INVESTIGATION ON THE DIFFERENT TYPES OF MATERIALS OF JOINING FOR AUTOMOTIVE PANEL

MOHAMAD SUHAIMI BIN SAMSUDIN

A report in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
Universiti Malaysia Pahang

NOVEMBER 2007

ABSTRACT

The technique of joining two or more different panels is called as Tailor Welded Blank (TWB). The panels could vary in thicknesses, grades or coating and joined by the mean of welding. This technique is widely being used by automotive manufacturer in the world because of the abundant benefits. But, Malaysian automotive manufacturers are still lack of this advancement. Hence, this project endeavors to build a platform for the industries by pioneering researches in this area. So, the purpose of the project is to find the best joining materials to be integrated into TWB by comparing each specimen and then proposed the potential TWBs to be used as automotive panel specially aimed for door inner panel for the hinge section. Base metals of 0.7mm thick from SPCC and SPCEN grades and 1.2 mm thick from SPHC, SAPH 370 and SGACC grades are chosen to be the joining materials and laser welding is chosen to be the method for joining. Each specimen will be tensile tested in order to find the properties that influence the weldability, formability and drawability of the TWBs. Then the data obtained will be analyze by distinguishing them into several sets of parameter to determine the significant factor and thus, decided the best material combination as the potential Tailor Welded Blanks.

ABSTRAK

Teknik menyambung dua atau lebih panel dipanggil sebagai Adunan Kepingan Dikimpal atau "Tailor Welded Blank" (TWB). Panel – panel ini boleh berbagai dari segi tebal, gred, salutan yang mana disambungkan melalui teknik kimpalan. Teknik ini digunakan oleh hampir kesemua pengusaha automotif di dunia disebabkan oleh kelebihannya. Tetapi, pengusaha automotif di malaysia masih tertinggal dari segi kemajuan ini. Oleh itu, projek ini berusaha membina asas kepada industri ini dengan memulakan penyelidikan di bidang yang dimaksudkan. Sebagai permulaan, projek ini bertujuan untuk mencari bahan peyambungan terbaik untuk diadaptasikan ke dalam TWB dengan membandingkan setiap spesimen seterusnya memilih kombinasi bahan berpotensi untuk diaplikasikan kepada panel automotif yang dikhususkan kepada panel dalaman pintu bahagian engsel. Kepingan logam dari gred SPCC dan SPCEN berketebalan 0.7mm dan gred SPHC, SAPH 370 dan SGACC berketebalan 1.2mm dipilih sebagai bahan peyambungan dan kimpalan laser dipilih sebagai cara peyambungan. Setiap spesimen akan diuji untuk mencari elemen yang mempengaruhi kebolehubahan, kebolehtarikan, dan kebolehkimpalan sesuatu TWB. Data yang didapati akan dianalisis dengan membezakan setiap spesimen kepada beberapa parameter untuk mementukan faktor-faktor yang mempengaruhi dan seterusnya memilih kombinasi bahan terbaik yang berpotensi dijadikan sebagai TWB.

TABLE OF CONTENTS

2 LITERATURE REVIEW

3 METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	-	Area
E	-	Modulus of Elasticity
e	-	Strain
F	-	Force
L_i	-	Instantaneous length
L_o	-	Initial length
P	-	Pressure
ΔL	-	Change in length
ε	-	Strain
σ	-	Stress

LIST OF ABBREVIATIONS

CQ	-	Commercials Quality
CR	-	Cold Rolled
DDQ	-	Deep Draw Quality
HR	-	Hot Rolled
JIS	-	Japanese Industrial Standards
SAPH	-	Hot Rolled Steel Sheet for Automobile Structural Uses
SGACC	-	Hot Dip Galvanized Cold Roll Steel Sheet with Commercial Quality
SPCC	-	Cold Rolled Steel Sheet with Commercial Quality
SPCEN	-	Cold Rolled Steel Sheet with Deep Drawing Quality
SPHC	-	Hot Rolled Steel Sheet with Commercial Quality
TWB	-	Tailor Welded Blanks
UTS	-	Ultimate Tensile Strength
YS	-	Yield Strength

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

During the past two decades, government fuel conservation and safety mandates along with environmental concerns have prompted the automotive industry to design lighter cars for reduced fuel consumption, while improving the overall structure of their vehicles for occupant safety. Corrosion protection was also much improved during this period. These changes added to escalating manufacturing costs at a time when the industry was struggling with a serious threat from global competition.

To reduce weight and costs, alternative materials such as aluminum and composite materials have been proposed and used for body panels, but none has shown the versatility of steel. High strength steels, coated steels, laminated steels and various drawing quality grades give steel the ability to meet most automotive requirements.

In conventional door, normal inner panel and bracket are two different parts. This method cost lots of money due to materials, dies, welding, assemblies, storage and logistic. By combining these two components into a single blank those difficulties can be reduce and allows automobiles to be manufactured more efficiently. As a result, a process called tailor welded blank has been developed and adapted by most automotive manufacturer nowadays. Not only door panel but also

others automotive panel employ this technique. So the aim of this study is to investigate whether the materials chosen are suitable for automotive door inner panel using the same concept of tailor welded blank.

1.2 Problem statements

i) The increasing demand for improved fuel efficiency and environmental concerns make the automotive industry to industry to design lighter cars for reduced fuel consumption.

ii) To reduce costs by using steels rather than highly cost alternative material.

1.3 Project Aim and Objectives

The aim of the project is to find the best joining materials for automotive door inner panel to be used in Tailor Welded Blank (TWB) technique. The objectives this study is to:

i) To compare the specimens after investigation in finding the best result.

ii) Propose new material combination to be applied in TWB process.

1.4 Project Scopes

This study will investigate on different type of material of joining by using automotive steel panel that are SPCC, SPCEN, SPHC, SGACC, and SAPH 370. The panels grades are chosen from normal draw, extra draw, galvanized and structural steels that typically used in automotive fields. To imitate the actual TWB panels,

method of welding two small panels with different thicknesses and properties will be done. The testing will be done by using tensile test machine.

CHAPTER 2

LITERATURE REVIEW

2.1 Tailor Welded Blanks

Tailor welded blank, where multiple sheets of material are welded together prior to the forming process. The differences in the material within a TWB can be in the thickness, grade, or coating of the material (Kinsey and Cao, 2003).

Tailor Welded Blanks (TWB) are those in which sheets of different thickness and/or properties are joined by laser, seam or plasma welding before press forming (Anon, 2004).

Tailor-welded blanks (TWB) are comprised of two or more sheets of metal which has dissimilar strength or thickness that are welded into a single blank. Tailor Welded Blanks are stamped into automotive body panels and offer reduced part weight and improved material use (Anon, 2004).

A tailor welded blank is composed of more than two materials with similar or different strengths or thicknesses joined together to form a single part before the forming operation. The main advantage of using a TWB is that it gives thicker or stronger materials at critical parts of the sheet metal blank so as to increase the local stiffness. This can also reduce the weight of automotive panels (Anon, 2003).

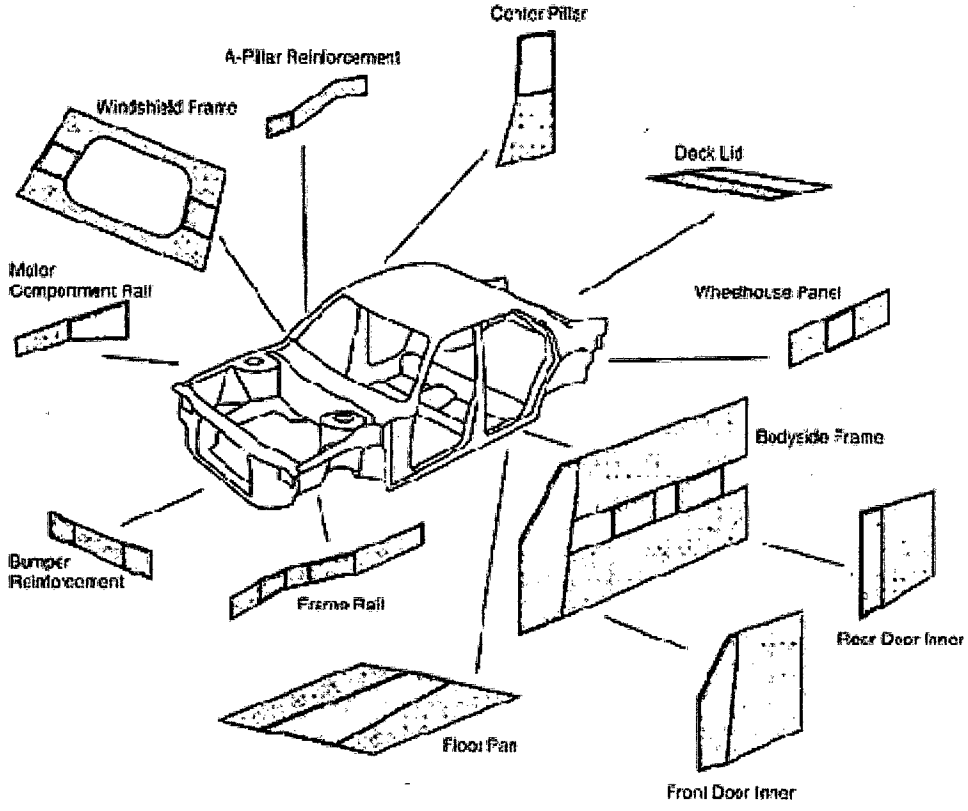

Figure 2.1: Examples of typical use of Tailor Welded Blanks (Anon, 1995)

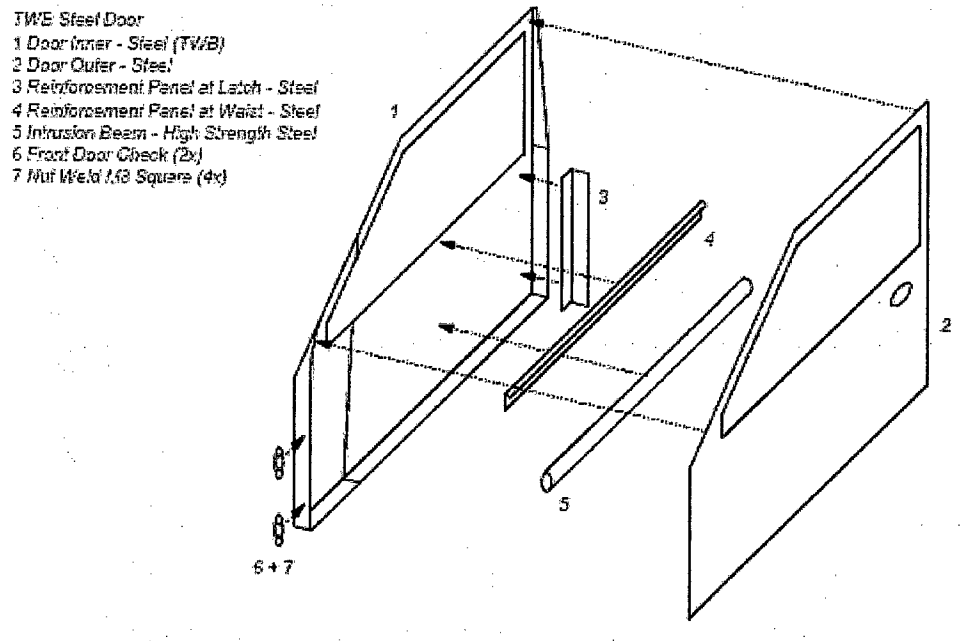

Figure 2.2: Steel door with tailor welded inner panel (Anon, 1999)

Types of welds which are used or have been considered for Tailor Welded Blanks include:

i) Laser Beam
ii) Resistance Mash Seam
iii) High-Frequency Induction
iv) Electron Beam (non-vacuum)

(Anon, 1995)

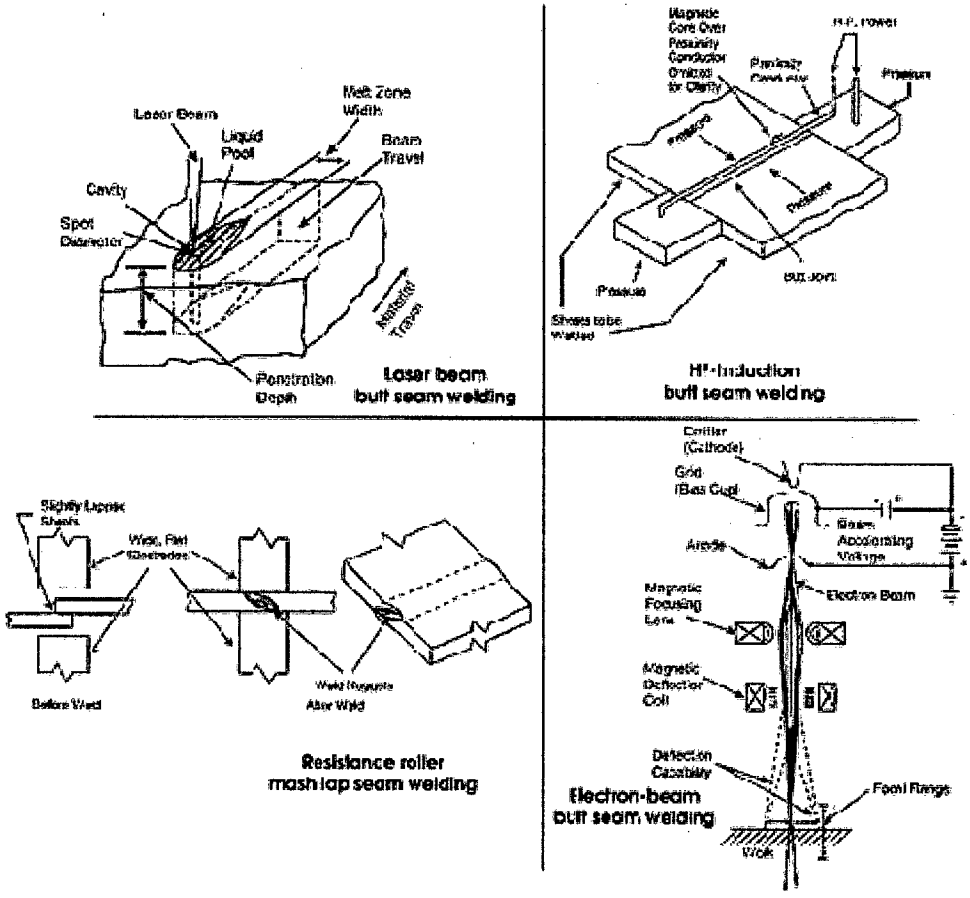

Figure 2.3: Welding types used for Tailor Welded Blanks (Anon, 1995).

2.2 Automotive Panels

There are many types of automotive panels depends on process, grades, coatings and thicknesses. One of the main producers of the material is coming from Japan and Korea and also they are the main player in these industries. So, Japanese Industrial Standards (JIS) is chosen for material grading through this entire project.

2.2.1 Hot Rolled (HR) Steel Sheet

Steel sheets produced right after hot rolling processes are called Hot Rolled Steel Sheet. There are many types of Hot Rolled Steel Sheet for example SPHC, SPHD, SPHE, SPFH, SAPH and etc. The abbreviations stated are named according to Japanese Industrial Standard (JIS) grade. Come in various length, width and thicknesses according to manufacturers.

2.2.1.1SPHC

SPHC is defined as Hot Rolled Steel Sheet with Commercial Quality (CQ). This type of sheet is used for general purposes such as general forming and deep drawing process.

SPHC in Japanese Industrial Standard (JIS) are coded under:

JIS G 3131: 2005 - Hot rolled mild steel plates, sheets and strips.

Table 2.1: Mechanical properties and chemical composition of JIS G 3131 hot rolled mild steel sheets and strips

Designation	Chemical Composition, %				Tensile Test	
					Tensile Strength N/mm²	Elongation, % Thickness 1.2 mm to 1.6 mm excl.
	C	Mn	P	S		
SPHC	0.15 max.	0.60 max.	0.050 max.	0.050 max.	270 min.	27 min.
SPHD	0.10 max.	0.50 max.	0.040 max.	0.040 max.	270 min.	30 min.
SPHE	0.10 max.	0.50 max.	0.030 max.	0.035 max.	270 min.	31 min.
SPHF	0.08 max.	0.50 max.	0.025 max.	0.025 max.	270 min.	37 min.

Table 2.2: Comparison of JIS specification with similar standards

	JIS	ASTM	BS	(DIN)	ISO
Hot-Rolled Mild Steel Sheets and Strip	G3131 SPHC	A569	BS 1449-HR14 BS 1449-HR15	DIN 1614-StW22	ISO 3573-HR1, 2, 3, 4 ISO 6317-HR1, 2, 3, 4
	G3131 SPHD	A621	BS 1449-HR3 BS 1449-HR4	DIN 1614-StW23	
	G3131 SPHE	A622	BS 1449-HR1 BS 1449-HR2	DIN 1614-StW24	

2.2.1.2 SAPH 370

SAPH is defined as Hot Rolled Steel Sheet for Automobile Structural Uses. This type of steel is outstanding in strength, drawability and weldability that are used for automobile frame, wheels and other parts.

SAPH in Japanese Industrial Standard (JIS) are coded under:

JIS G 3113:2006 – Hot rolled steel plate, sheet and strip for automobile structural uses.

Table 2.3: Mechanical properties and chemical composition of JIS G 3113 hot rolled steel sheet and strip for automobile structural uses

Designation	Chemical Composition, %		Tensile Test					
			Yield Point, N/mm²			Tensile Strength N/mm²	Elongation, %	
	P	S	Thickness 6 mm under	Thickness 6 mm to 8 mm excl.	Thickness 8 mm to 14 mm incl.		Thickness 1.6 mm to 2.0 mm excl.	Thickness 2.0 mm to 2.5 mm excl.
SAPH310	0.040 max.	0.040 max.	(185 min.)	(185 min.)	(175 min.)	310 min.	33 min.	34 min.
SAPH370	0.040 max.	0.040 max.	225 min.	225 min.	215 min.	370 min.	32 min.	33 min.
SAPH400	0.040 max.	0.040 max.	255 min.	235 min.	235 min.	400 min.	31 min.	32 min.
SAPH440	0.040 max.	0.040 max.	305 min.	295 min.	275 min.	440 min.	29 min.	30 min.

2.2.2 Cold Rolled (CR) Steel Sheet

Steel sheets produced after cold rolling processes are called Cold Rolled Steel Sheet. There are many types of Cold Rolled Steel Sheet for example SPCC, SPCC-T, SPCD, SPCE, SPCEN, SPFC (JIS grade) and etc. These types of steel are applied to

various fields including automotives, electric household appliances, and furniture office equipment.

2.2.2.1 SPCC

SPCC defined as Cold Rolled Steel Sheet with Commercial Quality (CQ). These types of steel are best suited for automobiles, electrical appliances, etc due to wider workable range.

SPCC in Japanese Industrial Standard (JIS) is coded under:

JIS G 3141: 2005 – Cold-reduced rolled carbon steel sheets and strips

2.2.2.2 SPCEN

SPCEN is defined as Cold Rolled Steel Sheet with Deep Drawing Quality (DDQ). These types of steel are best suited for automobiles, electrical appliances, etc due to wider workable range.

SPCEN in Japanese Industrial Standard (JIS) are coded same as SPCC:

JIS G 3141: 2005 – Cold-reduced rolled carbon steel sheets and strips

Table 2.4: Mechanical properties of JIS G 3141 cold rolled mild steel sheets and strips.

Type	Classification	Test: Classification according to nominal thickness (mm) / Tempering Symbol / Designation		Tension test: Yield point or yield strength (N/mm²) 0.25≦t	Tensile strength (N/mm²) 0.25≦t	Elongation min. % 0.60≦t<1.0
Standard cold-rolled steel sheets and coils *1 (JIS G 3141)	Commercial quality	SPCC	S, 8, 4, 2, 1		—	—
		SPCCT			270≦	36
	Drawing quality	SPCD	S	(≦240)	270≦	38
	Deep drawing quality	SPCE	S	(≦220)	270≦	40
		SPCF	S	(≦210)	270≦	42
	Extra-deep drawing quality	SPCG	S	(≦190)	270≦	44

Table 2.5: Chemical composition of JIS G 3141 cold rolled mild steel sheets and strips

Designation	C	Mn	P	S
SPCC	≦0.15	≦0.60	≦0.100	≦0.050
SPCD	≦0.12	≦0.50	≦0.040	≦0.040
SPCE	≦0.10	≦0.45	≦0.030	≦0.030
SPCF	≦0.08	≦0.45	≦0.030	≦0.030
SPCG(※)	≦0.02	≦0.25	≦0.020	≦0.020

2.2.3 Hot Dip Galvanized Steel Sheet

Hot-dip galvanized steel sheets are produced by applying a coating of molten zinc to the surface of hot-rolled or cold-rolled base material by the "hot dip" galvanizing process. There are much type of grade for example SGAHC, SGACC, SGACD, and etc. Having an excellent corrosion resistance, these products are used in a wide range of fields such as automotive, electric appliance, and building material applications.

2.2.3.1 SGACC

SGACC is defined as Hot Dip Galvanized Cold Roll Steel Sheet with Commercial Quality (CQ). This type of steel is use inner and outer panel of automobiles. Also use as fuel tanks.

SGACC in Japanese Industrial Standard (JIS) are coded under:

JIS G 3302: 2005 – Hot-dip zinc-coated steel sheets and coils

Table 2.6: Mechanical properties JIS G 3302 cold rolled hot-dip galvanized

Classification	Thickness mm	Yield Point min. Kg/m²	Tensile Strength min. Kg/m²	Elongation min. % Thickness mm		
				0.4025and over, under 0.60	0.6025and over, under 1.0	1.025and over, under 1.6
SGCC		-	-	-	-	-
SGCD1		-	28	34	36	37
SGCD 2		-	28	36	38	39
SGCD 3		-	28	38	40	41
SGCD 3N		-	28	38	40	41

Table 2.7: Comparison of JIS specification with similar standards

Classification / Standards	JIS G3302	ASTM		EN10142
		89	95	
Commercial	SGCC	A526	A 653-CQ	DX51D
Lock forming	SGCD1	A527	A 653-LFQ	-
Drawing	SGCD 2	A528	A 653-DQ	DX52D
Deep drawing	SGCD 3	-	-	DX53D
Non-Aging Deep Drawing	SGCD 3N	A642	A 653-DQSK	DX54D
Non-Aging Extra Deep Drawing	-	-	-	-

2.3 Laser-Beam Welding (LBW)

To produce a fusion weld, Laser-beam Welding utilizes a high-power laser beam as the source of heat. It has high energy density and, therefore, deep-penetrating capability because the beam can be focused onto a very small area. The beam can be directed, shaped, and focused precisely on the workpieces.

Laser-beam Welding creates good quality welds with minimum shrinkage and distortion. This type of welds have good strength and generally ductile and free of porosity. The process can be automated and can be used on a variety of materials thickness of up to 25mm (1in.). It is particularly effective in thin workpices.

Laser welding techniques nowadays are highly developed resulting very strong weld joints. Significant flexibility in product design, structural stiffness, crash