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Fabrication and Analysis of Thermo Plastics Welding

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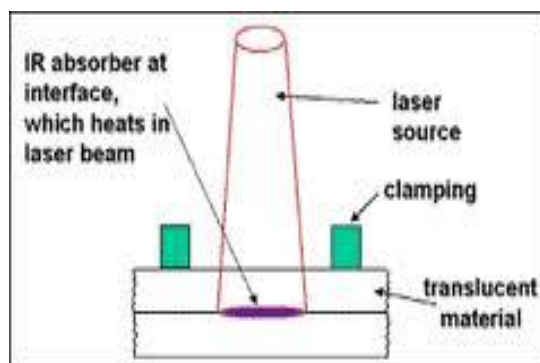
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I. INTRODUCTION

Plastic welding is also called as heat sealing, which is the process for welding or joining plastic work pieces. Thermoplastics like Polyethylene, Polypropylene, Polyvinyl Chloride, Polyurethane and Acrylonitrile Butadiene Styrene (ABS) are frequently used in plastic welding. Plastics that can be welded are called “*thermoplastics*” and when they are heated to a sufficiently high temperature they will soften and welded.

INFRAREDLAMP WELDING OF THERMOPLASTICS

This technique is also capable of handling large surface area products, as it is a simple operation to add more emitters to the heating bank



Infrared lamp welding

The newly developed, high power short wave infrared emitter is also proving more efficient and effective than infrared emitters previously considered for welding applications. Its high power density, developed at a lower operating temperature, means that it can transfer energy more efficiently than halogen emitters, while its lower mass filament makes it more responsive than ceramic emitters.

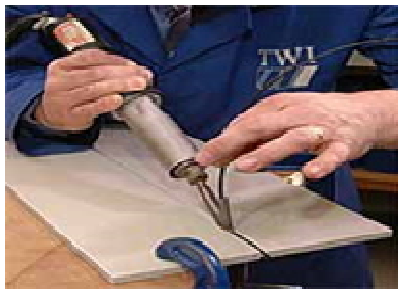
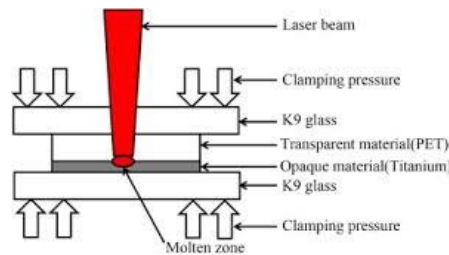
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LASER TRANSMISSION WELDING OF THERMOPLASTICS

When the heating phase was analyzed, it was seen that if the part absorbs the beam has high absorption the laser beam has a high absorption constant, this process can be readily described by a physic mathematical model, by analogy to single sided heat impulse welding.



Hot Gas Welding



Extrusion Welding



Butt Fusion Welding

PLASTIC WELDING ROD

Thermoplastics like Polyethylene, Polypropylene, Polyvinyl Chloride, Polyurethane and Acrylonitrile Butadiene Styrene (ABS) are frequently used in plastic welding. Plastics that can be welded are called “*thermoplastics*”. The thermosetting plastics are straight opposite to the thermoplastics in nature. In PLASTIC WELDING GUN both thermoplastics and thermosetting plastics can be welded. But the common fact in this material is both parent material and welding rod material should be same to execute the operation. It means that the defected part that to be welded and the welding rod must be similar in material. Also they must be similar in all aspects like properties and characteristics. Only then it is quite possible to execute the operation.

II. THERMOPLASTICS

Thermoplastic welding has been successfully used for over 30 years. It is a process that most people can learn to do in a very short time. Many products today are made with thermoplastics. Up till now there has been no simple means for repairing these plastics. The Malcom plastic welding kit has all the tools needed to perform most plastic welding repairs and fabrication work. In order to weld plastics, you must first have some basic understanding of what plastics are the various types of welds commonly used and an understanding of the differences of tack welding, pendulum welding and speed welding. The Plastic Welding School plastic welding instruction booklet is a basic training book that will help you understand what plastics are, the basics of welding plastics and how to fabricate and perform plastic repairs. Only through practice welding will confidence be achieved to begin fabrication and perform repairs.

The necessary conditions for welding are:

1. A plastic joining area.
2. The merging of the plastic materials.
3. A heat source. (Leister tools)

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4. The coordination of the process of the most important factors of heat - pressure - time
5. Only plastics that are thermoplastics can be welded and only like thermoplastics can be welded.

Each thermoplastic has a particular melting temperature and viscosity, therefore, it should be noted that only the same thermoplastics could be welded to each other.

Some thermoplastics, on account of their very high molecular mass, do not achieve a sufficient ability to flow and cannot be welded. The ideal welding temperature varies between the various types of plastics. The Leister tools allow you to dial in the correct temperatures of the various plastics that you may encounter.

CODE OF THERMOPLASTICS

The codes of thermoplastics are derived in detail as follows. The codes are nothing but the abbreviations. As the names of these plastics are somewhat difficult to pronounce and remember, the codes are derived. So it becomes simpler to pronounce and remember. In markets we can find only the codes of the plastics, not the expansions.

ABS	:	Acrylonitrile Butadiene Styrene
ABS/PC	:	Polymer alloy of above
PA	:	Polyamide (Nylon)
PBT	:	Polybutylen Terephthalate (POCAN)
PC	:	Polycarbonate
PE	:	Polyethylene
PP	:	Polypropylene
PP/EPDM	:	Polypropylene/Ethylenediene Rubber
PUR	:	Polyurethane (Not all PUR is weldable)
PVC	:	Polyvinyl Chloride
GRP/SMC	:	Glass Fiber Reinforced Plastics (Not weldable)

ACRYLONITRILE BUTADIENE STYRENE (ABS)

Acrylonitrile butadiene styrene is a common thermoplastic. Its glass transition temperature (ABS is amorphous and therefore has no true melting point) is approximately 105 °C (221 °F). It is a copolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. The proportions can vary from 15 to 35% acrylonitrile, 5 to 30% butadiene and 40 to 60% styrene. For the majority of applications, ABS can be used between -20 and 80 °C (-4 and 176 °F) as its mechanical properties vary with temperature. The properties are created by rubber toughening, where fine particles of elastomer are distributed throughout the rigid matrix. Production of 1 kg of ABS requires the equivalent of about 2 kg of petroleum for raw materials and energy. It can also be recycled. ABS plastic is damaged by sunlight. This caused one of the most widespread and expensive automobile recalls in US history.

PROPERTIES OF ABS:

ABS is derived from acrylonitrile, butadiene, and styrene. Acrylonitrile is a synthetic monomer produced from propylene and ammonia. The advantage of ABS is that this material combines the strength and rigidity of the acrylonitrile and styrene polymers with the toughness of the polybutadiene rubber. The most important mechanical properties of ABS are impact resistance and toughness. A variety of modifications can be made to improve impact resistance, toughness, and heat resistance. The impact resistance can be amplified by increasing the proportions of polybutadiene in relation to styrene and also acrylonitrile, although this causes changes in other properties. Generally ABS would have useful characteristics within a temperature range from -20 to 80 °C (-4 to 176 °F). Fibers (usually glass fibers) and additives can be mixed in the resin pellets to make the final product strong and raise the operating range to as high as 80 °C (176 °F). Pigments can also be added, as the raw material original color is translucent ivory to white. The aging characteristics of the polymers are largely influenced by the poly butadiene content.

POLYIMIDE (PA)

Polyimide (sometimes abbreviated PI) is a polymer of imide monomers. Polyimides have been in mass production since 1955. Typical monomers include pyromellitic dianhydride. Thermosetting polyimides are known for thermal stability, good chemical resistance, excellent mechanical properties, and characteristic orange/yellow color.

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PROPERTIES OF PA

Polyimides compounded with graphite or glass fiber reinforcements have flexural strengths of up to 50,000 p.s.i. (345 MPa) and flexural moduli of 3 million p.s.i. (20,684 MPa). Thermoset polyimides exhibit very low creep and high tensile strength. These properties are maintained during continuous use to temperatures of 450 °F (232 °C) and for short excursions, as high as 900 °F (482 °C). Molded polyimide parts and laminates have very good heat resistance. Normal operating temperatures for such parts and laminates range from cryogenic to those exceeding 500 °F (260 °C).

Polyamides' are also inherently resistant to flame combustion and do not usually need to be mixed with flame retardants. Most carry a UL rating of VTM-0. Polyimide laminates have a flexural strength half life at 480 °F (249 °C) of 400 hours.

POLYBUTYLENE TEREPHTHALATE (PBT) Polybutylene terephthalate (PBT) is a thermoplastic engineering polymer, that is used as an insulator in the electrical and electronics industries. It is a thermoplastic (semi) crystalline polymer, and a type of polyester.

PBT is resistant to solvents, shrinks very little during forming, is mechanically strong, heat-resistant up to 150 °C (or 200 °C with glass-fiber reinforcement) and can be treated with flame retardants to make it noncombustible.

PROPERTIES OF PBT:

PBT is closely related to other thermoplastic polyesters. Compared to PET (polyethylene terephthalate), PBT has slightly lower strength and rigidity, slightly better impact resistance, and a slightly lower glass transition temperature. PBT and PET are sensitive to hot water above 60 °C (140 °F). PBT and PET need UV protection if used outdoors, and most grades of these polyesters are flammable, although additives can be used to improve both UV and flammability properties.

POLYCARBONATE (PC)

Polycarbonates, known by the trademarked names Lexan, Makrolon, MakrocLEAR and others, are a particular group of thermoplastic polymers. They are easily worked, molded, and thermoformed. Because of these properties, polycarbonates find many applications. Polycarbonates do not have a unique plastic identification code.

PROPERTIES OF PC:

Polycarbonate is a very durable material. Although it has high impact-resistance, it has low scratch-resistance and so a hard coating is applied to polycarbonate eyewear lenses and polycarbonate exterior automotive components.

Polycarbonate has a glass transition temperature of about 150 °C (302 °F), so it softens gradually above this point and flows above about 300 °C (572 °F). Tools must be held at high temperatures, generally above 80 °C (176 °F) to make strain- and stress-free products.

Low molecular mass grades are easier to mold than higher grades, but their strength is lower as a result. The toughest grades have the highest molecular mass, but are much more difficult to process.

POLYETHYLENE (PE)

Polyethylene or polythene (IUPAC name polyethene or poly(methylene)) is the most widely used plastic, with an annual production of approximately 80 million metric tons. Its primary use is within packaging (plastic bag, plastic films, geomembranes, etc.). Polyethylene is a thermoplastic polymer consisting of long chains produced by combining the ingredient monomer ethylene (IUPAC name ethene), the name comes from the ingredient and not the actual chemical resulting.

The ethylene actually converts to ethane as it takes its place in a polymer and straight sections of the polymer are the same structure as the simple chain hydrocarbons, e.g., propane, decane and other straight single-bonded carbon chains.

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As with any polymer, the structure of the resulting substance defies molecular description due to cross branching of the chains. The scientific name polyethylene is systematically derived from the scientific name of the monomer.

PROPERTIES OF PE:

Depending on the crystallinity and molecular weight, a melting point and glass transition may or may not be observable. The temperature at which these occur varies strongly with the type of polyethylene. For common commercial grades of medium- and high-density polyethylene the melting point is typically in the range 120 to 130 °C (248 to 266 °F).

The melting point for average, commercial, low-density polyethylene is typically 105 to 115 °C (221 to 239 °F). Most LDPE, MDPE and HDPE grades have excellent chemical resistance and do not dissolve at room temperature because of their crystallinity.

Polyethylene (other than cross-linked polyethylene) usually can be dissolved at elevated temperatures in aromatic hydrocarbons such as toluene or xylene, or in chlorinated solvents such as trichloroethane or trichlorobenzene. When incinerated, polyethylene burns slowly with a blue flame having a yellow tip and gives off an odour of paraffin. The material continues burning on removal of the flame source and produces a drip.

POLYPROPYLENE (PP)

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made



poly propylene from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids.

PROPERTIES OF PP:

Most commercial polypropylene is isotactic and has an intermediate level of crystallinity between that of low-density polyethylene (LDPE) and high-density polyethylene (HDPE). Polypropylene is normally tough and flexible, especially when copolymerized with ethylene. This allows polypropylene to be used as an engineering plastic, competing with materials such as ABS.

The melting of polypropylene occurs as a range, so a melting point is determined by finding the highest temperature of a differential scanning calorimetry chart. Perfectly isotactic PP has a melting point of 171 °C (340 °F). Commercial isotactic PP has a melting point that ranges from 160 to 166 °C (320 to 331 °F), depending on atactic material and crystallinity. Syndiotactic PP with a crystallinity of 30% has a melting point of 130 °C (266 °F).^[2]

The melt flow rate (MFR) or melt flow index (MFI) is a measure of molecular weight of polypropylene. The measure helps to determine how easily the molten raw material will flow during processing. Polypropylene with higher MFR will fill the plastic mold more easily during the injection or blow-molding production process. As the melt flow increases, however, some physical properties, like impact strength, will decrease.

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POLYURETHANE (PUR)

A polyurethane (PUR and PU) is polymer composed of a chain of organic units joined by carbamate (urethane) links. Polyurethane polymers are formed by combining two bi- or higher functional monomers. One contains two or more isocyanate functional groups and the other contains two or more hydroxyl groups. More complicated monomers are also used. The alcohol and the isocyanate groups combine to form a urethane linkage.



POLYVINYL CHLORIDE (PVC)

PVC production is expected to exceed 40 million tons by 2016. It can be made softer and more flexible by the addition of plasticizers, the most widely used being phthalates. In this form, it is used in clothing and upholstery, electrical cable insulation, inflatable products and many applications in which it replaces rubber. Pure polyvinyl chloride without any plasticizer is a white, brittle solid. It is insoluble in alcohol, but slightly soluble in tetrahydrofuran.



Property	Density [g/cm ³]	Thermal conductivity [W/(m·K)]	Yield strength [MPa]	Young's modulus [psi]	Flexural strength (yield) [psi]	Compression strength [psi]	Coefficient of thermal expansion (linear) [mm/(m °C)]	Vicat B [°C]	Resistivity [Ω m]	Surface resistivity [Ω]
RIGID PVC	1.3–1.45	0.14–0.28	31–60	490,000	10,500	9500	5×10^{-5}	65–100	10^{16}	10^{13} – 10^{14}
FLEXIBLE PVC	1.1–1.35	0.14–0.17	10–25					Not recommended	10^{12} – 10^{15}	10^{11} – 10^{12}

III. THERMOSETTING PLASTICS

A thermosetting plastic, also known as a thermo set, is polymer material that irreversibly cures. The cure may be done through heat (generally above 200 °C (392 °F)), through a chemical reaction (two-part epoxy, for example), or irradiation such as electron beam processing.

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Thermo set materials are usually liquid or malleable prior to curing and designed to be molded into their final form, or used as adhesives. Others are solids like that of the molding compound used in semiconductors and integrated circuits (IC). Once hardened a thermo set resin cannot be reheated and melted back to a liquid form.

PROPERTIES OF THERMOSETTING PLASTIC:

Thermo set materials are generally stronger than thermoplastic materials due to this three dimensional network of bonds (cross-linking), and are also better suited to high-temperature applications up to the decomposition temperature. However, they are more brittle. Many thermosetting polymers are difficult to recycle.

DIFFERENCES BETWEEN THERMOPLASTICS AND THERMOSETPLASTICS

The essential difference is that thermoplastics remain permanently fusible so that they will soften and eventually melt when heat is applied, whereas cured thermoset polymers do not soften, and will only char and break down at high temperatures. This allows thermoplastic materials to be reclaimed and recycled.




The reason for this is that thermoplastics have relatively weak forces of attraction between the chains, which are overcome when the material is heated, unlike thermosets, where the cross-linking of the molecules is by strong chemical bonds.

Effectively the thermoset is one large molecule, with no crystalline structure. Compared with thermoplastics, thermosets are generally harder, more rigid and more brittle, and their mechanical properties are not heat sensitive. They are also less soluble in organic solvents.

WELDING TEMPERATURE OF PLASTICS:

THERMOPLASTICS	ABS	AB S/P C	PA	PBT	PC	PE hard	PE soft	PP	PP/E PDM	PUR	PVC hard	PVC soft	XENO Y(PC Alloy)
WELDING TEMPERATURE	350	350	400	350	350	300	270	300	300	300/ 350	300	350	350

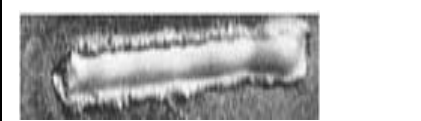
WELDING DEFECTS

DEFECTS	DESCRIPTIONS
	<ul style="list-style-type: none"> ➤ The weld was started correctly but completed too quickly. ➤ No wash indicates haste or too low a temperature.
	<ul style="list-style-type: none"> ➤ The hot-air tool was not allowed to attain the correct operating temperature. ➤ The weld was finished too soon, leaving a hole.
	<ul style="list-style-type: none"> ➤ Too much pressure has been applied to the rod leaving a low and deformed bead. ➤ Filling may be necessary

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	<ul style="list-style-type: none"> ➤ The welding temperature was too high, blistering the sides of the weld. ➤ The repair area may be brittle.
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CAUSES OF WELDING DEFECTS:

DEFECTS	CAUSES
Poor weld penetration (or) poor bonding	<ul style="list-style-type: none"> ➤ Incorrect weld site preparation ➤ Weld speed too fast / temperature too low ➤ Weld attempted with dissimilar materials ➤ Poor technique
Uneven weld bead width	<ul style="list-style-type: none"> ➤ Welding rod stretched ➤ Uneven pressure applied to welding rod
Charred weld	<ul style="list-style-type: none"> ➤ Welding speed too slow ➤ Temperature too high
Warping	<ul style="list-style-type: none"> ➤ Repair area overheated ➤ Parts fixed under tension ➤ Poor site preparation

IV. WORKING PRINCIPLE

- To weld the two plastic parts, a separate plastic rod is loaded in the gun and that rod is melted by the positive and negative power supply.
- The melted plastic is poured over the required plastic parts that to be joined.
- The main parts is nozzle ,element, copper rod,
- At the outer most end of the gun tube the nozzle holder which has nozzle is placed where the AC power supply
- As the plastic rod is being melted, the length of the rod is gradually reduced.
- Fabrication of the electric plastic gun based on the design developed, testing and proving the efficiency of the developed plastic gun than the existing hot air gun.
- The cost effectiveness of this new welding gun will also be assessed in the light of the present market value.

NOZZLE

The main purpose of nozzle in the advanced plastic welding gun is to melt the plastic rod and to guide the plastic rod over where the plastic welding to be carried out. In the nozzle two sub parts are used which are copper rod and the soldering filament. At the edge of the nozzle the power supply is given through the soldering filament and copper rod. The power supply is alternative current supply (AC Supply). So no additional controlling devices are needed to control (or) convert the current supply.

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COPPER ROD

A copper steel plate is bended as a hollow rod exactly to the same dimension of nozzle tip where the heat is to be produced. One end of copper rod is in round shape which is kept inside of the nozzle. The round shape side is not visible where three copper plates are attached in 120° of angle to each other.

Another end of the rod is bent into cone shape. The middle part of the copper rod is in round shape. Copper is a good heat conducting material. It needs less time to absorb the heat. Also copper does not melt soon. It can withstand the heat for long time period. That's why copper is implemented in this project at the heat produced zone.

NOZZLE HOLDER

To hold the nozzle rigidly the nozzle holder is provided. It has internal threads to tighten it on the front side of gun holder which has external threads. Also another side of the nozzle holder the internal threads in front to tighten it on the back side of nozzle which has the external threads.

AC POWER SUPPLY

To melt the plastic rod, the nozzle plate has to be heated so which the rod melts. The AC power supply is given to heat the nozzle. The handle has a deep hole for the passage to AC power supply line.

IZOD IMPACT TEST REPORT

Sample Number	1	2	3	4	5	6	7	8	9
Izod Impact Value for 3 mm Thick Specimen in J	0.4	0.4	0.3	0.25	0.25	0.3	0.35	0.3	0.35

V. CHARPY IMPACT TEST REPORT PLAN FOR FUTURE WORK

To weld the two plastic parts, a separate plastic rod is loaded into the system that rod is melted by the positive and negative power supply. The melted plastic is poured over the required plastic parts that to be joined for the system going to use the AC power and the copper nozzle as suited to the plastic rod .In which the plastic rod is loaded manually over system. And plastic rod will be actuating through the spring. And which has nozzle is placed where the AC power supply is given to the rod by nozzle so which the heat is produced and the plastic rod is melted.

As the plastic rod is being melted, the length of the rod is gradually reduced. The rod is pushed out to the nozzle by the spring action for continuous process of welding. After the rod is fully melted, a new rod can be replaced by opening the spring supporter and the welding can be continued.

Among the evolved conceptual design, the suitable one will be selected for further development Modeling and a new method of working principal of system will be carried out to project.

VI. CONSLUSION

This project provides more examples of plastic applications, types of welding technologies involved in the plastic materials .And the characteristics of thermoplastic and thermosetting plastics have given clearly.

And this project work has provided me an excellent opportunity and experience, to use my limited knowledge. I feel that the project work will be a good solution to the drawbacks of existing hot air plastic welding gun .In conclusion remarks of my project work, let me add a few more lines about my impression project work. In this project so far I have prepared that “**FABRICATION AND ANALYSIS OF THERMO PLASTICS WELDING**” model and its specification to design the new prototype model. And have been collected more journals related to the plastic welding to design system. In future I am going to fabricate new welding setup for plastic materials .And that will be more effective system than the available system at present. Moreover an effective comparison is made with the conventional

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welding model to enlist the advantages of this electric welding system. The cost effectiveness of this new welding gun will also be assessed in the light of the present market value.

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