INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & MANAGEMENT

FINITE ELEMENT ANALYSIS OF CIRCULAR SAW BLADE AND STRESS REDUCTION BY USING SURFACE COATING METHOD

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ABSTRACT

Circular saw blade in machining industry undergoes different cutting forces during machining of different materials. To analyze the effect of these cutting forces finite element analysis of the saw was done to calculate the stresses in hypermesh. This paper involves the analysis of the circular saw blade in Ls Dyna a module of Hypermesh. LS-DYNA is a multi-purpose, explicit and implicit finite element program used to analyze the nonlinear dynamic response of structures. For this analysis four specimens of different materials are used. The stresses generated after the analysis is compared and then the maximum value is noted. The circular saw is then coated with three different materials namely titanium TiC, TiN and Al_2O_3. Then the specimen who's cutting generated maximum value of stress in the circular saw blade is again cut by the coated circular saw blade. Then the stresses are again calculated and compared and the coating which reduces maximum stresses is selected.

KEYWORDS: Circular saw blade, finite element analysis, cutting forces, coating.

INTRODUCTION

Circular saw blades have variable applications in metal cutting industry. And because of variable applications the saw has to withstand variable cutting forces. Few researches have been done to calculate the stresses developed in the saw used in the industries for various operations. The stresses are generated because of the cutting forces generated during the operation. These stress leads to wear and built-up edges in the saw. The process of determining the stresses is practically a difficult process which requires an experimental setup. This thesis includes the use of finite element method on hypermesh, CAE software which reduces all the complexities of experimental setup. Also there are some methods available in surface technology like thermal treatment, thermochemical treatment, plating and coating which helps to reduce stresses. In current paper a circular saw is analyzed during cutting four different specimens. The stresses developed are then compared and by the method of coating higher stresses are reduced. For coating titanium nitride, aluminium oxide and titanium carbide are used. Values of stresses after coating are then compared.

METHODOLOGY

The circular saw blade used in this paper is shown in figure 1 and is made of HSS material. This material is generally used in industries for machining of different materials.

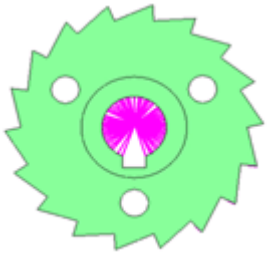


Figure 1: Circular saw blade

For further analysis, four different specimens were cut by the circular saw in LS-DYNA to determine the stresses generated in the saw as shown in figure 2. The four different specimens used are of steel, copper, aluminum and wood. The mechanical properties of these specimens are given in table 2.

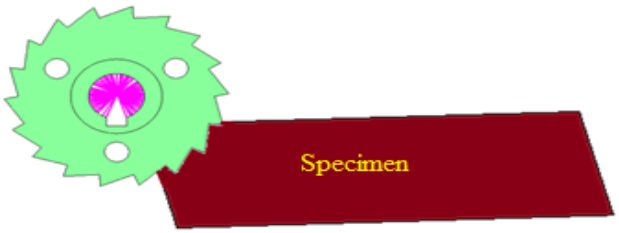


Figure 2: Circular saw blade

ISSN: 2277-5528
Impact Factor: 3.145

Table 1: Mechanical properties of the specimens used

Mechanical Properties	Elastic Modulus (GPa)	Poisson's Ratio	Yield stress (MPa)	Ultimate stress (MPa)	Density (*1000 kg/m3)
1. Steel	190-210	0.27-0.3	280-1600	340-1900	7.85
2. Copper	110-120	0.33-0.36	55-330	230-380	8.94
3. Aluminium	70	0.33	20	70	2.71
4. wood	10-11	-	40-70	50-100	0.56-0.64

When these specimens were cut by the saw on LS DYNA, the force-time history and stresses were noted and compared. The cutting forces with respect to time for the specimens were compared, the comparison is shown in figure 3 and it was found that the maximum cutting force generated in the optimized saw while cutting the steel specimens i.e. 1.2kN. Then the stresses developed in the circular saw were compared. From figure 4 it was found that maximum stresses developed during the cutting of steel specimens.

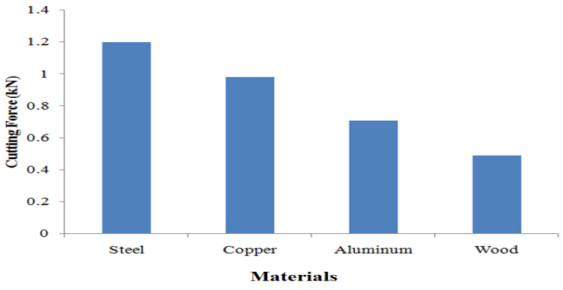


Figure 3: Comparison of cutting force generated while cutting the four different specimens.

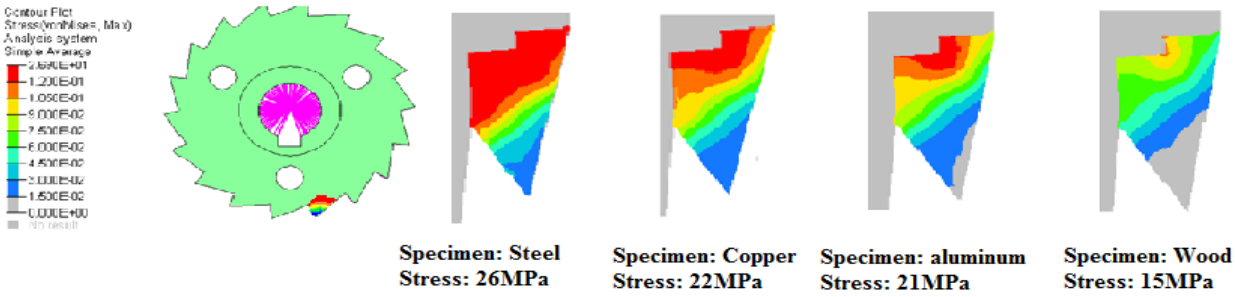


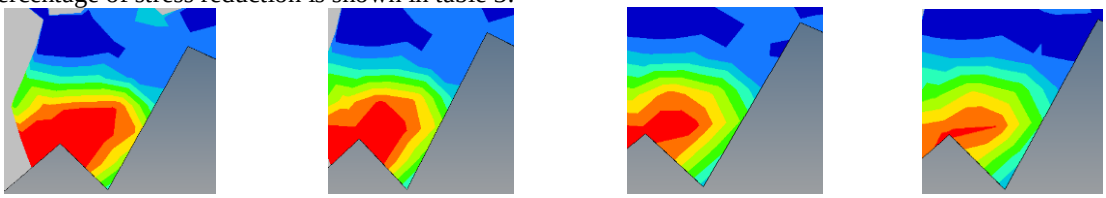
Figure 4: Comparison of stresses in the saw after cutting four different specimens.

To reduce the stresses a method of surface technology i.e. coating is used. The materials used for coating the circular saw are titanium carbide (TiC), titanium nitride (TiN) and aluminium oxide (Al_2O_3). The mechanical properties of these coating materials are shown in table 2.

Table 2: Mechanical properties of the coating materials

Properties	Titanium Nitride (TiN)	Aluminium oxide (Al_2O_3)	Titanium Carbide (TiC)
Density (g/cc)	5.22	3.69	4.94
Poisson's ratio	0.25	0.21	0.18 – 0.19
Modulus of elasticity (GPa)	251	300	448 - 451
Shear Modulus (GPa)	240	124	186

A coating of thickness 1mm is done on the circular saw. The steel specimen is again cut by the coated circular saw blade. The saw blade is coated with all the three coating material and one by one the steel specimen is cut by the entire coated circular saw blades. The stresses generated in the saw blade after coating are shown in figure 4 and the percentage of stress reduction is shown in table 3.



Stress without coating 26MPa | Stress after TiN coating 24.5MPa | Stress after Al_2O_3 coating 21.4MPa | Stress after TiC coating 15MPa

Figure 5: Comparison of stresses with and without coating.

Table 3: Stresses after coating

Coating material	Stress after coating (MPa)	Percentage of stress reduction
Titanium Nitride (TiN)	24.5	5.70 %
Aluminium oxide (Al_2O_3)	21.4	17.69 %
Titanium Carbide (TiC)	15	42.30 %

RESULT

The circular saw blade is analyzed for cutting four different specimen so as to determine the vlaue of stresses generated. The stresses developed in the entire four material i.e. steel, copper, aluminium and wood are given in table 4 below.

Table 4: Stress developed in the optimized saw while cutting four different specimens.

Specimens	Steel	Copper	Aluminium	Wood
Stress (MPa)	26	22	21	15

When these stresses were compared it was found that maximum stresses were developed in the circular saw while cutting the steel specimen i.e. 26MPa. So as to reduce this stress coating method was employed and the results after coating is shown in the table 5.

Table 5: Comparision of stresses reduced by the coated material

Coating material	Stress without coating (MPa)	Stress after coating (MPa)	Percentage of stress reduction
Titanium Nitride (TiN)	26	24.5	5.70 %
Aluminium oxide (Al_2O_3)	26	21.4	17.69 %
Titanium Carbide (TiC)	26	15	42.30 %

CONCLUSION

On analyzing the saw for cutting four different specimens i.e. aluminum, steel, copper and wood, it was found that maximum stress of 26MPa was developed while cutting steel specimen. So as to reduce this stress the saw was coated with three different materials having wear resisting properties. Out of which titanium carbide coating reduced the stresses from 26 MPa to 15 MPa. The percentage of stress reduction after titanium carbide (TiC) coating was 42 % which will affect tool life positively since TiC gives abrasion resistance and prevents the chip from dissolving the tool material, leaving craters. Also all the analysis was done on a finite element analysis software i.e. Hypermesh which helped to reduce the complexities of experimental setup.

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