CAPABIIITY OF FORGING TECHNIQUE TO PRODUCE ROUND SHAPE FLANGE USING (POM) MATERIAL UNDER COLD AND HOT CONDITIONS

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ABSTRACT

The paper studied capability of forging process to produce round shape flange using acetal (celcon^R) polymer which is an engineering crystalline material having a good ductility if it is preheated The process done under cold & hot conditions This kind of technique guarantees a product with high strength and stiffness better than what injection molding could achieve. The products showed crack and curling traces on the flange under cold forging, but a good product was achieved by heating the billet and the tools to (100C^o)with improvement in the mechanical properties. The paper discussed also through (stress – strain) curves manner of deformation through forging action. The results explained that POM (celcon^R) is forgeable polymer if it is preheated at (100 C^o) using slow speed press by closed die forging process under applied pressure of 170Mpa to produce round shape flange, while this technique failed to forge same polymer at room temperature.

الخلاصة

درست الورقة امكانية طريقة الكبس بالقوالب المغلقة فى انتاج (شفة دائرية) من مادة (اسيتيل سيلكون) وهي مادة بلاستيكية هندسية بلورية لها القابلية على مطاوعة الكبس كلما كانت ساخنة. وقد اجريت التجربة وذلك بالكبس على البارد مرة وبالكبس بعد تسخين القطعة المشغولة مرة اخرى . هذه الطريقة تضمن صلادة و مقاومة للمنتج افضل مما تفعله طريقة البثق . كانت النماذج المنتجة تحت ظروف درجة حرارة الغرفة تحوى عيوب التكسر والالتواء, بينما كانت النماذج في الحالة الثانية حيث تم تسخين القطعة المشغولة والقالب لدرجة100مئوى كاملة الشكل والأبعاد مع تحسن في الخصائص الميكانيكية. الورقة درست كذلك سلوك المادة اثناء عملية الكبس من خلال منحنيات الجهد والاجهاد. النتائج اوضحت ان الاسيتل له المطاوعه الكافيه اذا تم تسخينه لدرجة(100مئوى) لكى ينتج شفة دائرية بواسطة طريقة الكبس بالقوالب المغلقة تحت صغط (170 ميكاباسكال), بينما فشلت النماذج التى انتجت دون تسخين مسبق باستخدام نفس طريقة الصنع .

KEY WORDS

(Forging _ POM_ recovery _ dwell time _billet _ SPF)

CLAIMS:
1. Forgeability of acetal (celcon^R) through closed die forging technique to produce flange under cold (room temp.) & hot (100 C^o) conditions
2.Behaviour of the polymer through forging action taking into consideration that typical forging process using acetal is usually done at (155C^0) **(Kulkarni1995)** . Melting temperature for it about (165C^0)

INTRODUCTION
Closed die forging is a process in which a billet or blank is subjected to bulk deformation by application of compressive pressure with constraining dies which are generally made from steel **(Coffman1990).** The billet (POM) is made of formaldehyde and it always has been referred to as (acetal). This polymer as an engineering material had been fabricated by forging process which was previously applied only to metals; it has been successfully employed with many types of polymeric materials **(Kulkarni, yong-Seon Lee 2002)** which have to be ductile, with most deformation non-recoverable to minimize spring back and time dependent strain. (POM) can be difficult cold forged **(Kulkarni 1995)**. It typically fabricated after heating at (155C^0). Cold forming implies that the process is performed at room temperature with out heating the material or the tools. In general a polymer can be either cold or warm formed. Solid phase forming (spa) indicates any of them. The process is selected depending on the application. This technique insures better mechanical properties and can produce a complex shape with high thickness or deals with polymers of (ultra high molecular weight) which are mostly beyond the capability of injection molding process **(kulkarni 995).**

DIMENSIONS AND MEASUREMENTS:

- **Billet dimensions**: the billet was solid plastic rod

Cross-section area = 25mm
Height = 65mm

- **Die dimensions**: the die was made of hardened carbon steel

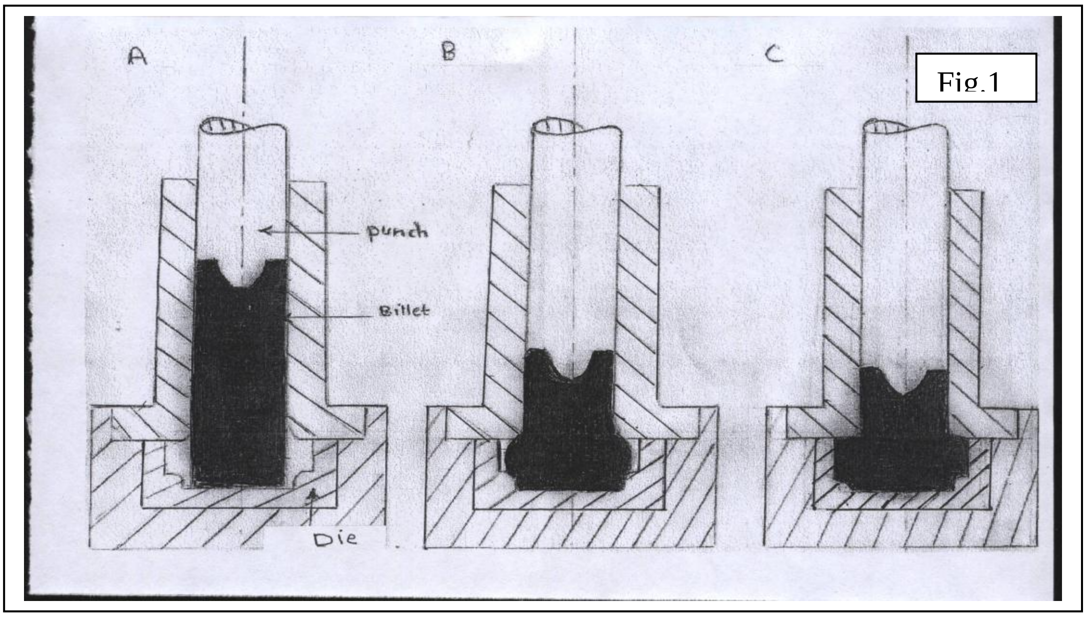
Outside diameter = 51mm
Inside diameter = 39mm
Height = 10mm
Cone diameter (bottom part) = 28mm
Cone height = 5mm

- **Billet test measurements :**

mechanical properties

Tensile strength at 1%strain	Modulus tensile	Modulus flexural	Hardness(ROCKWELL) (wt=100gm)
62Mpa	2.87Gpa	2 Gpa at 23C^0 0.9 Gpa at 100 C^o	M84

Table 1



(Fig. 1): shows steps of forging actions

- (A) punch is ready to start forging
- (B) Punch is moving down pushing the polymer according to load increasing, and then gradually the die filled with polymer except corners.
- (C) Increasing of pressure gradually to fill corners.

This process influenced by load increase which was done gradually while trial and error were the only way to examine what was going on inside die cavity step by step, so many samples were spent for this purpose

EXPERIMENTAL PROCEDURES:

1. The process was done using slow speed press.
2. A load cell consisted of strain gauge was used to transmit the compressive load to the strain recorder then to an amplifier. The amplifier then connected to Bryan X-Y plotter to get graphs of load against displacement, then to be converted later to (stress-(strain) curves describing the style of flow done by yielding action.

A. Cold forging

The billet was simply put into the die at room temperature, and then forging carried out. .

Load would then be increased and when the pen on the plotter started to move vertically (Fig.2), load then held constant at that particular value for (2 minutes) to prevent recovery.

B. Hot forging

The billet was put into the die and whole assembly was placed in an oven over night. The temperature was adjusted at 100C^{o}. The strain gauge was insulated from the hot punch by the use of an asbestos slab to prevent unwanted effect of strain gauge due to heating. After putting the die assembly below the machine punch, switching on, then the head of machine was brought down and the forging carried out. When the pen of the plotter started to move vertically, load was again held constant at that particular value (100second).

RESULTS AND DISCUSION:

* RESULTS:

Product test.
Dimensions stability = within 1 % in all directions
Modulus improvement increased by 50% in one direction
Tensile strength increased by 150% in one direction

* DISCUSSION:

Typical forging pressure for preheated billet (5 C^o) below softening point is around 40Mpa. Cold forging pressure recorded in such work to be (3-5)times that of typical heating, while in the case of heating billet and tools to(100C^o) would be (2- 3) times that of typical heating(Coffman1990) , sometimes the use of (MoS_2) based lubricant gives an advantage by lowering forging force value. .
In this paper, a cold forging at room temperature and a hot forging at (100 C^o) had been done using MoS_2 based lubricant to reduce forging pressure, the results indicated that curling, and cracks traces appeared on the flange under cold forging. On the other hand smooth product -with improvements in the mechanical properties -was achieved by heating the billet and the tools at (100 C^o).

A. **Load –displacement curves behavior**: (see Fig.2)
Curves at both conditions showed viscoelastic behavior of (POM)
1. OA-section which represented a behavior of elastic material.
2. AB-section which represented viscous non-linear deformations because of this polymer behavior, AB line was not fully horizontal straight line.
The load required to form the general shape of flange was at ranges:

- (40-65 KN) to achieve (11.5) mm as reduction in height at cold forging for (section AB).

- (20-35 KN) to achieve (10) mm as reduction in height at hot conditions for (section AB).
3. BC-section which indicated load applied to fill the corners which were last part of flange to achieve:

- Total reduction in height was (22.5mm) including elastic part using range of loads (65-90 KN) at cold forging.

- Total reduction in height was (20mm) including elastic part using range of loads approached (85 KN) at hot conditions. (Fig.1) shows the details of the forging process stages.

The total percentage reduction in height in each case was (34%)

Cold forging of celcon (pom) to produce flange

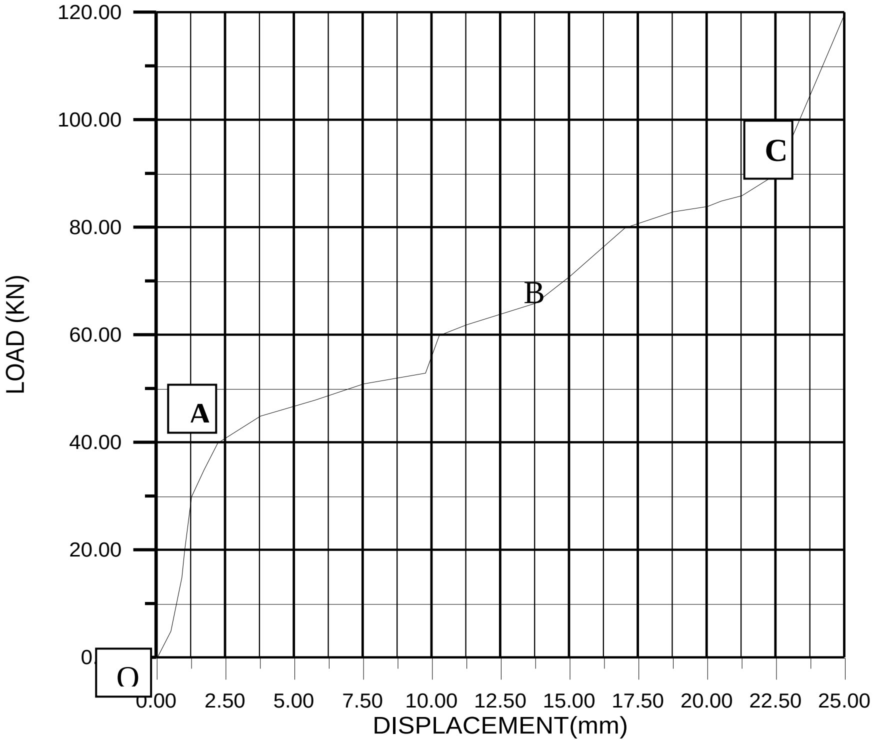


Fig.2-a Load-displacement graph

Hot forging of celcon (POM) to produce flange

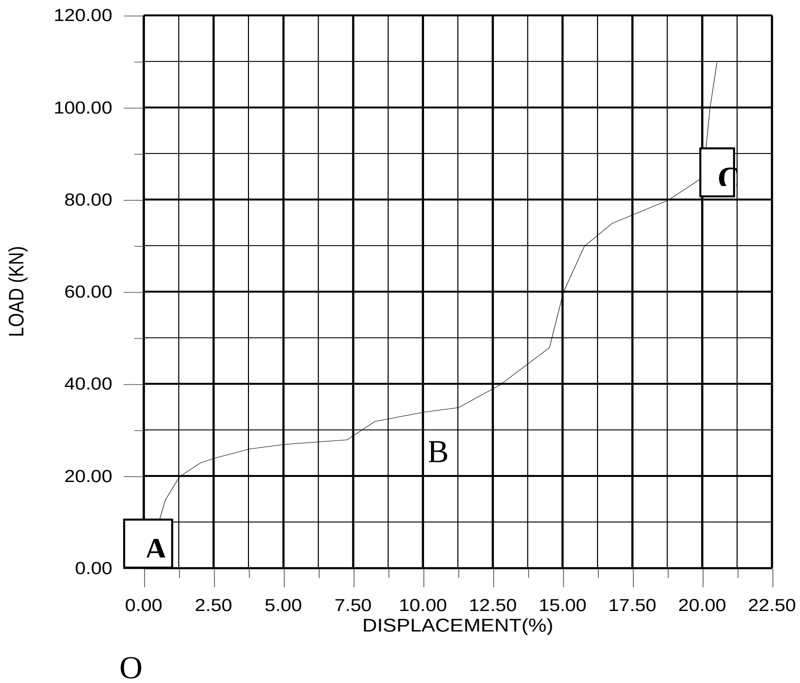


Fig.2-b Load - displacement graph

B. Strain rates:

According to the types of deformation shown on Fig.3

There are two parts of strain:

- Elastic part which obeys Hooks law, hence
  Stain = stress/ modulus
- Viscous non-linear part: This polymer is viscoelastic material, so no straight linear deformation. The polymer behaved as viscous material & as non- linear, in this meaning,

The total strain –according to Maxwell model- is equal to both. (Crawfor 1985)

So, total strain = (stress1/modulus) + (stress2/vicous element).

Any way, from fig.3:

The strains at

cold condition = 37%, achieved under applied pressure of 180 Mpa

hot condition = 30%, achieved under applied pressure of 170 Mpa

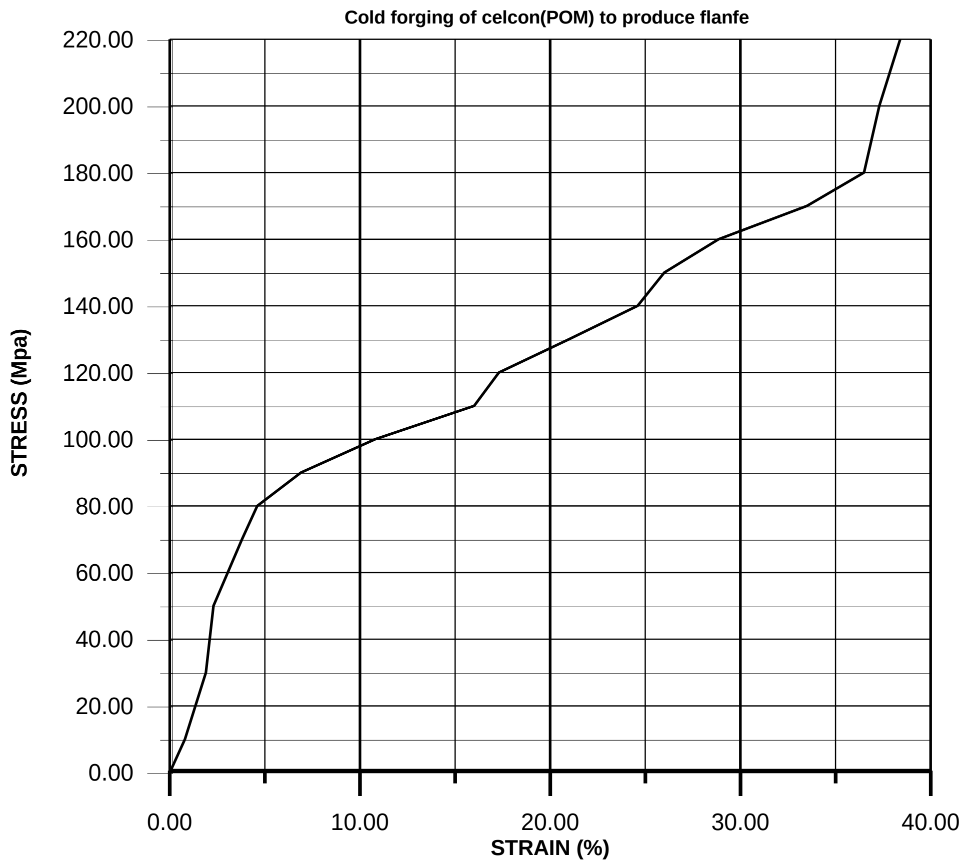


Fig.3-a stress-strain graph explains the type of deformation of POM during cold forging process under increased pressure.

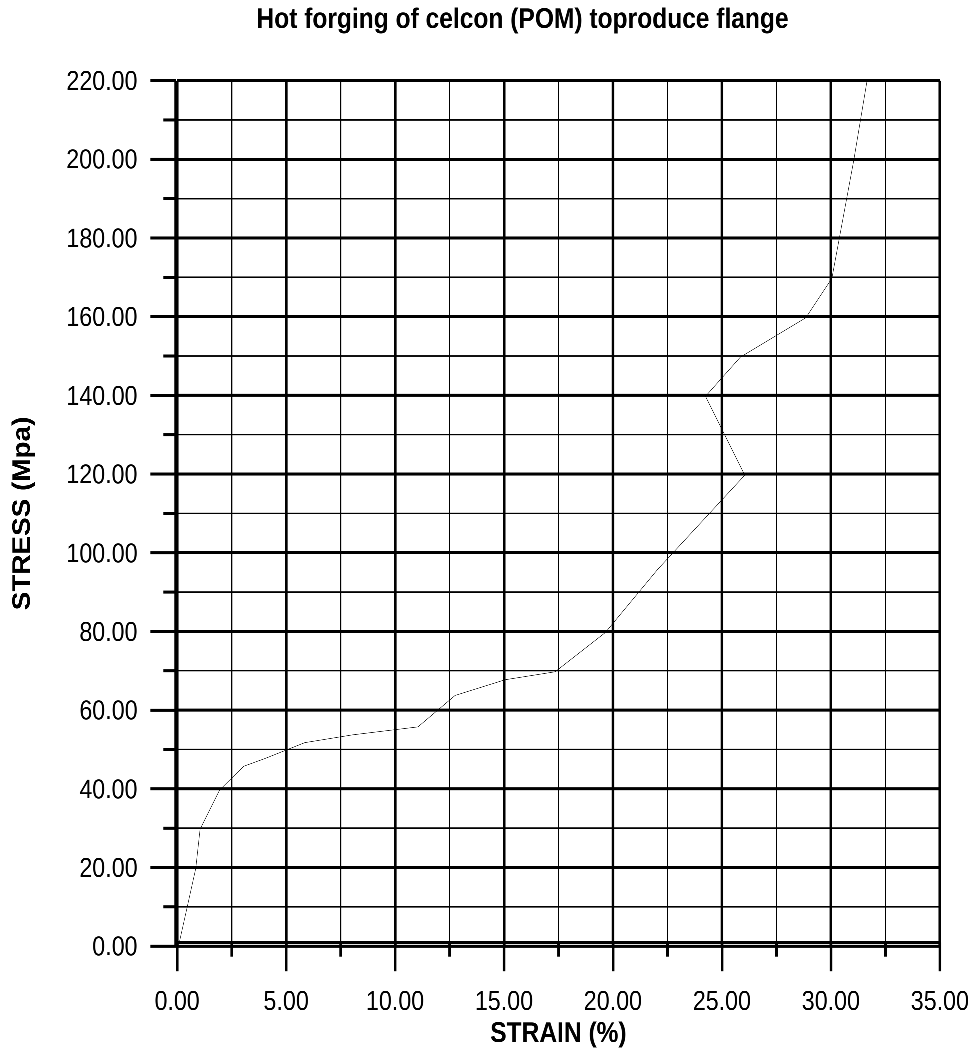
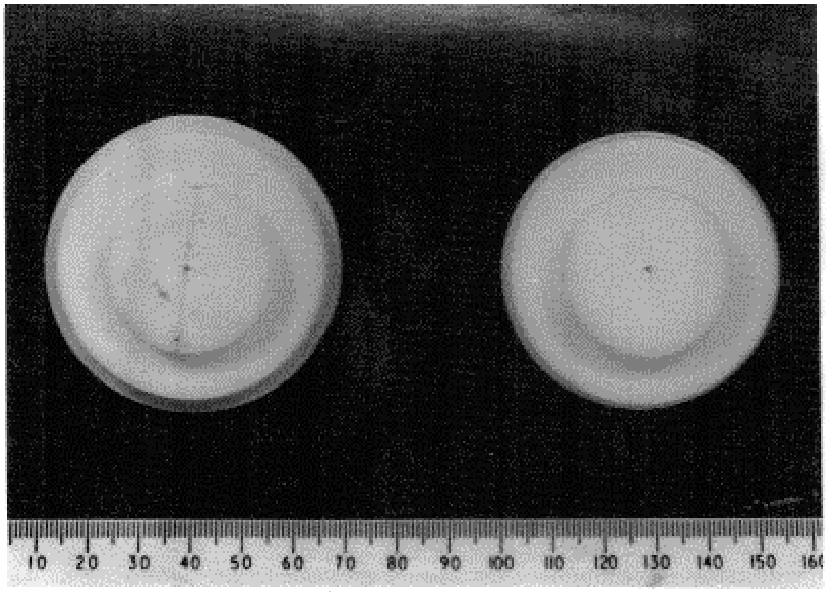
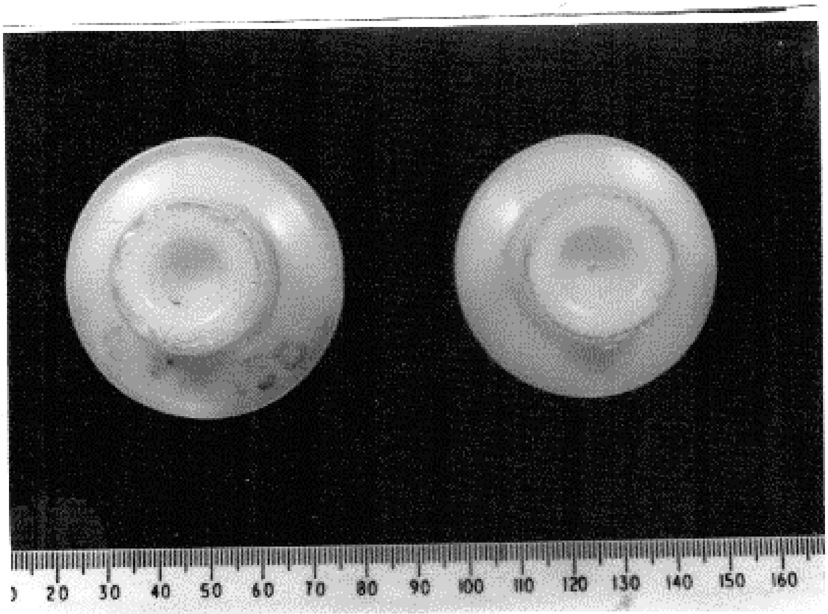


Fig.3-b stress-strain graph explains the type of deformation of preheated POM polymer during forging process under increased pressure.



(1) (2)

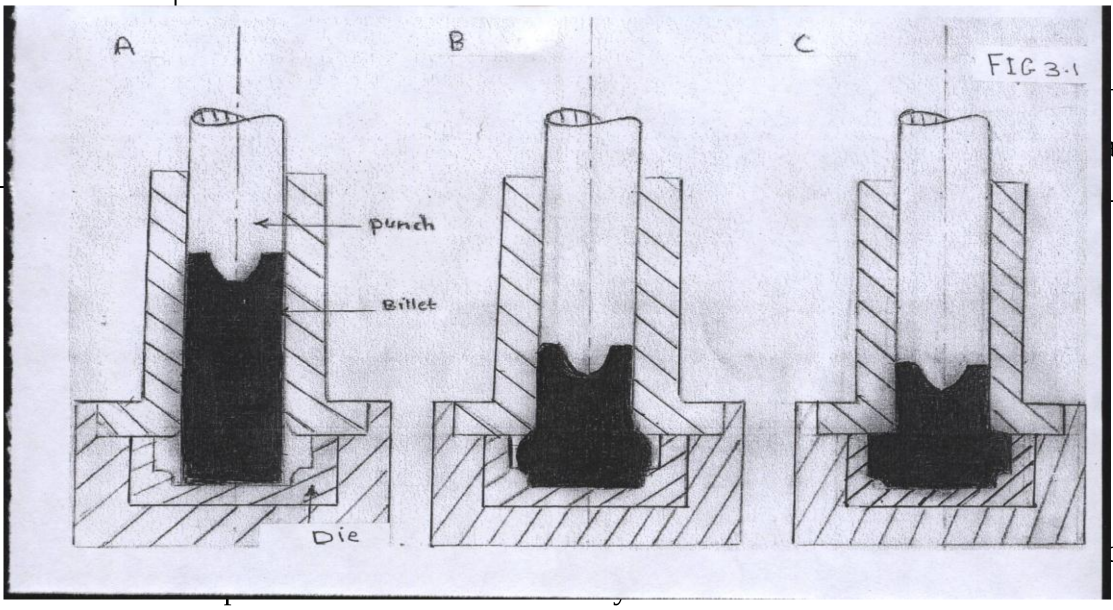
FIG. 4.1-A BOTTOM VIEW



(1) (2)

FIG. 4.1-B TOP VIEW

Fig.4: (Pictures show a complete shinny flanges produced at (100C^o) by closed die forging process under pressure about 170Mpa



de them for those

2. Products that produced at cold condition showed curling and crack traces.
3. a smooth & shinny flange as shown in (Fig.4.1) was produced with improvement in the mechanical properties as mentioned before.
4. This work insured forgeability of acetal (celcon^R) at (100C^o) by closed die forging process at applied pressure around 170 Mpa.
5. The paper discussed the behavior of the polymer at cold & hot conditions
6. The disadvantages:
   - Too long dwell time (100sec.)
   - High pressure was required comparing to typical forging process.
7. This kind of flanges is similar to those used in following applications:
Timing pulley flange, vacuum flange, pipe fitting.

REFERENCES

* Api-Kolon(1995)- Engineering plastics

* K.M.KULKARNI(1995)- Review of forging

* P.M.COFFMAN (1990)- Forging of plastics by metal working technique

* PARSONS, I.M. WARD, P.S. HOPE and S.HENDERSON (1985)
journal of mechanical working technology

* R.J.CRAWFOR(1985)- Plastic engineering

* Yong-Seon Lee & Junes-Hwan(2002) "Experimental & analysis evaluation for elastic deformation behaviors of forging" Journal of materials processing technology, Vol.127
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