



An innovative method to join two polymer rods through Y-shape extrusion channel



Pintu Kumar, Sudhansu Sekhar Panda*

Department of Mechanical Engineering, Indian Institute of Technology Patna, Bihar 801106, India

ARTICLE INFO

Keywords:

Y-shape extrusion channel
Temperature
Polymer
Joining
Destructive testing

ABSTRACT

In everyday life polymer structures are widely used as advance structural material for several products due to low weight and high strength to weight ratio. Bonding of polymers are very difficult to achieve during heating (welding) process and hence present paper focussed on an eco-friendly deformation technique to join two round shape polymers parallel to each other. In this technique two similar nature of polymer rod joined when passed through preheated Y-shape extrusion channel maintaining a constant die temperature and constant reduction ratio. Universal testing machine (UTM) is used to extrude the polymer and joint strength of extruded samples are characterised by using numbers of destructive testing such as tensile, compression, peeling, lap shear, and micro hardness test. In peeling and lap-shear test, failure does not occur along the joint of extruded sample showing robustness of bonding. Base polymer which does not have any joint section failed early as compared to extruded sample during peeling and lap shear test. Hardness of joint section is higher than heat affected zone (HAZ) as well as base polymer as observed through micro hardness test. Concave shape of joint is an indication of better interlocking and hence improvement of joint strength as compared to other solid state joining. Polymers processed at 2/3rd of melting point have thin joint and void free interface as observed through its microstructure.

1. Introduction

Importance of polymer materials because of the benefits accruing from their low weight to strength ratio, corrosion resistance, design flexibility, reduced manufacturing costs and dimensional stability have increased in the field of advanced industrial applications [1]. Polymers with unique mechanical properties have significant role in a particular application. Hence joining similar and dissimilar nature of polymer as well as metal provides an opportunity to use the advantages of both the materials [2]. Part made with combination of similar or dissimilar materials such as metal-metal, polymer-polymer and metal-polymer are in high demand. Such materials are used to fabricate lightweight hybrid components for automobile and aerospace industry [3]. Aim of joining two materials is to improve the product design and their mechanical properties to utilise it in an efficient and functional manner based on type of applications. Few examples of polymer to polymer combinations can be seen in the welding of thermoplastic composites [4]. Unique chemical properties of polymers enable them to reform a new functional integration via formation of complex shapes during the molding process.

It is a challenging task to ensure optimal mechanical performance

for a low weight material to join for any structural applications. However, joining of two polymers is very difficult to achieve good bonding through a heating process. Conventional method such as mechanical fastening, hot knife welding and adhesive bonding are most popular techniques to join the polymers [5–7]. Stress concentration, requirement of extensive surface preparation, extra weight, material metallurgical differences and harmful environmental emissions are certain limitation of the mechanical fastening and adhesive bonding technique.

Recently researchers are focusing on non-conventional energy sources such as microwaves, high speed lasers, and solar energy to join the plastics. By using microwaves good quality joints are obtained because of interaction between incident microwave radiation and the target material [8]. High speed laser welding is used to join the plastic films for industrial applications [9]. Joining of similar polymers such as polypropylene, polystyrene and polyethylene are also performed by concentrating solar energy by a specially designed solar energy concentrator [10]. All these methods are highly productive, but their initial setup costs are very high.

Friction stir welding (FSW) provides us an opportunity to achieve a cost effective weld which is used to generate the welding temperature

* Corresponding author.

E-mail addresses: pintu.pme13@iitp.ac.in (P. Kumar), sspanda@iitp.ac.in (S.S. Panda).

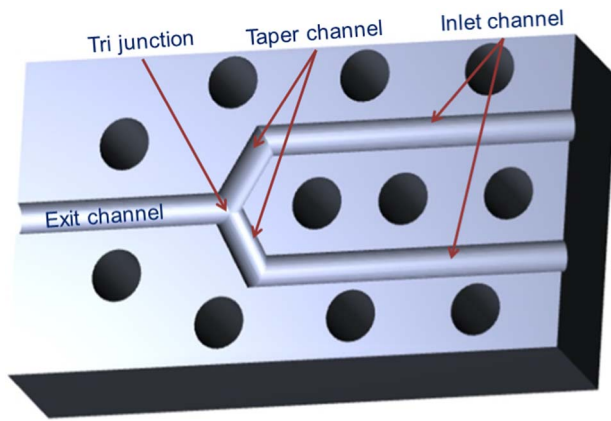


Fig. 1a. Schematic of Y-shape channel Creo model.



Fig. 1b. Schematic of Y-shape channel actual model.



Fig. 1c. Cylindrical punch made of ejector pin.

below the melting point of polymers [11]. In FSW joining of polymers are done by a rotating tool moving along longitudinal direction of the welding line. A rotating tool generates heat due to friction between tool shoulder and the materials. Due to heat generated the materials to be weld soften and fused together without reaching to its melting point. Chances of sticking of soften polymers over tool surfaces in FSW process can be avoided by appropriate selection of tool materials, tool design and FSW parameters [12].

FSW is one of innovative application in joining of metals, but not suitable for plastic joining because tools shoulder remove the material due to which void is generated inside the joint. Authors have tried different configuration of threaded pin profile along with vibration to

retain the softened plastics at the weld zone [13]. There is no other alternate procedure available to reduce the effect of void from welded polymer in the weld line.

In extrusion load is applied to deform the billet, which generate high extrusion pressure at reduced die section [14–16]. Pressure developed inside the channel depends on extrusion die angle and reduction ratio [17,18]. Numbers of work have been reported for various type of extrusion channel [19,20] which mainly used to obtain different cross sections of extruded sample. In cold extrusion failure of die, punch and fracture of billets are normally observed at high extrusion load, hence constant heat source of preheated die have been used to avoid such defects as reported by earlier researchers [21,22]. They also observed deterioration in mechanical properties of extruded samples using preheated die.

The present approach utilise a new die design (Y-shape) to join two polymer rods which is based on deformation technique. The joining of polymers through an extrusion channel is possible when soften polymers pass through a reduced die section of extrusion channel. Pressure developed in reduce die section minimises the void without over weighing the weight of the product. Application of present concept is relevant for welding industries looking for simpler method to join the similar nature of polymers in an environmental friendly way.

This work explores the feasibility of effective joining of thermo-plastics such as polymer using a Y-shape extrusion channel. In this technique no additives are added (mechanical fastening, adhesives, welding) and can be reused, hence becomes environmental friendly. Effect of different parameters such as die angle, temperature and reduction ratio along with analysis of compression test, tensile test, peeling test, lap shear test, micro hardness and microstructure of the resultant joints are discussed. Present work discusses about the new approach of joining, experimentation, destructive and non-destructive testing for characterizing the joint strength.

2. Experimental methodology

Details of the experimental procedure carried out for joining of polymer in the present work are discussed in following subsection.

2.1. Preparation of billet

Commercially available base polymer rod (Anulon 114 Polyamide) having chemical composition $[-NH-(CH_2)_5-CO]_n$ with molybdenum disulphide) is used for joining through Y-shape extrusion channel. In order to join similar polymer rods, billet of 11.9 mm diameter and 100 mm length are prepared from base polymer. The dimensions of billets are based on die configuration with a diametrical clearance of 0.1 mm.

2.2. Design of die and punch

In order to join base polymer rods, proper die and punch design is needed. Symmetrical die angle (120°) at each turn of Y-shape channel has been designed using Creo 3.0 as shown in Fig. 1a. Keeping 120° die angle of both channel results the extrusion angle to be set at 60° . Each split die have two inlet channel, two taper channel and one exit channel as shown in Figs. 1a and 1b, where 12 mm channel diameter is kept constant throughout the length. Length of inlet channel, taper channel and exit channel are 120 mm, 25 mm and 65 mm respectively. To avoid sharpness at die corners, 5 mm roundness are maintained in the design. Similarly punch with 0.05 mm diametric clearance in reference to inlet channel has been designed. Creo model generated has been used in fabrication of Y-shape extrusion channel and punch.

Two mild steel plates with $200\text{ mm} \times 120\text{ mm} \times 30\text{ mm}$ are taken on the surface grinder (KGS250H) to achieve 0.005 mm accuracy of

Download English Version:

<https://daneshyari.com/en/article/7121791>

Download Persian Version:

<https://daneshyari.com/article/7121791>

[Daneshyari.com](https://daneshyari.com)