CHAPTER 6
CONCLUSION

Within the scope of this investigation the conclusions of the research work carried out on the topic “Experimental investigation and analysis on machinability during turning operation using Taguchi method” have been presented in this chapter under the following sub-sections.

6.1 Effect of cutting parameters on surface roughness

6.2 Effect of cutting parameters on material removal rate

6.3 Effect of cutting parameters on machining time

6.4 Effect of cutting parameters on machining force

6.5 Effect of cutting parameters on power requirement

All the experiments are carried out according to design of experiments approach using Taguchi method in dry environment.

6.1 EFFECT OF CUTTING PARAMETERS ON SURFACE ROUGHNESS

- L8 orthogonal array is used for medium duty lathe for machining of Al6061T6.
  - Surface roughness of the material decreases with increase in cutting speed and nose radius leading to excellent surface finish because of the increase in the amount of material removed from the work piece.
  - Surface roughness of the material increases with increase in feed rate and depth of cut leading to poor surface finish because of the increase in temperature due to high friction between the tool and the work piece.
• The ANOVA analysis on the basis of sum of squares shows that the feed rate with 43% was found to be the major factor affecting the surface roughness, whereas the nose radius with 39.3% was found to be the second influential factor followed by cutting speed with 14.1% and depth of cut with 3.5%.

• The ANOVA analysis on the basis of mean squares shows that the percentage of contribution of feed rate with 43% was found to be the major factor affecting the surface roughness, whereas the nose radius with 39.3% was found to be the second influential factor followed by cutting speed with 14.1% and depth of cut with 3.5%.

• The ANOVA analysis on the basis of confidence level indicates that feed rate gives the highest percentage of contribution of 66% and the nose radius is the second most influential factor with a value of 65% followed by cutting speed with 49% and depth of cut with 28%.

• Using Minitab software the mathematical model has been developed relating the surface roughness with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.

○ **L8 orthogonal array is used for medium duty lathe for machining of Al7075.**

• Surface roughness of the material decreases with increase in cutting speed and depth of cut leading to excellent surface finish because of the increase in the amount of material removed from the work piece.

• Surface roughness of the material increases with increase in feed rate leading to poor surface finish because of the increase in temperature due to high friction between the tool and the work piece. The variation of surface roughness with increase in nose radius is negligible.
• The ANOVA analysis on the basis of sum of squares and mean squares shows that the feed rate of 41% was found to be the major factor affecting the surface roughness, whereas the nose radius of 11.9% was found to be the second influential factor followed by cutting speed of 10.3% and depth of cut of 0%.

• The ANOVA analysis on the basis of confidence level indicates that feed rate gives the highest percentage of contribution of 81% and the nose radius is the second most influential factor with a value of 68% followed by cutting speed with a value of 66% and depth of cut with a value of 5%.

• Using Minitab software the mathematical model has been developed relating the surface roughness with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.

- L31 orthogonal array is used for CNC LT16 XI lathe for machining of Al6061T6.

• Surface roughness of the material increases with increase in feed rate reaches a maximum and then decreases, for a variation in feed rate of cutting tool from 0.01 mm/rev to 0.09 mm/rev. Therefore at a low feed rate of the cutting tool produces excellent surface finish.

• Surface roughness of the material increases with increase in speed with a sudden drop at 1500 rpm and then decreases, for a variation in speed of work material from 500 rpm to 2500 rpm. Therefore at a low speed of the cutting tool produces excellent surface finish.

• Surface roughness of the material decreases with increase in depth of cut with a maximum at 1.625 mm and then decreases, for a variation in depth of cut of work material from 0.5 mm to 2 mm. Therefore at a high depth of cut of the cutting tool produces excellent surface finish.
Surface roughness of the material increases with increase in rake angle with a minimum at 10° and then increases, for a variation in rake angle of the tool from 9° to 12°. Therefore at a low rake angle of the cutting tool produces excellent surface finish.

The ANOVA analysis on the basis of sum of squares shows that the cutting speed with 64.7% was found to be the major factor affecting the surface roughness, whereas the depth of cut with 17.9% was found to be the second influential factor followed by feed rate with a value of 9.4% and rake angle with a value of 8%.

Using Minitab software the mathematical model has been developed relating the surface roughness with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

- **L31 orthogonal array is used for MTAB XLTURN lathe for machining of Al7075**

  - Surface roughness of the material decreases with increase in feed rate until 0.099 mm/rev and then increases, for a variation in feed rate of cutting tool from 0.054 mm/rev to 0.179 mm/rev. Therefore at a feed rate of 0.099 mm/rev of the cutting tool produces excellent surface finish.

  - Surface roughness of the material decreases with increase in speed, for a variation in speed of work material from 231 rpm to 809.6 rpm. Therefore at a high speed of the cutting tool produces excellent surface finish.

  - Surface roughness of the material decreases with increase in depth of cut, for a variation in depth of cut of the work material from 0.5 mm to 1.5 mm. Therefore at a high depth of cut of the work material produces excellent surface finish.

  - Surface roughness of the material increases with increase in rake angle till a value of at 10.5° and then decreases, for a variation in rake angle of the tool from 10° to
The ANOVA analysis on the basis of sum of squares shows that the cutting speed of 48.4% was found to be the major factor affecting the surface roughness, whereas the rake angle of 19.6% was found to be the second influential factor followed by feed rate with a value of 18.6% and depth of cut with a value of 13.3%.

Using Minitab software the mathematical model has been developed relating the surface roughness with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

6.2 EFFECT OF CUTTING PARAMETERS ON MATERIAL REMOVAL RATE

L8 orthogonal array is used for medium duty lathe for machining of Al6061T6. Material removal rate of the material increases with increase in feed rate, cutting speed, depth of cut and nose radius leading to excellent machining performance because of the increase in the amount of material removed from the work piece with increase in the length of the tool travelled.

The ANOVA analysis on the basis of sum of squares shows that feed rate with a value with 38.56% was found to be the major factor affecting the material removal rate, whereas the depth of cut with 9.6% was found to be the second influential factor followed by nose radius with 4.1% and cutting speed with 3.4%.

The ANOVA analysis on the basis of mean squares shows that feed rate with a value with 38.56% was found to be the major factor affecting the material removal rate, whereas the depth of cut with 9.6% was found to be the second influential factor followed by nose radius with 4.1% and cutting speed with 3.4%.
The ANOVA analysis on the basis of confidence level indicates that the feed rate gives highest percentage of contribution with 57% and depth of cut is the second most influential factor with a value with 36% followed by nose radius with 25% and cutting speed with 23%.

Using Minitab software the mathematical model has been developed relating the material removal rate with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.

- L8 orthogonal array is used for medium duty lathe for machining of Al7075.
  - Material removal rate of the material increases with increase in feed rate, cutting speed, depth of cut and nose radius leading to excellent machining performance because of the increase in the amount of material removed from the work piece with increase in the length of the tool travelled.
  - The ANOVA analysis on the basis of sum of squares and mean squares shows that cutting speed of 18.5% was found to be the major factor affecting the material removal rate, whereas the feed rate with 10.5% was found to be the second influential factor followed by nose radius of 5.7% and depth of cut of 1.4%.
  - Using Minitab software the mathematical model has been developed relating the material removal rate with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.
L31 orthogonal array is used for CNC LT16 XI lathe for machining of Al6061T6.

- Material removal rate of the material increases with increase in feed rate, cutting speed and depth of cut leading to excellent machining performance because of the increase in the amount of material removed from the work piece with increase in the length of the tool travelled.

- Material removal rate of the material does not vary with increase in rake angle for a variation in rake angle of cutting tool from 9\(^\circ\) to 12\(^\circ\). Therefore, rake angle has very little influence on optimum machining performance related to material removal rate.

- The ANOVA analysis on the basis of sum of squares shows that the depth of cut with 41.9% was found to be the major factor affecting the material removal rate, whereas the cutting speed with 32.7% was found to be the second influential factor followed by feed rate with 24.5% and rake angle with 0.8%.

- Using Minitab software the mathematical model has been developed relating the material removal rate with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

L31 orthogonal array is used for MTAB XLTURN lathe for machining of Al7075

- Material removal rate of the material increases with increase in feed rate, cutting speed and depth of cut leading to excellent machining performance because of the increase in the amount of material removed from the work piece with increase in the length of the tool travelled.
- Material removal rate of the material does not vary with increase in rake angle for a variation in rake angle of cutting tool from 10° to 12°. Therefore, rake angle has very little influence on optimum machining performance related to material removal rate.

- The ANOVA analysis on the basis of sum of squares shows that the depth of cut of 38.1% was found to be the major factor affecting the material removal rate, whereas the cutting speed of 37.1% was found to be the second influential factor followed by feed rate with 24.4% and rake angle with 0.4%.

- Using Minitab software the mathematical model has been developed relating the material removal rate with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

6.3 EFFECT OF CUTTING PARAMETERS ON MACHINING TIME

- **L8 orthogonal array is used for medium duty lathe for machining of Al6061T6.**

- Machining time of the material decreases with increase in feed rate and cutting speed leading to excellent machining performance because of the increase in the velocity of the tool and the work piece.

- Machining time of the material does not vary with increase in depth of cut and nose radius which indicates that depth of cut and nose radius does not affect the machining performance related to machining time.

- The ANOVA analysis on the basis of sum of squares shows that feed rate and nose radius with a value of 44.4% were found to be the major factor affecting the machining time, whereas the depth of cut with 11.1% was found to be the second influential factor followed by cutting speed with 0%.
• Using Minitab software the mathematical model has been developed relating the machining time with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation

- **L8 orthogonal array is used for medium duty lathe for machining of Al7075.**
  - Machining time of the material decreases with increase in feed rate and cutting speed leading to excellent machining performance because of the increase in the velocity of the tool and the work piece.
  - Machining time of the material does not vary with increase in depth of cut and nose radius which indicates that depth of cut and nose radius does not affect the machining performance related to machining time.
  - The ANOVA analysis on the basis of sum of squares and mean squares shows that feed rate with a value of 1.63 was found to be the major factor affecting the machining time, whereas the cutting speed with a value of 0.219 was found to be the second influential factor followed by nose radius of 0.068 and depth of cut with 0.
  - The ANOVA analysis on the basis of confidence level shows that feed rate and speed with 100% was found to be the major factor affecting the machining time, followed by nose radius of 0.068 and depth of cut with 0.
  - Using Minitab software the mathematical model has been developed relating the machining time with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation
L31 orthogonal array is used for CNC LT16 XI lathe for machining of Al6061T6.

- Machining time of the material decreases with increase in feed rate and cutting speed leading to excellent machining performance because of the increase in the velocity of the tool and the work piece.
- Machining time of the material has very little variation with increase in depth of cut and rake angle which indicates that depth of cut and rake angle does not affect the machining performance related to machining time.
- The ANOVA analysis on the basis of sum of squares shows that the depth of cut with 75.9% was found to be the major factor affecting the machining time, whereas the cutting speed with 21.2% was found to be the second influential factor followed by rake angle with 1.7% and feed rate with 1.1%.
- Using Minitab software the mathematical model has been developed relating the machining time with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

L31 orthogonal array is used for MTAB XLTURN lathe for machining of Al7075

- Machining time of the material decreases with increase in feed rate and cutting speed leading to excellent machining performance because of the increase in the velocity of the tool and the work piece.
- Machining time of the material has very little variation with increase in depth of cut and rake angle which indicates that depth of cut and rake angle does not affect the machining performance related to machining time.
The ANOVA analysis on the basis of sum of squares shows that the cutting speed of 63.8% was found to be the major factor affecting the machining time, whereas the depth of cut with 34.5% was found to be the second influential factor followed by feed rate and rake angle with 0.8%.

Using Minitab software the mathematical model has been developed relating the machining time with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

6.4 EFFECT OF CUTTING PARAMETERS ON MACHINING FORCE

- L8 orthogonal array is used for medium duty lathe for machining of Al6061T6.
  - Machining force of the material increases with increase in feed rate and depth of cut leading to poor machining performance because of the increase in the contact area between the tool and the work piece.
  - Machining force of the material does not vary with increase in cutting speed and nose radius which indicates that cutting speed and nose radius does not affect the machining performance related to machining force.
  - The ANOVA analysis on the basis of sum of squares shows that feed rate with a value of 69.65% was found to be the major factor affecting the machining force, whereas the nose radius with 20.35 was found to be the second influential factor followed by cutting speed and depth of cut with 0%.
  - The ANOVA analysis on the basis of confidence level shows that feed rate with a value of 57.36% was found to be the major factor affecting the machining force, whereas the nose radius with 44.23 was found to be the second influential factor followed by cutting speed and depth of cut with 0%.
Using Minitab software the mathematical model has been developed relating the machining force with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.

- **L8 orthogonal array is used for medium duty lathe for machining of Al7075.**
  - Machining force of the material increases with increase in feed rate and depth of cut leading to poor machining performance because of the increase in the contact area between the tool and the work piece.
  - Machining force of the material does not vary with increase in cutting speed and nose radius which indicates that cutting speed and nose radius does not affect the machining performance related to machining force.
  - The ANOVA analysis on the basis of sum of squares and mean squares shows that feed rate with a value of 41.08% was found to be the major factor affecting the machining force, whereas the cutting speed with 14.3% was found to be the second influential factor followed by depth of cut with 0% and nose radius with 0%.
  - The ANOVA analysis on the basis of confidence level shows that feed rate with a value of 50% was found to be the major factor affecting the machining force, whereas the cutting speed with 34% was found to be the second influential factor followed by depth of cut with 0% and nose radius with 0%.
  - Using Minitab software the mathematical model has been developed relating the machining force with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.
L31 orthogonal array is used for CNC LT16 XI lathe for machining of Al6061T6.

- Machining force of the material increases with increase in feed rate and depth of cut leading to poor machining performance because of the increase in the contact area between the tool and the work piece.
- Machining force of the material does not vary with increase in cutting speed and rake angle which indicates that cutting speed has little effect and nose radius has no effect on the machining performance related to machining force.
- The ANOVA analysis on the basis of sum of squares shows that the depth of cut with 51% was found to be the major factor affecting the machining force, whereas the feed rate with 35.9% was found to be the second influential factor followed by cutting speed with 12.9% and rake angle with 0.2%.
- Using Minitab software the mathematical model has been developed relating the machining force with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

L31 orthogonal array is used for MTAB XLTURN lathe for machining of Al7075

- Machining force of the material increases with increase in feed rate and depth of cut leading to poor machining performance because of the increase in the contact area between the tool and the work piece.
- Machining force of the material does not vary with increase in cutting speed and rake angle which indicates that cutting speed and rake angle have little effect on the machining performance related to machining force.
The ANOVA analysis on the basis of sum of squares shows that the depth of cut with 61.1% was found to be the major factor affecting the machining force, whereas the feed rate with 38.2% was found to be the second influential factor followed by cutting speed and rake angle with 0.4%.

Using Minitab software the mathematical model has been developed relating the machining force with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

6.5 EFFECT OF CUTTING PARAMETERS ON MACHINING POWER

- **L8 orthogonal array is used for medium duty lathe for machining of Al6061T6.**

  - Machining power of the material increases with increase in feed rate, cutting speed, depth of cut and nose radius leading to poor machining performance because of the increase force required for removal of material from work piece.

  - The ANOVA analysis on the basis of sum of squares shows that feed rate with a value of 82.2% was found to be the major factor affecting the machining power, whereas the depth of cut with 20.5% was found to be the second influential factor followed by nose radius with 8.9% and cutting speed with 7.4%.

  - The ANOVA analysis on the basis of confidence level indicates that feed rate gives the highest percentage of contribution of 57.35% and the depth of cut is the second most influential factor with a value of 35.86% followed by nose radius with 25.15% and cutting speed with 23.05%.

  - Using Minitab software the mathematical model has been developed relating the machining power with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.

- **L8 orthogonal array is used for medium duty lathe for machining of Al7075.**
• Machining power of the material increases with increase in feed rate, cutting speed, depth of cut and nose radius leading to poor machining performance because of the increase force required for removal of material from work piece.

• The ANOVA analysis on the basis of sum of squares and mean squares shows that cutting speed with 16.8% was found to be the major factor affecting the machining power, whereas the feed rate with 9.5% was found to be the second influential factor followed by nose radius with 5.2% and depth of cut with 1.3%.

• The ANOVA analysis on the basis of confidence level shows that cutting speed with 34% was found to be the major factor affecting the machining power, whereas the feed rate with 27% was found to be the second influential factor followed by nose radius with 20% and depth of cut with 10%.

• Using Minitab software the mathematical model has been developed relating the machining power with cutting parameters such as Feed, Speed, Depth of cut and Nose radius. The model is found valid within the scope of this investigation.

L31 orthogonal array is used for CNC LT16 XI lathe for machining of Al6061T6.

• Machining power of the material increases with increase in feed rate, cutting speed and depth of cut leading to poor machining performance because of the increase force required for removal of material from work piece. Rake angle has very little effect on machining power.

• The ANOVA analysis on the basis of sum of squares shows that the depth of cut with 39.7% was found to be the major factor affecting the machining power, whereas the cutting speed with 34% was found to be the second influential factor followed by feed rate with 25.5% and rake angle with 0.8%.
Using Minitab software the mathematical model has been developed relating the machining power with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

L31 orthogonal array is used for MTAB XLTUR lathe for machining of Al7075

- Machining power of the material increases with increase in feed rate, cutting speed and depth of cut leading to poor machining performance because of the increase force required for removal of material from work piece. Rake angle has very little effect on machining power.

- The ANOVA analysis on the basis of sum of squares shows that the depth of cut of 38.1% was found to be the major factor affecting the machining power, whereas the cutting speed of 37.1% was found to be the second influential factor followed by feed rate with 24.4% and rake angle with 0.4%.

- Using Minitab software the mathematical model has been developed relating the machining power with cutting parameters such as Feed, Speed, Depth of cut and Rake angle. The model is found valid within the scope of this investigation.

All the conclusions are in conformity with the literature survey.