The effect of twist on the mechanical properties of twisted textured polyester yarns was studied. 80 denier textured polyester yarns were twisted with various tex twist factor (Tex^{1/2} turns/cm) from 9 to 108. With increase in twist, the yarn tenacity first increased and then gradually decreased, the elongation at break increased up to a twist factor of 72 and then remained nearly constant, the work of rupture first increased sharply and then decreased sharply, and the yarn diameter decreased sharply up to a twist factor of 27 and then remained constant.

Keywords: Breaking elongation, Crimp contraction force, Twisted textured yarn, Work of rupture, Yarn diameter, Yarn tenacity

1 Introduction
Twisted textured yarn fabrics are popular in apparel textiles such as crimp woolly, Dani chiffon, Dechine, etc. Although twisting is necessary for avoiding the fraying tendency of the textured filaments during weaving, it also affects the fabric handle and is considered to be one of the important parameters for achieving a desired fabric handle. Besides this, the variability in twist also affects the dye uniformity in twisted textured yarn fabric. Much work has been reported on the effect of twist on physical and dye sorption properties of continuous filament yarn. However, very little work is reported on twisted textured yarn characteristics. The present work is aimed at studying the influence of twist on mechanical and dyeability characteristics of the twisted textured yarn and fabric. This paper reports the results of the effect of twist on mechanical properties of twisted textured yarns.

2 Materials and Methods
The raw materials used and their characteristics are given in Table 1. The first and second quality partially oriented polyester yarns (134/34) were texturized on Giudici Marchon TG 20 F super draw texturing machine (550 m/min) with d/y ratio 2.02, draw ratio 1.76 and first and second heater temperatures of 195°C and 140°C respectively. The textured yarns were twisted on conventional uptwister with 300-3600 tpm at an interval of 300. The twisted yarns having twist factor of 27 and more were steam set to remove the snarling tendency. Twist and denier were measured by the conventional technique. The tensile properties were measured on Instron tensile tester (Model 6021). Crimp contraction force was measured with 2% overfeed at 150°C on Dynafil-M. The diameter was measured with the help of a projection microscope.

3 Results and Discussion
3.1 Effect of Twist on Yarn Denier
Fig. 1 shows that there is a progressive increase in denier with increasing twist, as expected, due to yarn contraction caused by twisting.

3.2 Effect of Twist on Tenacity
Generally, the tenacity of continuous polyester filament yarn decreases gradually with increasing twist. But Fig. 2 shows that in the case of textured polyester filament yarn, yarn tenacity first increases and then gradually decreases. The initial rise in tenacity may be attributed to the asymmetric distribution of tensile forces in the textured

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1st quality polyester POY</th>
<th>2nd quality polyester POY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denier</td>
<td>134.1</td>
<td>135.2</td>
</tr>
<tr>
<td>(0.65)*</td>
<td>(1.03)*</td>
<td></td>
</tr>
<tr>
<td>Strength, cN</td>
<td>297</td>
<td>294</td>
</tr>
<tr>
<td>(2.74)*</td>
<td>(5.40)*</td>
<td></td>
</tr>
<tr>
<td>Elongation, %</td>
<td>126.5</td>
<td>123.0</td>
</tr>
<tr>
<td>(3.25)*</td>
<td>(3.90)*</td>
<td></td>
</tr>
<tr>
<td>Draw force*, cN</td>
<td>50.96</td>
<td>53.01</td>
</tr>
<tr>
<td>(2.07)*</td>
<td>(2.33)*</td>
<td></td>
</tr>
<tr>
<td>U%</td>
<td>0.45</td>
<td>0.56</td>
</tr>
</tbody>
</table>

* Figures in parantheses indicate CV%.
* Draw force at 200°C with 1.7 draw ratio.
Fig. 1 - Effect of twist on yarn denier

Fig. 2 - Effect of twist on yarn tenacity

Fig. 3 - Effect of twist on CV% of strength

Fig. 4 - Effect of twist on breaking elongation

Fig. 5 - Effect of twist on work of rupture

Fig. 6 - Effect of twist on crimp contraction force

yarn⁵, which are equalized due to increase in interfilament frictional forces caused by twisting and contribute to higher tensile strength. The decrease in tenacity at higher twist level is, however, attributed to the well known obliquity effect. It is observed from Figs 2 and 3 that at a twist factor of 27 the tenacity is maximum and the strength variability is minimum. Hearle⁶ also suggested that yarn variability interacts with twist, resulting in an increase in tenacity at low twist factor.

3.3 Effect of Twist on Breaking Elongation

Fig. 4 shows that in the case of first quality yarn, the breaking elongation first increases up to a twist factor of 63 and then remains nearly constant with further increase in twist whereas in the case of second quality yarn, elongation at break first increases up to a twist factor of 72 and then decreases slightly. When the twist is inserted in the textured filament yarns, the cohesive force prevents the filament having less extensibility to break earlier. This helps the breaking point to be concentrated at a single point in the yarn, delaying the occurrence of rupture and thus increasing the breaking elongation. At higher twist level, equalization of tension is prevented by the very high interfilament frictional forces and, therefore, breaking elongation remains more or less steady. This is in agreement with the observations of Kilby⁷.

3.4 Effect of Twist on Work of Rupture

Fig. 5 shows that with the increase in twist, the energy to break the yarn increases sharply and after a certain twist level, it decreases sharply. The initial rise in work of rupture with increasing twist may be attributed to the initial increase in both tenacity and elongation of the yarn. However, at high twist level, the tenacity decreases and elongation at break remains constant and so the work of rupture decreases.

3.5 Effect of Twist on Crimp Contraction Force

Fig. 6 shows that the crimp contraction force (CCF) increases up to a twist factor of 18 and
then falls sharply and remains steady. Initial increase in CCF is due to the presence of twist. The yarns having twist factor of more than 18 are steam set, so sharp fall of the contraction forces is expected. In both the first and second quality yarns the trend is nearly same but CV % of this force is more in the case of second quality yarn (Fig. 7). It is also observed that the CV % of contraction force for set yarn is high because even small variation in force will give higher CV % as the mean value of the force is very low.

3.6 Effect of Twist on Yarn Diameter

One of the main objectives of texturing the polyester filament yarn is to produce the bulk (bulk is directly related with yarn diameter) in the yarn. But when the textured yarns are twisted, the diameter of the yarn decreases. Fig. 8 shows that the yarn diameter decreases sharply up to a twist factor of 27 and then it remains constant. During twisting of textured yarn two phenomena are expected: (a) decrease in diameter due to increase in packing density, and (b) increase in diameter due to yarn contraction. The initial sharp decrease is due to predominance of (a) over (b). But after a certain twist both (a) and (b) may compensate each other maintaining constant diameter.

4 Conclusions

4.1 Yarn tenacity first increases with the increase in twist and then decreases gradually. The yarn variability in terms of strength affects the tenacity of the yarn and this variability is more at higher twist level.

4.2 Breaking elongation increases up to a twist factor of 72 and then remains nearly constant, i.e. at higher twist level the breaking elongation is not affected.

4.3 Work of rupture increases sharply with increasing twist and after a certain twist it falls sharply.

4.4 Crimp contraction force rises slowly with increasing twist, but for steam set yarns, it is very low and remains unaffected. The CV % of this force is always higher in second quality yarn.

4.5 With increase in twist, the yarn diameter decreases sharply up to a twist factor of 27 and then it remains constant.

4.6 The effect of twist on both first and second quality polyester yarn is nearly the same.
Acknowledgement

The authors are grateful to Petrofils Co-operative Ltd, Baroda, for supplying necessary POY polyester yarn and to Mr D. I. Atodaria of Gipilon Texturizing Pvt. Ltd, Udhna, for allowing to texturize the polyester yarn. They are also thankful to Dr M. V. S. Rao, Mr R. K. Datta and Mr Y. C. Mehta for valuable guidance during this work and to Mr A. B. Talele for help in preparing the manuscript.

References

5 Fitzgerable and Hughey, Texturing synthetic fibres for stretch and bulk, paper presented at the southern textile research conference held at Hilton Head Island, S.C, 22 May 1964.