volume and geometry) and general parameters (e.g. feasibility criteria and forming line parameters), the calculations are processed. The results are then transferred from the calculation to the result sheet. The first calculations performed are to test the feasibility of the roll profile part. This guarantees that gross errors regarding manufacturability, especially during the design phase of the part, are avoided. Feasibility is analysed regarding issues such as maximum profile height, material yield strength and maximum processing speeds (e.g. cutting,stamping, welding). (Kevin Sweeney*, Ulrich Grunewald,2002)

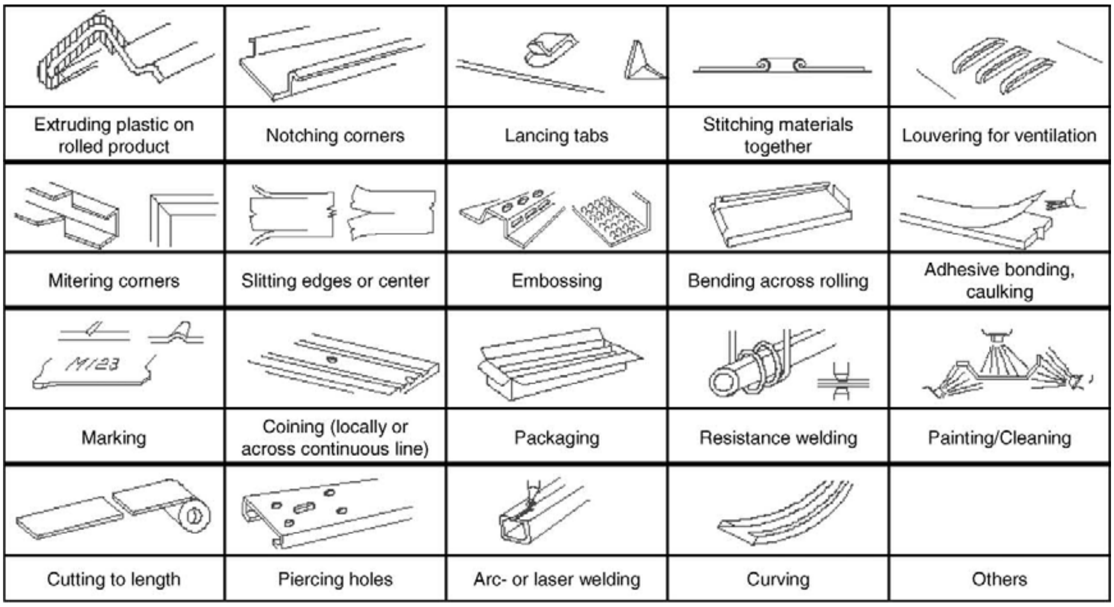


Fig. 2.3 Additional technologies incorporated into roll forming process chain(Kevin Sweeney*, Ulrich Grunewald,2002)

2.4 ROLL FORMING PROCESS

Roll forming is a progressive process that passes a metal strip through a series of specially shaped roller dies to form, ultimately, a desired roll formed profile. Strip stock is fed through successive pairs of contoured rolls that progressively form the workpiece to meet the desired specifications. The roll forming process characteristics include:

(i) Its common usage to mass produce mass long metal pieces with relatively close tolerances,
(ii) The utilization of ductile workpiece materials, softer metals,
(iii) Working with materials that are usually less than 1/8" thick and 20" wide,
(iv) The capability to produce desired workpieces at a forming speed of 100 feet per minute (fpm),
(v) Its strong suitability to produce decorative and structural metal products often for roofing and siding.

The illustration that follows provides a look at a typical progressive roll forming die process showing a strip of metal being progressively shaped by the pairs of mated rolls of roll. It is normal to find roll forming stations with 10 to 12 stages before the material achieves the final desired roll formed shape or profile.

As the metal strip is moved through the drawing process, it is exposed to a series of progressive die stations, each one changing the metal configuration left on the metal by the previous station. Therefore, the metal workpiece is created in a series of stamping stages.

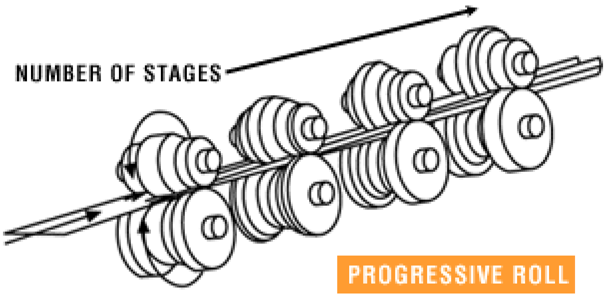


Figure 2.5 example of progressive roll for roll forming machine

To achieve the desired roll formed profile, sets of mated dies are constructed. The size of the rolls is dependant upon the material to be formed, the material thickness, and the formability of the material required.[Anon,2000]

The most common materials used in the progressive roll forming process include aluminum and steel, including many alloys of each.

2.4.1 ROLL FORMING TECHNIQUES

There are two methods commonly used when shaped parts are rolled formed. They are the:

(i) precut or cut-to-length roll forming,
(ii) the post-cut roll forming.

The selection of the best roll forming process is normally based on the difficulty of the cross section and the production length required by the end-user specifications. (Corrugated Metals uses the post-cut method which provides a higher level of precision to meet our customers' needs.)

2.4.2 Precut Roll Forming

The material to be roll formed is cut-to-length before being fed into the roll forming machine. Normally, this process includes both a stacking and feeding system that moves the metal blanks into the roll forming machine running at a fixed speed (normally between 50 to 250 feet per minute), and a post production conveying and stacking system. This roll forming technique is typically used for lower volume parts. It is also used when notching can’t be easily handled in a post-cut line.

Tool cost is economical for the pre-cut roll forming process since cutting requires only an end notch die or flat shear die. However, end flare is more obvious and side roll tooling is needed to obtain a high-quality finished shape. [Anon, 2000]

2.4.3Post-Cut Roll Forming

The most efficient, consistent, and least problematic process is the post-cut roll forming method. It is the most widely used roll forming process and is what is used at Corrugated Metals. The post-cut roll forming process requires:

(i) an uncoiler
(ii) a roll forming machine
(iii) a cutout machine, and
(iv) a runout table.

Post-cut roll forming can be supplemented by a variety of secondary, or auxiliary, operations including:

(i) pre-notching
(ii) punching
(iii) embossing
(iv) marking
(v) trimming
(vi) welding
(vii) curving
(viii) die forming

When used in conjunction with post-cut roll forming, these operations can eliminate the need for stand-alone secondary operations providing a complete or net shape profile. The cost of tooling, and the tooling changeover time for post-cut roll forming, are greater than for the precut method, but are usually more than offset by the other advantages[Anon, 2000]

2.5 STAMPING

Stamping includes variety of operation, such as punching, blanking, embossing, bending, flanging, and coining. Simple or complex shapes are formed at high production rates. Tooling and equipment cost can be high, but labor cost is low (Kalpakjian & Schmid, 2006).

The automotive stamping process can be considered the first step in the production of an automobile, supplying the external panels of the automobile from which the other components are attached. In the stamping plant under investigation, both internal and external panels are produced. The exterior surface (skin) panels are of primary interest, since they have the most stringent quality requirements.(Adam de Ruyter, May 2002)

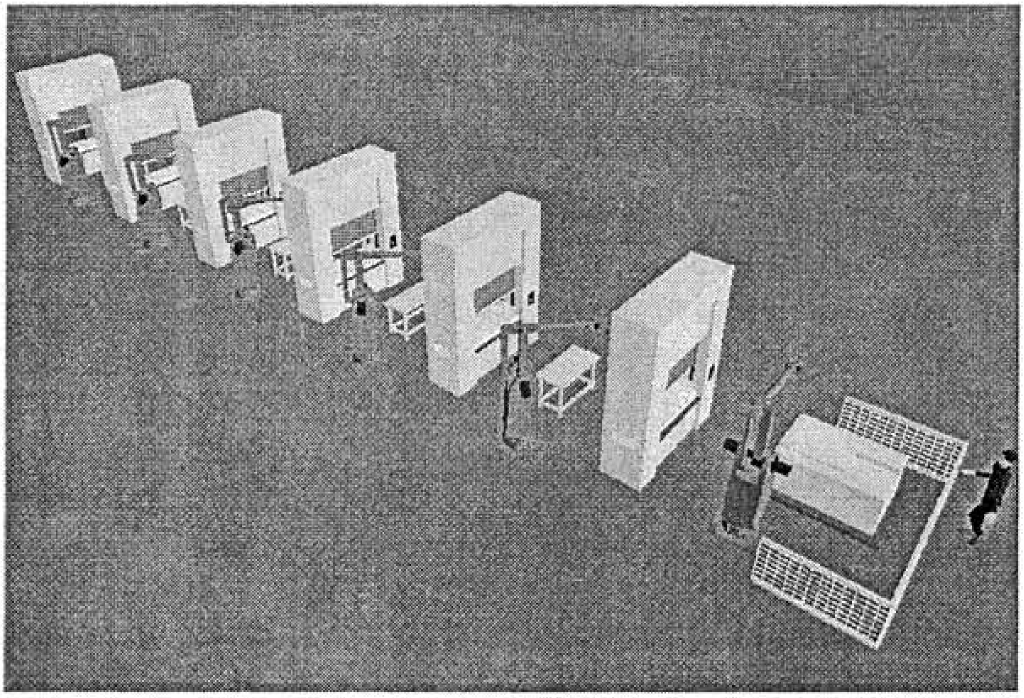


Figure 1 - A typical press-line found in the Ford Geelong Stamping Plant [1].

.(Adam de Ruyter, May 2002)

Metal stamping is a process employed in manufacturing metal parts with a specific design. A metal alloy sheet is used as the stock. This stock is either stamped on a press using dies and punches or drawn into shapes on hydraulic deep drawing machines. Common examples are sheet metal machines, automobile parts, metal components used in audio and video devices, aerosol spray cans, and even military tanks. A household example is the use of sheets of metal to make pots and pans. [Anon,2007]

Figure 2.6: Automotive stamping

2.5.1 Metal Stamping Operation

Metal stamping processes use dies and punches to cut the metal into the required shape. The male components are called punches and the female components are called dies. Press machine tools are used in the stamping process. The die, made of hardened steel, has a contour that matches the shape of the finished part and is mounted on the table of the press. The punch, made of hardened tool steel or carbide, also matches the contour of the part but is slightly smaller to allow clearance between the die and the punch. It is mounted in the head or the turret, which moves down and punches the metal. The thickness of the sheet metal does not change during this process.

Design and manufacture of dies and punches is a highly skilled process and master craftsmen use precision jig boring, grinding, EDM, and lapping machines to produce highly accurate dies.[Anon, 2007]

Progressive stamping is used to design complex profiles. In this process, the profile is cut in steps with a series of different sized die and punch combinations. The first punch in the series cuts a smaller profile and the next punch finely polishes the metal to obtain a desired shape. Tumbling process or deburring is used to remove any sharp edges and burrs. All through the process it is important to maintain a minimum wall thickness for the punched hole.

The metal may be plated with palladium, nickel or tin to protect it from oxidization. Plating improves the durability and solderability of the product. For additional shelf life, the sheet metal is also pre-plated before the actual stamping process. The product is then cleaned to dispose of excess oils, grease, films or other materials used during the stamping process. The heating process follows the cleaning process to enhance the toughness of the metal product. In some cases, to ease the stamping process, the sheet metal is subjected to a stress relieving process that removes internal stresses in the sheet and improves its machineablity.[Anon, 2007]

2.5.2Metal Stamping Techniques

Several metal stamping techniques are extensively used in industries and engineering applications. Below are some of the techniques in metal stampings:

(i) **Fine blanking** is used when high accuracy is required. It is adopted when metal parts with smooth edges are to be produced. Fine blanking is a cold extrusion process not to be confused with stamping. This process is used to produce final shape parts that do not require subsequent finishing operations. Fine blanking process proves to be a cost effective as it is a single step operation.

(ii) **Progressive die stamping** is a forming process that uses a series of dies to work simultaneously on the sheet metal. This process used to fabricate small parts at a fast pace. Progressive die stamping combines forming and cutting process, which saves time and money. Die stepping technique is adapted to stamp the sheet metal simultaneously. A series of dies is used to draw the sheet metal and all the dies stamp the sheet metal simultaneously.

(iii) **Deep drawing** is used when recessed cavities in parts need to be formed. In this process, the sheet metal is subjected to plastic deformation by using a die and a punch. Once the yield point is reached, the metal starts to flow. A series of processes like sizing, blanking, swaging, etc. Factors like ductility of the metal, diameter to height of the component and corner radius play an important role. Using improper metal stock, a low quality dies, or excessive pressure can lead to defects like strains or ruptures that are immediately visible. Clips, springs, and special purpose rings are manufactured using either the hot or cold wire drawing technique. The die has a hole of the required wire size and shape. Metal is either drawn through the hole or extruded to form a coil. [Anon, 2007]

2.6 ROLL FORMING ADVANTAGES AND LIMITATIONS

2.6.1 Advantages

Roll forming offers a number of distinct advantages over other metal fabricating methods. Advantages include:

(i) The initial cost of a roll forming line is no more, and often less, than the cost of a standard stamping line or progressive die operation.

(ii) Production speeds of 50-600 feet per minute can be attained but 100-180 feet per minute is a reasonable average for most current equipment.

(iii) Roll forming is a high volume process that makes uniform and accurately dimensioned parts.

(iv) Parts are produced with little handling, minimizing labor costs, needing only the coils to be loaded at the starting end of the machine and removal of finished parts at the other end. This process can usually be handled with a minimal number of operators.

(v) Roll forming can also be used for low-volume production because setup or changeover time for new parts is not lengthy.

(vi) Maintenance costs are generally low. The form rolls can produce several million feet of product before problems occur when properly maintained.

(vii) The roll forming process is easily combined with other operations and processes to automatically form a considerable range of metal parts.

2.6.2 Limitations

A few limitations also exist. Roll forming limitations include:

(i) Experienced roll design engineers must design those rolls designed for complex shape forming.

(ii) Complicated tubular shapes, and some closed shapes, may need mandrels to form the shape accurately.

(iii) Delicate, breakable, machine parts may need recurrent replacement during high volume production runs.[Anon, 2000]

2.7 BUMPER BEAM

An elongated tubular vehicle bumper beam, the bumper beam having a cross-sectional configuration comprising an upper wall and a lower wall, each of the upper wall and lower wall having an outer edge and an inner edge, an outer wall interconnecting the outer edges of the upper and lower walls, and an inner wall interconnecting the inner edges of the upper and lower walls, an inner portion of the upper wall being angled downwardly into connection with the inner wall and an inner portion of the lower wall being angled upwardly into connection with the inner wall, said upper wall having a substantially horizontally oriented portion extending between said downwardly angled inner portion and the outer wall, and said lower wall having a substantially horizontally oriented portion extending between said upwardly angled inner portion and the outer wall, the inner wall being of less height than the outer wall, and reinforcement means interconnecting said outer and inner walls to resist collapse of said bumper beam when the outer wall is subject to impact, said reinforcement means comprising an elongated web extending the full length of said bumper beam, said web having an outer edge integrally connected to said outer wall midway of the height of said outer wall, said web having an inner edge integrally connected to said inner wall midway of the height of said inner wall, said web throughout its length being U-shaped in section taken transversely of said bumper beam such that for one half of its width said web is arched upwardly and for the other half of its width said web is arched downwardly in a smooth continuous accurate formation, said bumper beam being formed of a lightweight material selected from the group consisting of aluminum, magnesium and plastic. (Stewart, R. L., et al., 1993).

A bumper beam includes an open front section made from a high-strength material such as ultra-high-strength steel (UHSS) material, and further includes a mating back section made of lower-strength material attached to a rear side of the front section along abutting flanges. The front and back sections combine to define different tubular cross sections. The front section can be roll-formed, and the back section can be stamped, thus taking advantage of roll-forming processes' ability to form high-strength materials, while allowing the back section to have a more complicated shape and be stamped. The abutting flanges telescoping overlap in a fore-aft direction of the vehicle and are welded together at locations that potentially experience shear upon impact, but the flanges of the front section are captured within the flanges of the backs section, thus providing impact strength even if the attachment locations shear off. (Heaterington, D.W., et al., 2004).

A bumper beam which can be formed easily by simple bending works is provided. The bumper beam is formed into a U-shaped sectional shape having a vertical wall and upper and lower horizontal walls connected to the vertical wall by bending a sheet of metal plate. Each lengthwise end portion of the metal plate is formed with upper and lower tapering horizontal wall extension parts and an intermediate part separated from the horizontal wall extension parts by cut-out spaces. The intermediate part comprises upper and lower horizontal wall remaining parts separated from the horizontal wall extension parts by the cut-out spaces and a vertical wall extension part. The intermediate part is bent toward opening side of the U-shaped section with the horizontal wall remaining parts stacked and welded to the horizontal wall extension parts. (Wada, T., Akiyama, H., 1995).

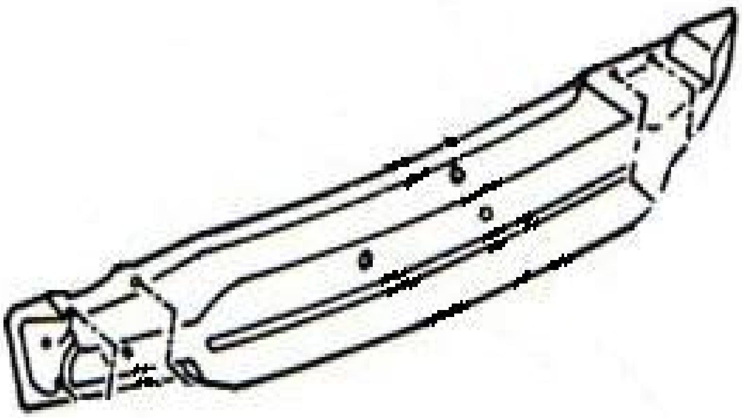


Figure 2.4: Bumper beam (Stamping process)

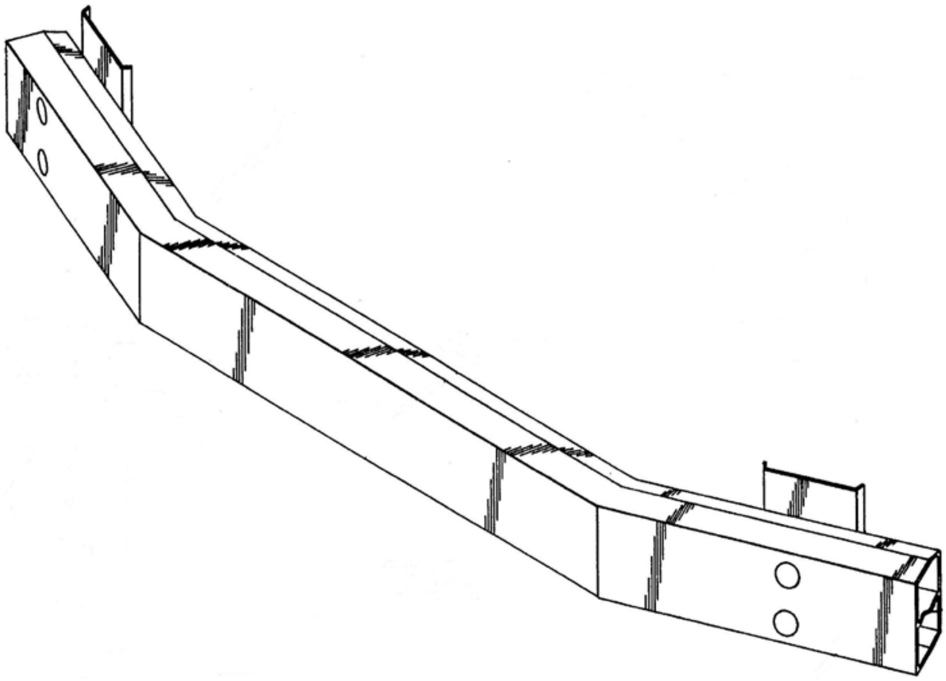


Figure 2.5: Bumper beam (Roll forming process).

CHAPTER 3

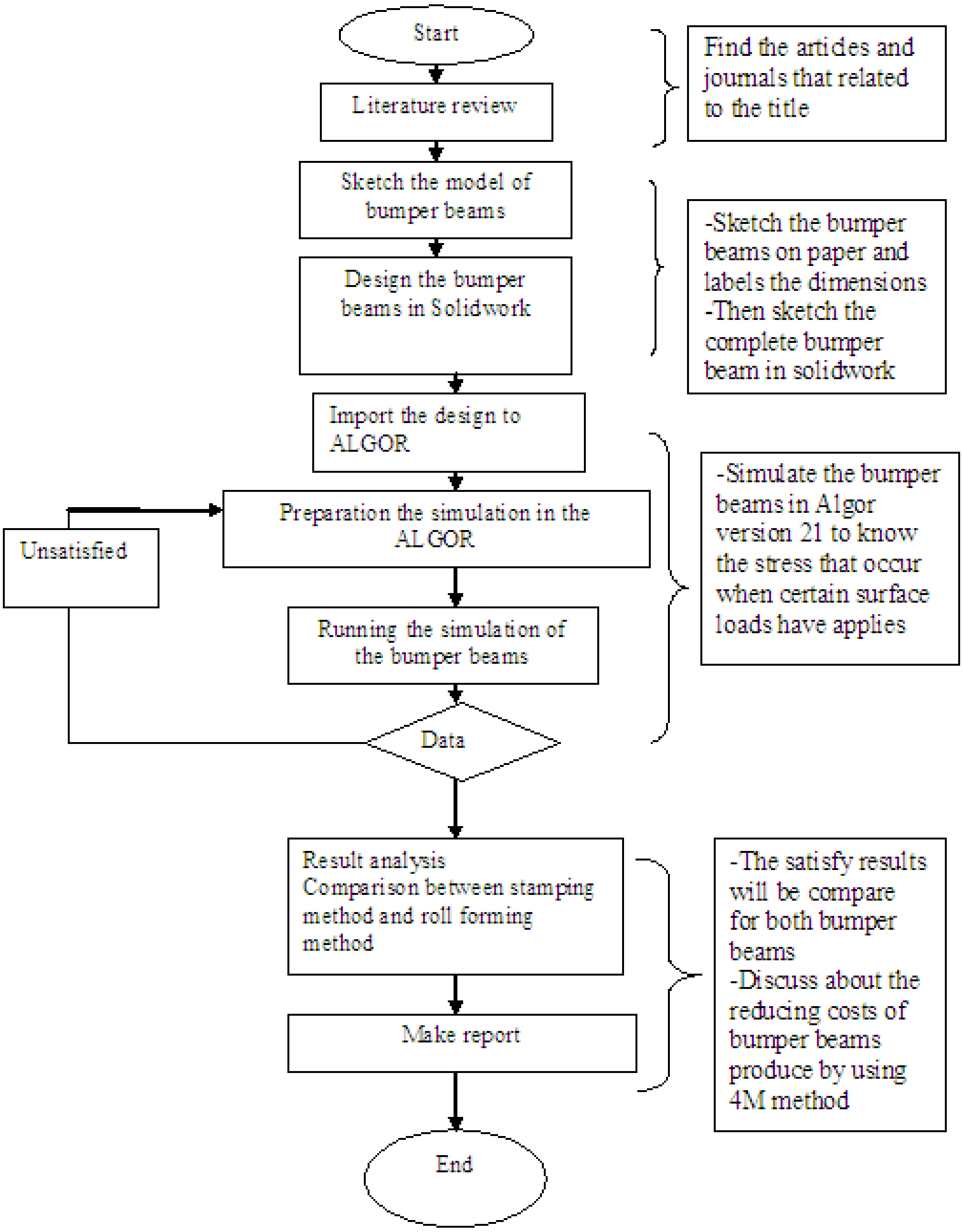
METHODOLOGY

3.1 INTRODUCTION

This chapter will further describe the study framework for the investigation on roll forming and stamping bumper beam. This chapter will be most crucial part in completing this study course. Study flow will going to be smooth by following the right pace of progress. It is also to avoid the research to alter course from the objectives that have been stated or in other words the methodologies can be described as the framework of the research where it contains the elements of work based on the objectives and scope of the research.

By doing the framework the supervisor also can get the overall view of the research and how it is going to be done. This framework can help the supervisor the watch over the progress and at the same time correcting and adding element that is lacking from the research.

3.1.1 Research Methodology and Work Plan



3.2 LITERATURE REVIEW

Methodology of this project begins with the studying on the literature review of the previous analysis and the journal that relate to the roll forming and stamping bumper beam. In the literature review, all of the information needed is retrieved as to increase more knowledge in comprehending the subject matter that is mostly on roll forming bumper beam, stamping bumper beam and etc. For an example before trying to understand what is roll forming bumper beam, the previous method of bumper beam which is stamping has to understand first. So an abundant resource of input has to be digested with enthusiasm. Reading books, browsing the internet, having discussion with supervisor has helped a lot in collecting the resources.

3.3 SKETCH THE MODEL OF BUMPER BEAM

Bumper beam which make by using stamping and roll forming method was sketch and all parameters that related to bumper beam was identified by doing this sketching. This is help students to be easier to design the bumper beam for the analysis in the CAD software. This sketching will be the guidance in order to design it in Solidwork.

3.4 DESIGN THE BUMPER BEAM IN SOLID WORK/CATIA

The CAD software has been utilized by using Solidwork 2005. This software help to sketch complex part compare with Finite Element Model software (ALGOR) that very difficult to sketch complex part.

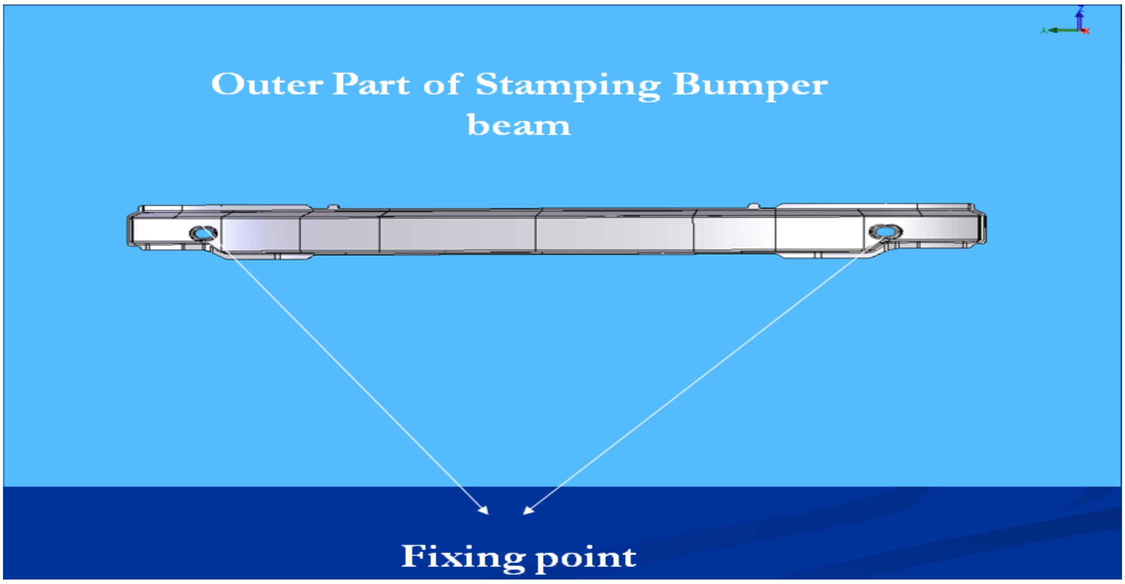


Figure 3.1 Stamping (bracket) bumper beam

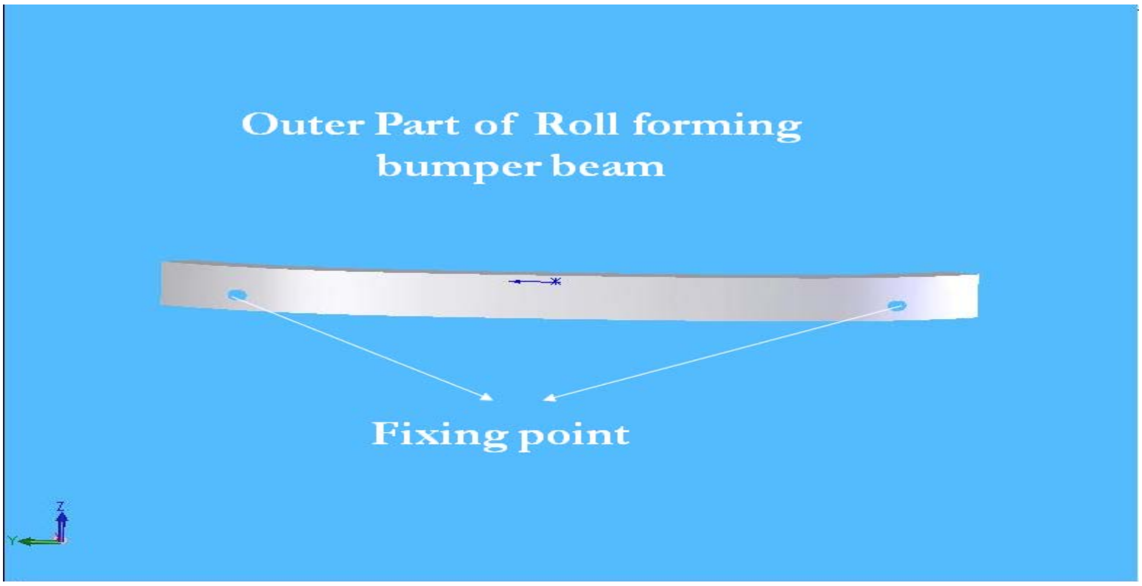


Figure 3.2 Roll forming bumper beam

3.4 IMPORT THE DESIGN TO ALGOR

Both bumper beams that has been design in solidwork will be import to the finite element method software which is Algor in order to make analysis to the bumper beams. Stress analysis will be done in Algor to see the result of using stamping method and roll forming method. If the result indicate that both of it has approximately same value of stress analysis that mean roll forming method can be use to replace stamping method in making of bumper beams. This is because roll forming method offer the low cost for producing bumper beam rather than stamping method that was largely used nowadays.

3.5 PREPARATION THE SIMULATION IN THE ALGOR

The bumper beams that are import to Algor will be analyses. Stress Analysis will be done to the both bumper beams for comparison. For this analysis Algor software version 21 has been choose.

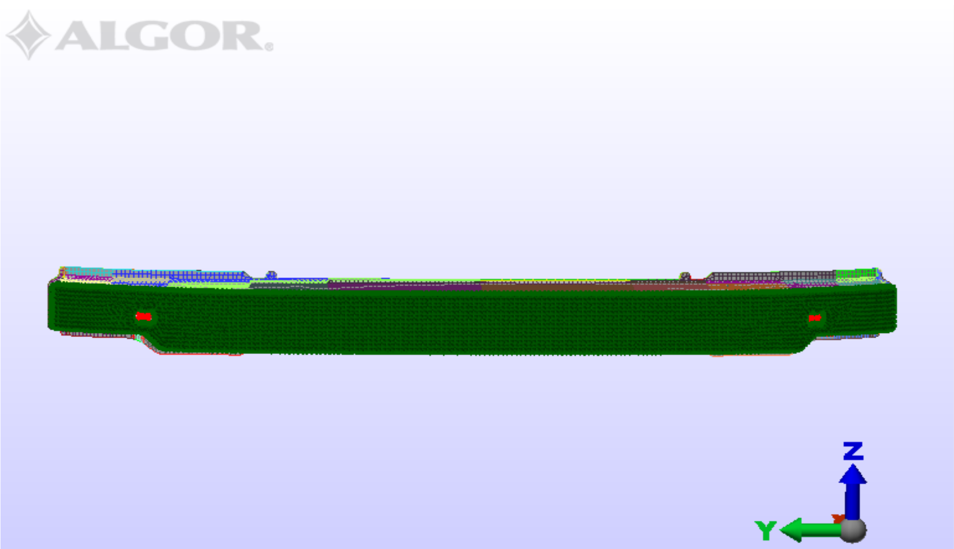


Figure 3.3 Surface loads that have been applied to the stamping bumper beam

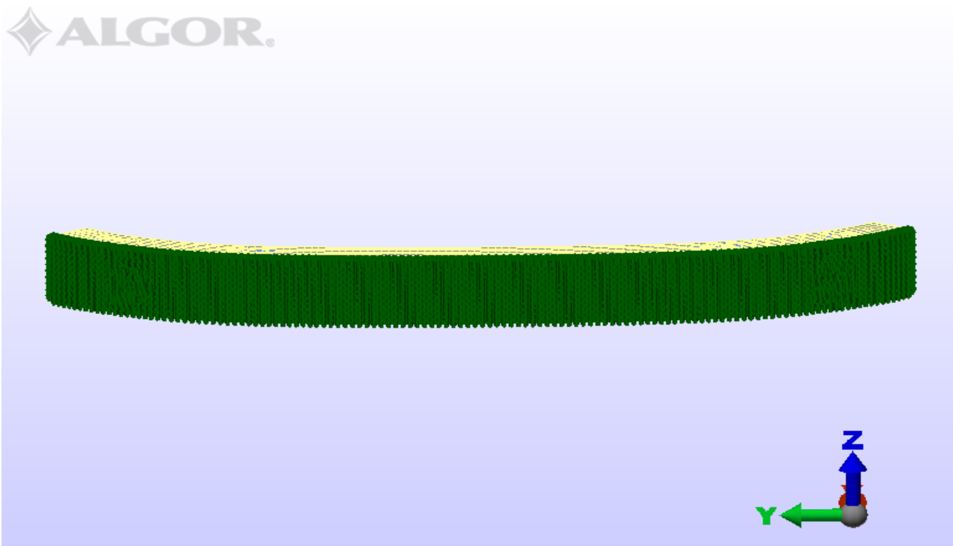


Figure 3.4 Surface loads that have been applied to the roll forming bumper beam

3.6 RUNNING THE SIMULATION OF THE BUMPER BEAM

After all parameters that should be considers has satisfied, the simulation will be running in Algor software to get the results. The results are important in order to make comparison of both bumper beams.

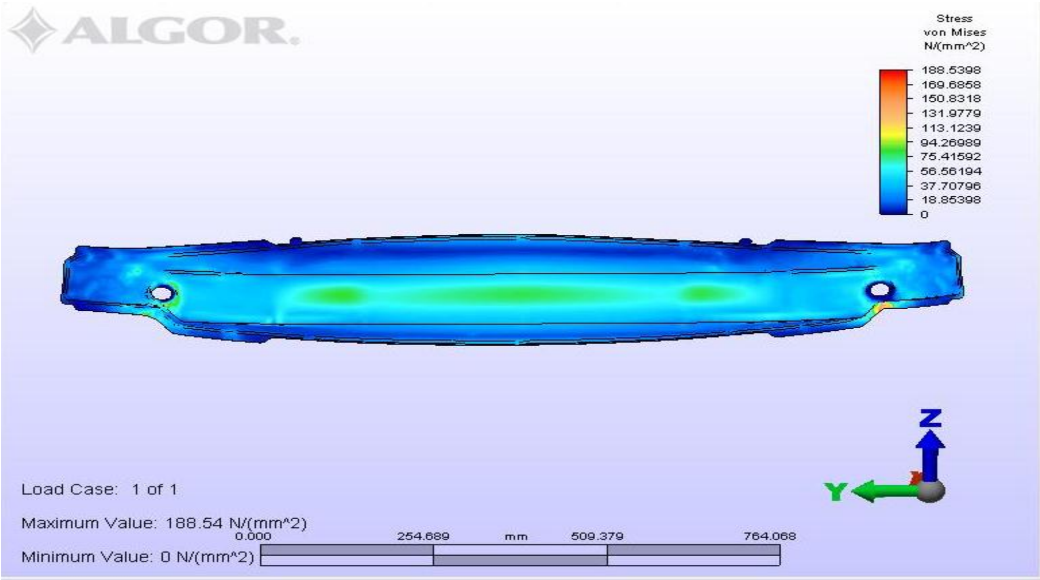


Figure 3.5 Simulation of stamping bumper beam in Algor

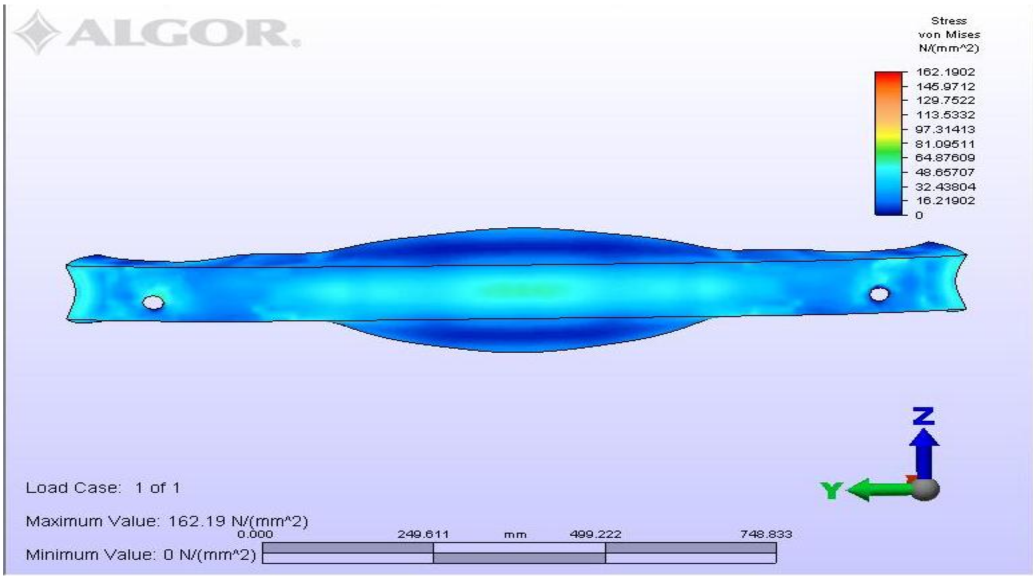


Figure 3.6 Simulation of Roll Forming bumper beam in Algor

3.7 DATA

The data will be collect after running the analysis. The results are very important in order to make comparison. It will be the proof that roll forming method can be use in making bumper beams. Then the cost comparisons between both bumper beams have been calculated. The production cost for both bumper beams have been compared to show the advantages of using roll forming method.

3.8 EXPERIMENTAL RESULT ANALYSIS (COMPARISON BETWEEN STAMPING METHOD AND ROLL FORMING METHOD)

The collected data will be analyzed since the objective of this thesis is to make comparison between stamping and roll forming method. This is the most important part in this thesis because it will show if this thesis success or not.

3.9 MAKE REPORT

Lastly, the conclusion will be build base on the results of the analysis that was done in Algor software. If the results indicate that the stress analysis for roll forming bumper beam is approximately to the stamping bumper beam, that means roll forming method can be use in the future for making bumper beams..

CHAPTER 4

RESULTS AND DISCUSSIONS

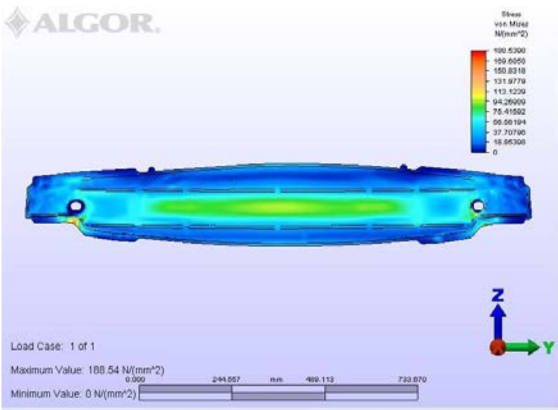
4.1 INTRODUCTION

This chapter discuss about the result obtained from the simulation in the Algor Fempro software. The objective of this chapter is to compare the roll forming and stamping bumper beam in term of strength and cost. From the Algor we can see the von misses stress of both bumper beams. The strength of roll forming bumper beam should be higher to the stamping bumper beam. Overall result obtained come out to be as expected as in the literature review.

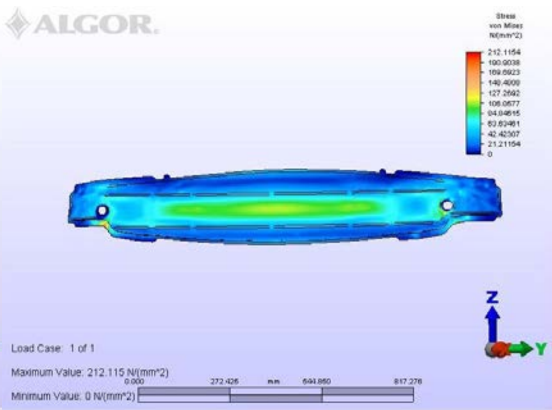
4.2 RESULTS

4.2.1 Results of Stress Analysis for Stamping Bumper Beam

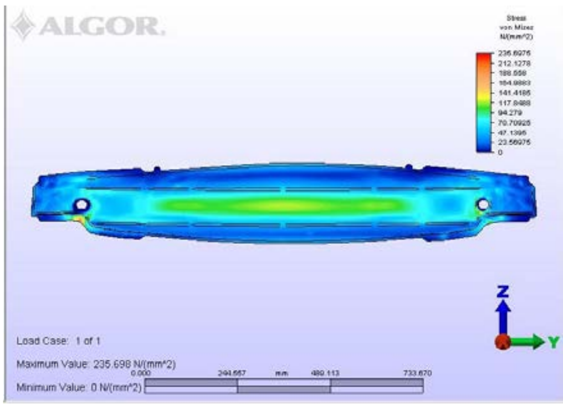
a)



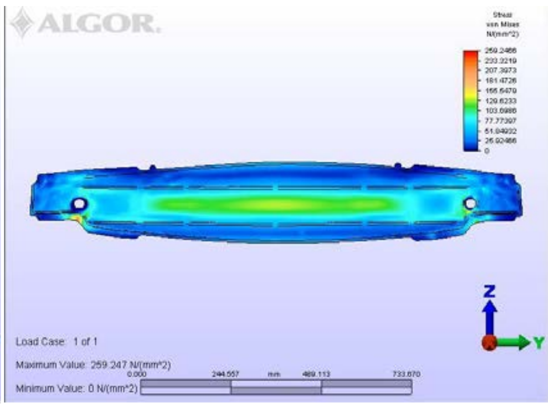
b)



c)



d)



e)

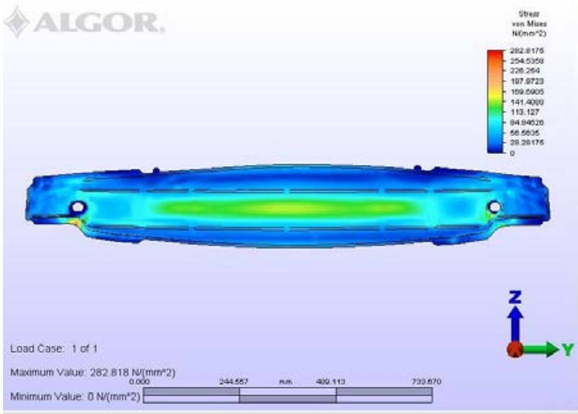
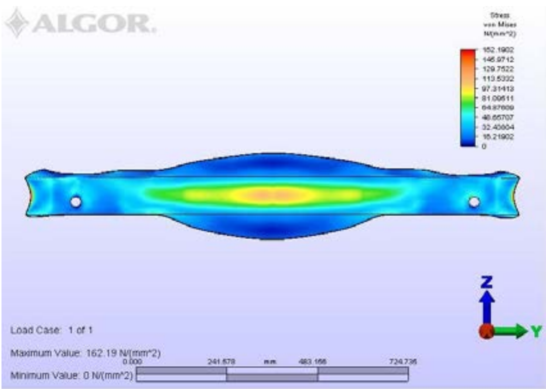


Figure 4.1 Show the stress concentration in variable force for stamping bumper beam ; a)7663.24N,b)8621.48N,c)9579.96N,d)10537.11N,e)11495.23N

4.2.2 Results of Stress Analysis for Roll Forming Bumper Beam

a)



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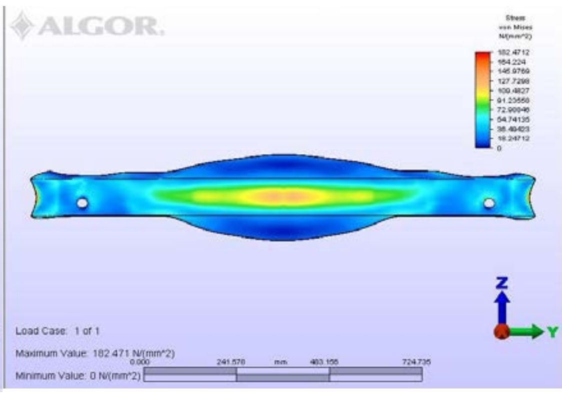
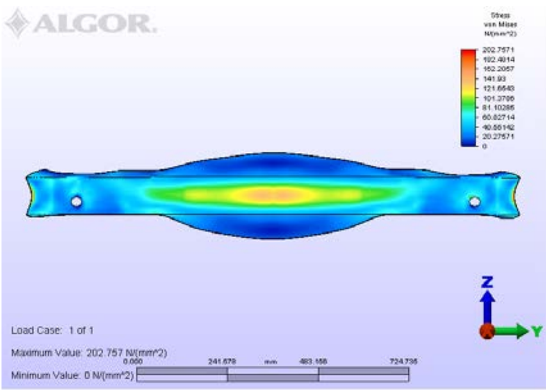
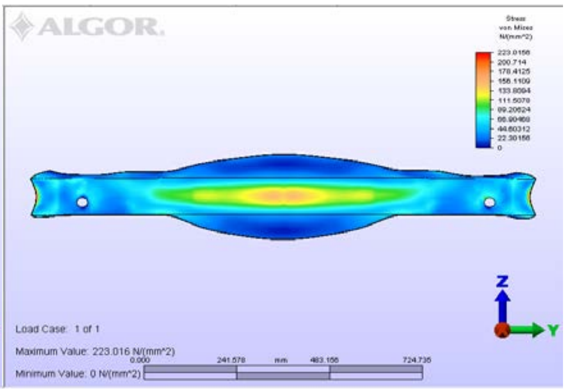


c)



d)



e)

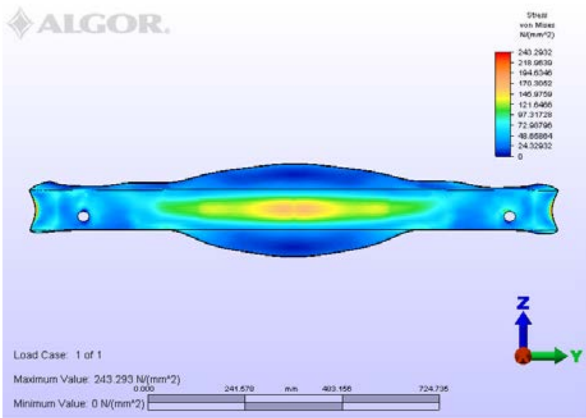


Figure 4.2 Show the stress concentration in variable force for roll forming bumper beam ; a)7663.24N,b)8621.48N,c)9579.96N,d)10537.11N,e)11495.23N

4.2.3 Discussion

In this design, both bumper beams from stamping and roll forming method have been simulated in Algor version 21. The designs are base on Proton Persona 1.6 bumper beam that show in the figure below.

Figure 4.3 Proton Persona Bumper beam

Detailed FE analysis as follows:

(i) In this analysis, 2 bumper beams designs were used as subject of studies:

a) Stamping bumper beam
b) Roll forming beam

(ii) After setting the entire design dimension, the detailed bumper beam geometric models were generating using computer aided design software. In this project, Solidwork 2005 software had been use.

(iii) Then, the creation of mesh using Algor by converting IGES file format from Solidwork into Algor which is then implemented for FE solver (Algor) for finite element analysis.

(iv) For this model, material that were use in making this model is AISI steel 1005 as the bumper beam using SPHC steel in real life but in the Algor this material is not available. This simulation was done by applying static surface load to the front bumper beam.

From the results obtain the critical part appear at the back both bumper beams after the surface loads applied at the front bumper beams. This is because the front bumper beam will having compression stress so that the back of the bumper beam will having tensile stress from the impact of compression stress.

Table 4.1 Von mises Stress of Stamping bumper beam

Surface Load(N)	**Maximum value(N/mm2)**	**Minimum Value(N/mm2)**
7663.24	188.54	0
8621.48	212.12	0
9579.96	235.70	0
10537.11	259.25	0
11495.23	282.82	0

Table 4.2 Von mises Stress of Roll Forming bumper beam

Surface Load(N)	**Maximum value(N/mm2)**	**Minimum Value(N/mm2)**
7663.24	162.19	0
8621.48	182.47	0
9579.96	202.76	0
10537.11	223.02	0
11495.23	243.29	0

Table 4.1: Von mises Strain of Stamping bumper beam

Surface Load(N)	Maximum value(mm/mm)	Minimum Value(mm/mm)
7663.24	0.00121608	0
8621.48	0.00136814	0
9579.96	0.00152025	0
10537.11	0.00167214	0
11495.23	0.00182417	0

Table 4.2: Von mises Strain of Roll Forming bumper beam

Surface Load(N)	Maximum value(mm/mm)	Minimum Value(mm/mm)
7663.24	0.00104613	0
8621.48	0.00117694	0
9579.96	0.00130778	0
10537.11	0.00143845	0
11495.23	0.00156924	0

4.2.4 Discussion of results

The results from Algor show the different value of von mises stress for forces 7663.24N, 8621.48N, 9579.96N, 10537.11N and 11495.23N for stamping and roll forming bumper beam. The maximum and minimum values of stress are increasing when the forces applied are increased. These phenomenons happen to both of bumper beams. The values of stress for both bumper beams showed in table 4.1 and 4.2. These results have been proved that roll forming bumper beam is better than stamping bumper beam in term of stress analysis. This is because when certain surface loads applied on the surface bumper beam the stress occur in stamping bumper beam is higher than roll forming. The higher stresses occur mean the strength of the bumper beam is lower. The roll forming bumper beam results showed that the stresses values are lower than stamping beam. It is important to each bumper beam to have lower stress value because when accident occurs the bumper beam will be function to reduce the impact of the accident. So that roll forming bumper beam is better than stamping bumper beam in term of stress produce when certain surface loads applied to it.

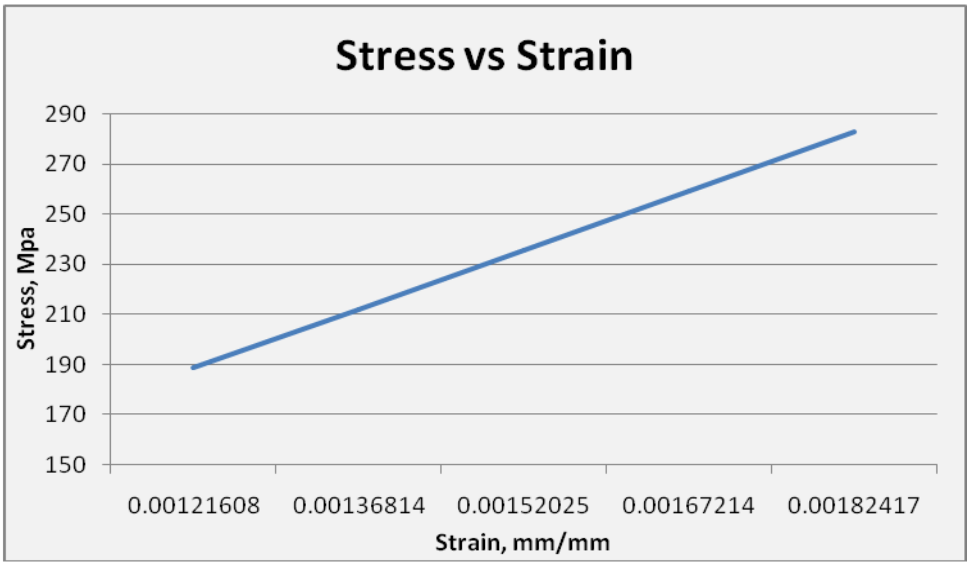


Figure 4.3: Maximum stress-Maximum strain curves for Stamping bumper beam

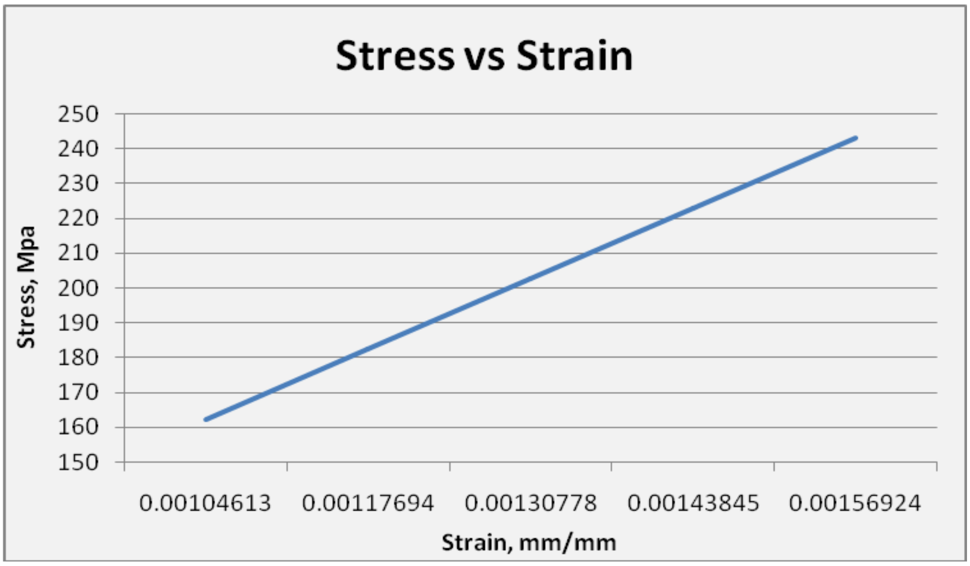


Figure 4.4: Maximum stress-Maximum strain curves for Roll Forming bumper beam

4.2.5 Discussion

From the graph above we can conclude that the strength of both bumper beams are increasing until certain limit it will fracture. In real life bumper beam is manufacture by using SPHC steel but in this Algor analysis the material use is AISI 1005 steel because SPHC steel is not available in this software. The ultimate tensile strength (UTS) of AISI 1005 is 376.3MPa and the yield strength is 284.7MPa. So from the results of simulation the stamping bumper beam highest stress is 282.82MPa and for roll forming bumper beam is 243.29MPa. These results show both bumper beams the stresses are below the UTS of the material. If the stress appear above this UTS the bumper beams with be fracture.

4.3 COMPARISON OF CROSS-SECTION BUMPER BEAMS

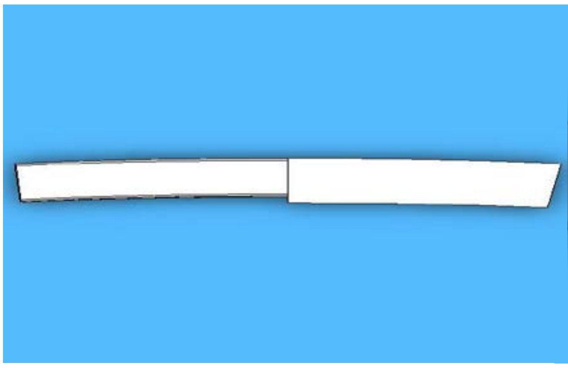


Figure 4.5 Front view

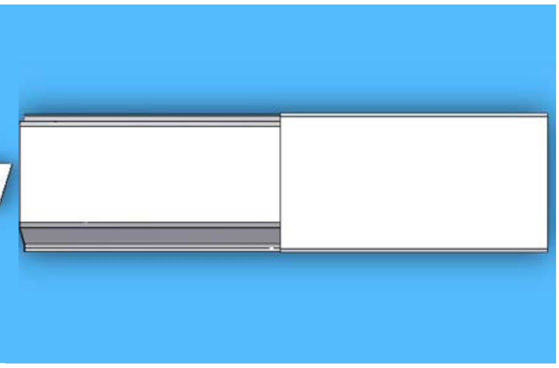


Figure 4.6 Top view

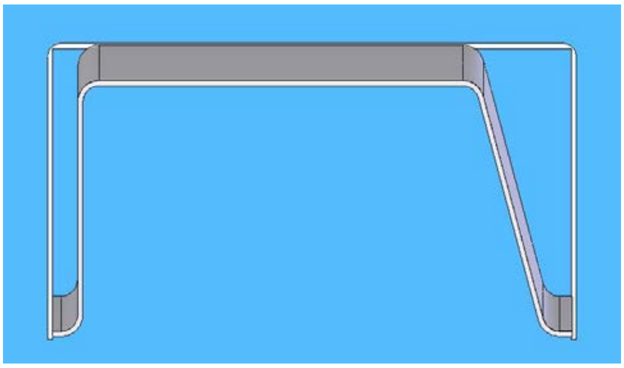


Figure 4.7 Side view

From the figure above the cross-section of roll forming and stamping bumper beam are almost similar. Both bumper beams has been cut by measuring from the middle part until 245.4mm long. This figure has been prove that by using roll forming method also can produce the same cross-section or shape as stamping bumper beam but using less cost. This is because of the factors of material, human and equipments of the machine in roll forming are cheaper than stamping. Material that use in stamping is bigger than roll forming because the material that use in stamping need to put on die before it can be stamp. Furthermore the material will become waste as the blanking material will produce after stamping process. Compare to roll forming, the material that rolls in roll forming machine will not produce blanking material. In term of human, the worker that needs to handle roll forming machine is just only one or two person compare to stamping machine the worker that required handling machine around six people. Stamping process also use a lot of money to design dies for stamp. Each die cost very expensive since it need to import from other countries such as Japan, Korean and Taiwan. So, roll forming is a better process that can replace stamping in term of bumper beam produce.

4.4 ROLL FORMING AND STAMPING BUMPER BEAM COMPARISON

Table 4.3 Roll Forming bumper beam and stamping bumper beam comparison

Item	**Roll forming Bumper Beam**	**Stamping Bumper Beam**
Man	X	
Machine	X	
Method	X	
Material	X	

The table above shows the different between roll forming and stamping bumper beam. These are the main items that need to consider in order producing low cost bumper beam.

4.4.1 Man

In the roll forming process one or two worker needed to handle the machine. This is because the machine of roll forming is smaller than stamping machine. Roll forming just needed a few process but in stamping it use more process likes drawing, trimming, blanking, and flanging. Each process it uses at least one worker to handle machine so that the stamping process use more worker than roll forming.

4.4.1.1 Labours cost estimation

Stamping Machine = 4 persons to handle
Roll forming machine = 1 person to handle

Cost labours for stamping process = RM 600 x 4
= RM 2400

Cost labour for roll forming process = RM 600 x 1
= RM 600

4.4.2 Machine

In term of machines the roll forming use small machines compare to stamping. The cost of machines for both process are expensive but for the stamping machines the cost is higher because the dies that use in stamping are expensive. There was no dies produce in Malaysia. The dies only design in Malaysia but the real dies needed to import from Taiwan, Japan and Korea. So the cost will become expensive.

4.4.2.1 Stamping Machine

The stamping machine used is Polystra Stamping Machinery. The cost of this machine is around 26 Millions.

Table 4.4 Specifications of Stamping Machine

Steel handling		**Foil Handling**	
Max. Speed per Hour	1300-3000	Min. Diameter of Foil	2x90mm
Max. Sheet Size	640x900mm	Max. Width of Foil	870mm
Min. Sheet Size	290x400mm	No. of Foil Pull Units (Servo type)	3
Max. Stamping Area	600x840mm	No. of Rewinding Program (times)	1-99
Min. Grip Distance	8-10mm	No. of Foil rewinding rollers	3 sets
Max. Sheet Thickness	0.65mm		

Heat		**General Specifications**	
No. of Heating Zones	3	Power Supply 3 phase	17KW
No. of Heating Elements	9pcs	Length of Machine	3970mm
No. of Temperature Controllers	3 sets	Width of Machine	2615mm
		Height of Machine	1830mm

Figure 4.8 Stamping Machine

4.4.2.2 Roll forming Machine

The roll forming machine use is Hebei Feixiang roll forming machinery. The cost of this machine is around 3 Millions.

Table 4.5 Specification of roll forming machine

Sheet Thickness	0.3 – 0.8 mm
Forming speed	20 – 24 m per minute
Roller shaft Diameter	70 mm
Roller Stations	Up Down } 15-25
Motor Output	10-20 hp
Length x Width	L 8 – 12 m W 1.4 - 1.8 m

Figure 4.9 Roll Forming Machine

4.4.3 Method

For the method stamping bumper beam using more process to make a bumper beam such as drawing, trimming, blanking, and flanging to produce while roll forming bumper beam just using roll forming machine to produce a bumper beam. Furthermore the bumper beam need to move to each station as in stamping it have 4 step processes that is drawing, trimming, blanking and flanging. Compare to roll forming the bumper beam did not need to move the roller will push it to the next processes.

4.4.4 Material

Both process using same material as a raw material. The material is SPHC but in stamping process the sizes of material use is bigger than roll forming. This is because the materials that need to put on dies should be bigger than the size of dies before it can be stamp.

4.4.4.1 Cost of material Calculation

4.4.4.1.1 Stamping Material

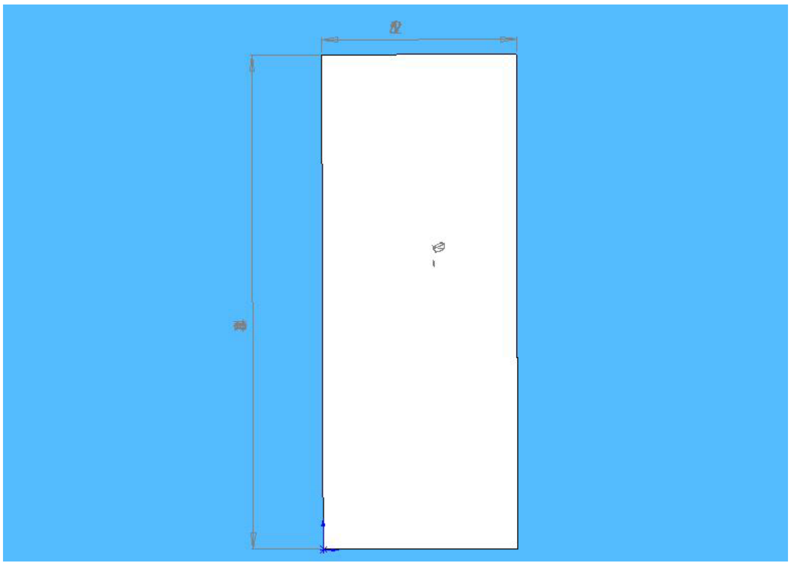


Figure 5.0 Size of Stamping material

Mass of Steel = width x Length x Thickness x density of steel

=561.22mm x 1434.74mm x 1.2mm x 7.85×10^{-6}

=7.585 kg

Cost of material = RM 17 x 7.585

= RM 128.95

4.4.4.1.2 Roll Forming Material

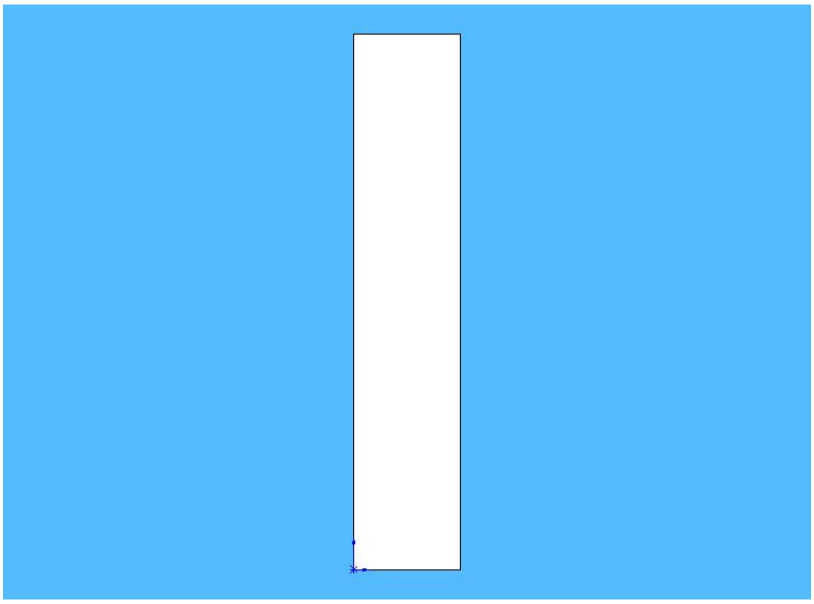


Figure 5.1 Size of Roll Forming material

Mass of Steel = width x Length x Thickness x density of steel

=261.22mm x 1311.60mm x 1.2mm x 7.85×10^{-6}

=3.227 kg

Cost of material = RM 17 x 3.227

= RM 54.86

4.5 COMPARISON OF BOTH MATERIALS

From the above calculation the results show that the mass of roll forming material is lower than stamping material. This is because of in stamping process the material use is bigger than actual size of bumper beam. This is important to use bigger material because the material will be stamp on die. Instead of roll forming, the material use is almost similar to actual size of bumper beam. The calculations show the roll forming use only half of mass of material that use in stamping. The less mass of material mean the price of material use also cheaper. This is because the price of steels depends on the mass. The bigger of the mass steel use the price also will be more expensive. In term of material mass the roll forming provided the lower mass of material usage compare to stamping process. This is proved by the above calculations.

4.6 OVERALL COST PRODUCTION OF BUMPER BEAM

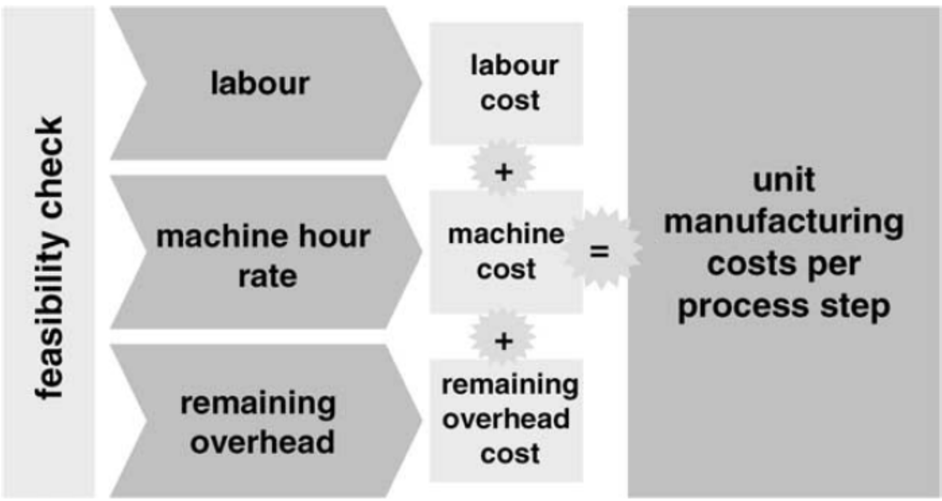


Figure 5.2: The cost of production bumper beam calculation

4.6.1 Stamping Bumper Beam

Cost of production= Labours Cost + Machine Cost + Remaining Overhead
Cost (Dies Cost)
= RM 2400 + RM 26 million + RM 30 000
= RM 26 032 400

4.6.2 Roll Forming Bumper Beam

Cost of production = Labour Cost + Machine Cost + Remaining Overhead
Cost (Roller Cost)
= RM 600 + RM 3 Million + RM 10 000
= RM 3 010 600

4.7 DISCUSSION

From the above calculation it proves that the stamping bumper beam use high production cost compare to roll forming bumper beam. From the costs calculation it shows that stamping bumper beam use about RM 26 032 400 for the production costs instead of roll forming bumper beam it use about only RM 3 010 600 for the production costs. This calculations are proved that the large different about production cost between stamping and roll forming. Using roll forming as the replacement for stamping in making bumper beam make a company can reduce a lot of money.

Table 4.4: SWOT analysis table

	Roll Forming Bumper Beam	**Stamping Bumper Beam**
Strength	The strength of roll forming bumper beam is higher than stamping bumper beam. The workers that need to handle roll forming machine less than stamping.	The stamping machine can make variable shape but roll forming machine can not provide it. Furthermore this process can produce big volume of bumper beam at certain period
Threaten	Roll forming method can not produce variable shape just a long beam	The dies of stamping is expensive and the material that use also bigger than roll forming
Opportunity	By using roll forming the cost of producing bumper beam will be decrease	The mass production of stamping bumper beam is higher compare to roll forming.
Weakness	The process of producing this type of bumper beam is a little bit slow than stamping	This process use a big size of materials and blanking material will become waste

Table 4.5: QCD comparison for both processes

	Roll Forming Bumper Beam	Stamping Bumper Beam
Quality	The quality of roll forming bumper beam is satisfied because the strength of this type of bumper beam is higher than stamping	The quality is satisfy in term of the design of bumper beam produce with variable shape but the strength of bumper beam is lower than roll forming
Cost	The cost of producing bumper beam is lower because of the machine; material and worker that use in roll forming are low cost.	The cost is higher because the dies, worker and material that use are in expensive cost.
Delivery	The bumper beam produce is little bit slowly than stamping.	Time taken for producing bumper beam is faster than roll forming.

4.7 RESULT CONCLUSION

To achieve the objective of this project the analysis must be done and the results must be discussed in order to make sure the results can be use. Two type of bumper beam must be analyzed there are:

(i) Roll Forming Bumper Beam
(ii) Stamping Bumper Beam

From the analysis that have been done, roll forming produce lower stress after certain surface loads have been applied to it. Furthermore the comparison between both bumper beams showed that roll forming bumper beam use lower cost for production compare to stamping bumper beam. As a result both objectives of this project have been achieved.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

As a conclusion, this project on comparison of roll forming and stamping bumper has been completed successfully. From Algor analysis the roll forming bumper beam produce lower stress after certain surface loads have been applied. The results show that the maximum stress for stamping bumper beam is 282. 82 MPa and for the roll forming is 243.29 MPa. These values are below the Ultimate Tensile Strength of the material properties for AISI 1005 Steel that is 376.3 MPa. Roll forming show that for the same value of surface load the stress appear to the bumper beam are less than stamping bumper beam. For the bumper beam it is to have lower stress value when high loads have applied. This is because when accident happens and the car hit something the bumper beam will be function to absorb the impact from the accident. Base on the results that get from Algor analysis this thesis was prove that roll forming is better than stamping bumper beam. Furthermore to produce the roll forming bumper beam also using lower cost compare to stamping bumper beam. It have been proved by some calculation of material sizes, the machines use and the number of worker use to produce roll forming bumper beam are lower than stamping. The production cost of the stamping bumper is about RM 26 032 400 while the roll forming production cost is RM 3 010 600. It is show very large cost different between both process so that a company can reduce a lot of money if they use roll forming as the process for production bumper beam. In the end, all the requirement of the aims and objectives of the project have been fulfilled.

5.1 RECOMMENDATION AND SUGGESTION

There are several steps and procedures that could have been taken to improve the result thus, obtaining more accurate and reliable data. The following steps and procedures are recommended:

(i) Using the advance finite element software likes Nastran Patran and Ls Dyna for analysis the bumper beam to get more accurate results. This is because Algor has a limitation that make it can not simulate precisely.

(ii) The surface loads that apply to bumper beam should be separate into 3 part that are 2 both side and the middle side in order to know the stress concentration of the bumper beam.

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(Access on Saturday, 5 April 2008)

http://www.zycon.com/Products/Automotive-Metal-Stamping.html
(Access on Saturday, 5 April 2008)

APPENDIX A

SURFACE LOADS CALCULATION

Gen-2 car weight=1207kg

Velocity of the car=80km/hr, 90 km/hr, 100 km/hr, 110 km/hr, 120 km/hr

t=12.6s

EXAMPLE OF CALCULATION

Acceleration, $a = \frac{V2-V1}{t}$

$= \frac{80-0}{12.6}$

$= 6.349\ ms^{-2}$

Forces, F= mass x acceleration

=1207 x 6.349

=7663.24N

APPENDIX B

Stamping Machine

Die block

Stamping machine

APPENDIX C

Roll Forming Machine

Coil of material

Roll Forming Machine