

Design and Development of Friction Stir Extruder

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Abstract

The proposed work aim is to design and manufacturing of friction stir extruder, it is one of the important tool to produce the wire or rod from machined chips of Al, Mg alloy or softer metals. The set up has been evaluated using plastic deformation inherent in the process to stir, mechanically alloy, consolidate and feedstock metals into a useful product form of highly engineered materials in a single step because FSEP is a solid-state metal conversion process it eliminates the energy intensive melting and casting steps in current metal, material synthesis process there by significantly reducing energy consumption. Friction Stir Extruder has to be design and manufactured with hot worked tool steel by considering design parameters such as diameters of plunger and cartridge with good surface roughness and usually associated with great and adequate experience.

Keywords: Machines, Operations, Friction Stir Extruder.

Introduction

In general light weight soft metals such as Al, Mg, Cu alloy etc. scraps were recycled through melting and casting, solid state consolidation process, cold and hot extrusion process. There are two general processes for extruded products called conventional and direct conversion method. In conventional method the purity, quality and mechanical properties are not that much enough compared to direct conversion method. A novel technology with an energy efficient, zero emissions, excellent quality and good mechanical properties of wire or rod can be

extruded through friction stir extrusion process and this technology was recently introduced by W.Thomas in 1993. The principle of friction stir extrusion process is that the metal scrap or chips obtained from the machining, clean the metal scrap in a chemical to remove oil and grease and held in a cylindrical stationary container (Cartridge) and a rotating plunger inserted in a cartridge and made to rotate due to rotation of plunger frictional heat generates this heat is helps to the metal scrap gets consolidated and plasticized, this plasticized metal scrap is passes through a hollow beneath of plunger through a nozzle is attached at the bottom of the plunger and wire or rod extruded and called as friction stir extrusion process (FSEP). For this purpose, the main components are used in the friction-stir extrusion process consist of a cartridge and plunger called as Friction Stir Extruder. The friction stir extruder is made of hardened and high strength tool steel, 2436 steel alloy, H13 hot worked tool steel etc. In this proposed work the design and manufacturing of friction stir extruder has been carried out. The working principle of FSEP as shown in figure.

Literature Survey

From the previous work in FSEP the machined chips are held in a stationary cylindrical container called cartridge and a rotating cylindrical plunger that is made to rotate in the cartridge and moves in axially downward direction under an axial pressure and a rotation, resulting in generation of heat energy due to friction to facilitate heating the metal scrap and get plasticize to consolidate. At this stage the metal chips are in plastic condition is made to pass through the nozzle at the bottom of the container to which a hollow cylindrical ram is attached. The material that ejects through the nozzle passes through the hollow ram beneath and takes the shape of wire. Another variation of the process is the cartridge is made to rotate keeping the plunger stationary as shown in figure.2.

Design of Friction Stir Extruder

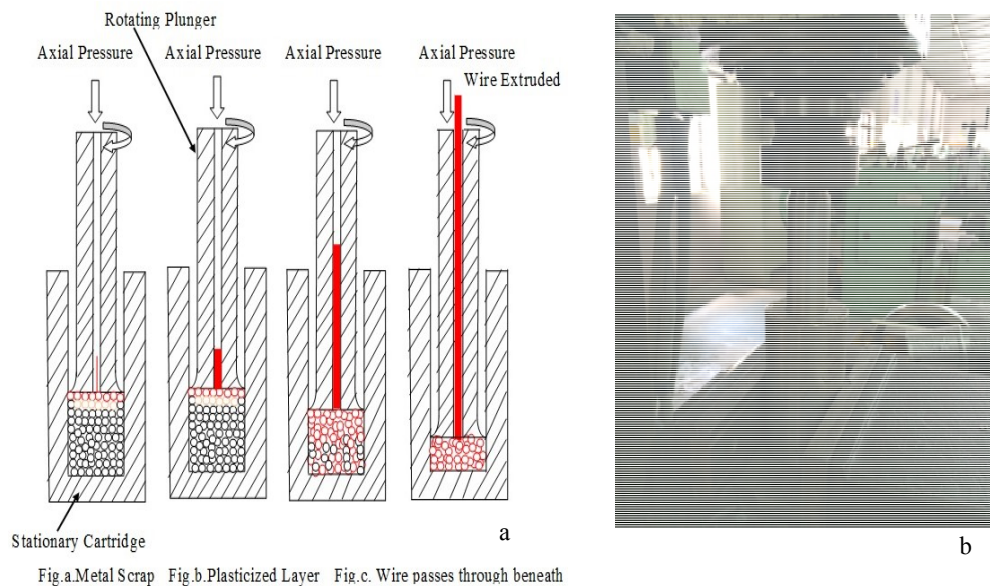


Fig.1.a.b. Working of Friction stir extrusion process

In friction stir extrusion process the main elements were used for extrusion process to carry out work using plunger and cartridge with suitable design parameters and dimensions. From the literature the design, diagram and dimensions of cartridge and plunger has been studied, considerable designed dimensions have been considered. While in design of plunger and cartridge some important parameters such as rotational speed of plunger, axial pressure or force, co-efficient of friction, surface roughness, nozzle angle etc. has to be considered. To draw A 2D and 3D drawing has been drawn using Auto CAD and CATIA

S.No	Design parameters of Cartridge, Plunger and Nozzle
1	Power = $2\pi NT/60$
2	Torque (T) = F x r
3	Force(F) = Axial pressure x Area
4	Radius(r) = $d / 2 = 30 / 2$
5	Shear stress (τ) = $16T/\pi d^3$
6	Angle of Nozzle(α) = $\tan^{-1}[(D-d) / 2xL]$
7	Friction Coefficient(μ) = F / R _n
8	Surface Roughness(Ra) = $(h_1+h_2+.....h_n) / n$

Dimensions of Cartridge, Plunger and Nozzle		
Cylinder Cartridge (mm)	Cylindrical hollow Plunger (mm)	Nozzle (mm)
Inner Diametr(d)=30	Diameter = 28.8	Dia at entry = 5
Outer Diametr(D) = 2*d	Length = 200	Dia at exit = 8
Length = 110	Through hole = Ø5	Outer dia = 15
Depth of Hole = 90		Length = 25
		Angle(α) = 4.57°

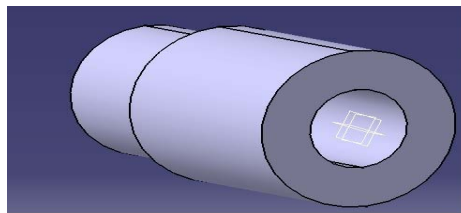


Table. 1. Design parameters of Cartridge, Plunger and Nozzle

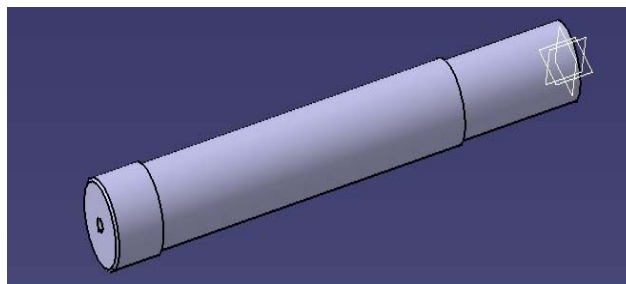


Fig.2.Solid model of cylindrical cartridge and Hollow Plunger in CATIA

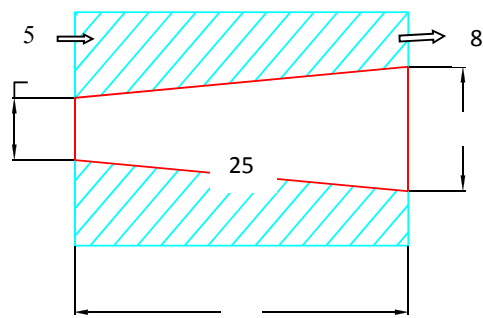


Fig. 3. Design of Nozzle

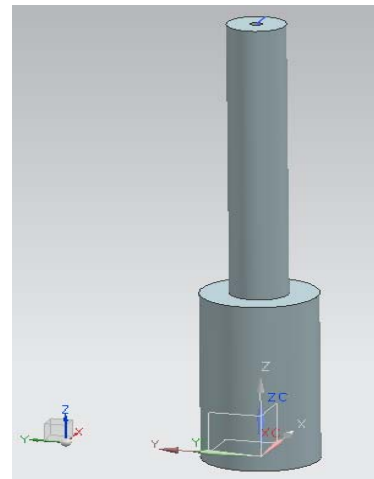


Fig.4. Solid model of cartridge &

Experimental Work

Materials

The material has been used to develop the cartridge and plunger with H13 hot worked tool steel having good mechanical, properties, high strength, toughness, resist high temperature, wear, corrosion resistance and Material is non reactivity. The various shapes of cartridge and plunger have been designed and developed based on overcoming the problem that has arisen in the experimentally.

Machining Operations

The various machining operations has been carried out on Lathe, milling and drilling machines as follows.

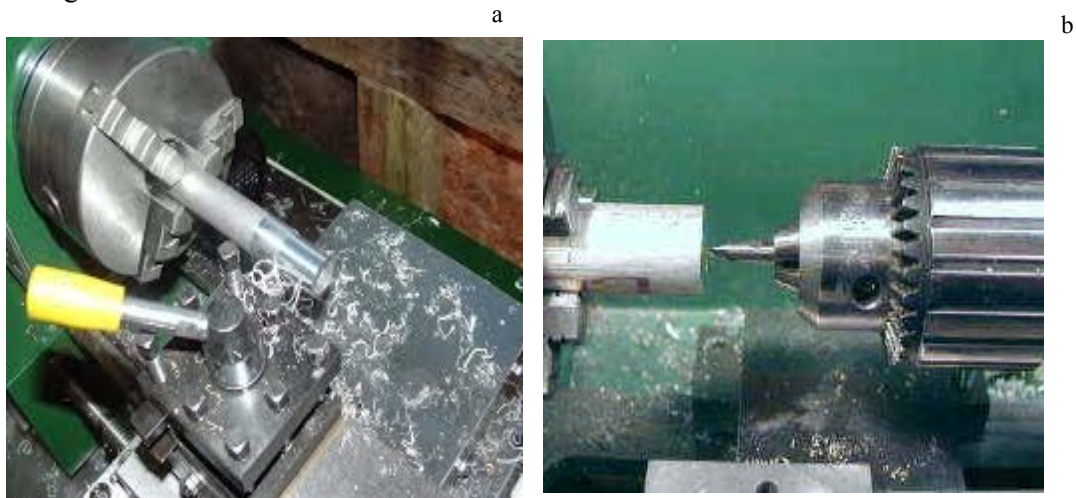


Fig.5.a.b. Machining Operations Carried on Machines

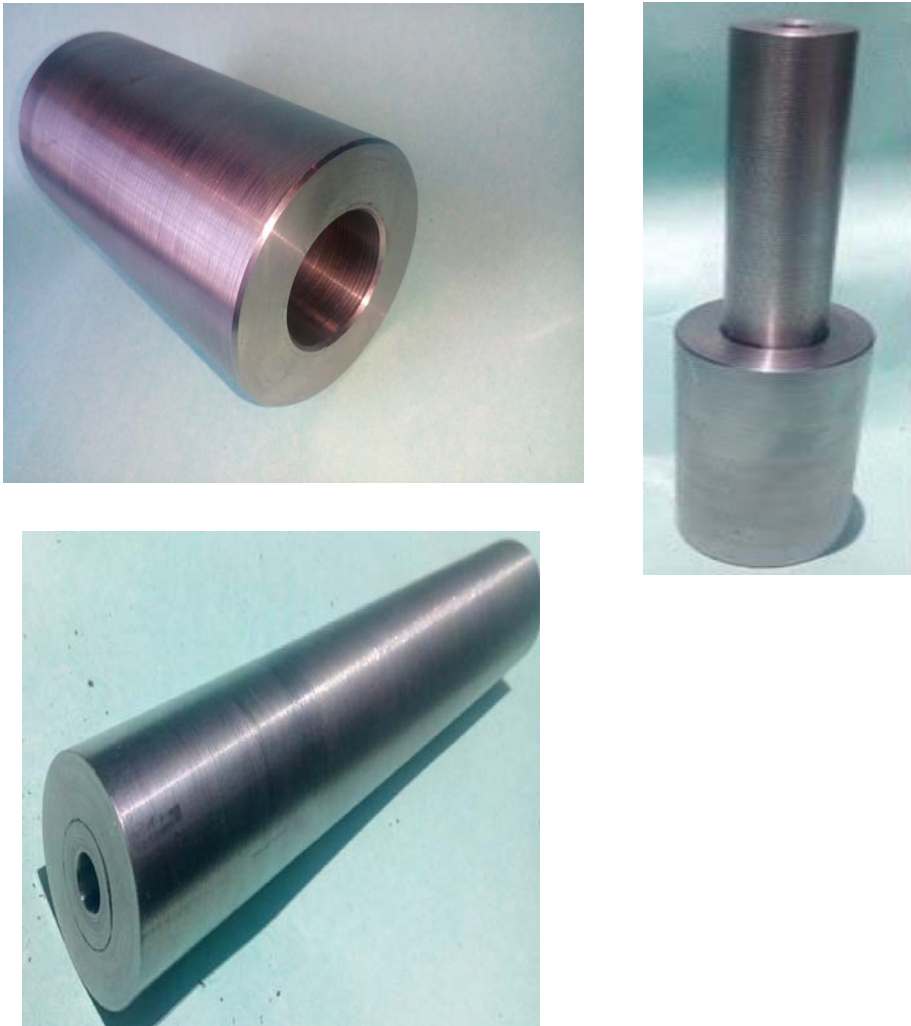


Fig.6.a.b.c. Cartridge & Plunger with inserted nozzle

The various operation needs to be performed to obtained a product using various machine tools is used to finish the goods. Lathe machine with single point H.S.S tool, carbide tipped tool is used to turning, facing, drilling, grooving, knurling operations etc. Milling is a operation to make a surface flat, smooth, and required shape of the job using multi point cutting tool. The drilling is a operation to make a hole using inside or outside of the object using portable or radial drilling machines with help of H.S.S Drill bit for making hole. Knurling is a operation to make small grid type on external surface of the object for gripping purpose using lathe machine. The threading is a operation can perform external surface on the object and internal threading inside the object can be performed. Wire cut operation is to cut a required shape or cut it into two half or two parts the cartridge and plunger has cut into parts so that we can be removed any material struck

inside the hole of cartridge and plunger. Heat treatment is process to obtained high hardness and withstand high temperature while performing experimental work. Polishing is the operation to smoothen the internal or external surface of the cartridge or plunger.

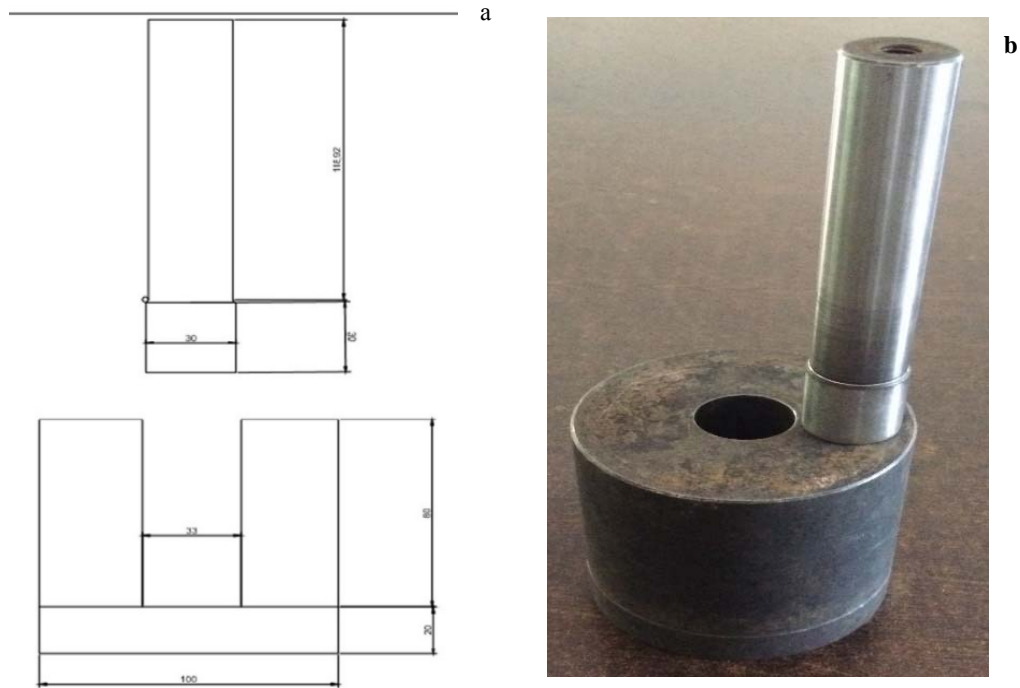


Fig.7.a.b.Cylindrical Cartridge & Plunger



Fig.8.Square shape Cartridge &



Fig.9.Plunger with grooves



Fig.10.Rectangular shape Cartridge



Fig.11. Fabrication of Hollow Cylindrical Plunger

Results and Discussions

- The cartridge and plunger have been designed and developed with H13 tool steel and dimensions collected from the previous literature survey, developed with a various dimension, size and shapes to overcome arisen problem in the experimental work.
- Cartridge is having a cylindrical hole 30mm to 35mm as shown in figer.7.a. and through cylindrical hole in the plunger with 5mm shown in figure.11.
- The wire extruded through hole of plunger from the beneath of nozzle and it has been designed and developed based on the requirement of experimental work to overcome the arisen problem.

Conclusions

- The various shapes cartridge has been designed and developed. hollow plunger with nozzle shape and grooves provided at one end of the plunger to stir the material properly while carry out the experimental work. has been design and developed.
- The size, shape of the cartridge and plunger will be given us to conduct experiment with proper gripping purpose of the friction stir extruder on the machine table.

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