CHAPTER 6

INVESTIGATIONS ON HOOP STRESSES IN MAGNESIUM ALLOYS BLANKS

6.1 INTRODUCTION

A number of operations and flow conditions are involved in the fluid assisted deep drawing process. In this process hoop stresses are produced in the blank circumferentially which is in between blank holder and die surface due to punch force applied on it. The hoop stresses are higher which shows higher draw ratios and high forming limits. In this process hoop stresses are studied on blanks made of magnesium alloys at different radii of blanks with constant thickness and heavy machine oil as medium.

6.2 RESULTS AND DISCUSSION

6.2.1 Hoop Stresses

The hoop stress distribution along the magnesium alloys blanks during the fluid assisted deep drawing process is given in eq.(3.19).The geometry of process, process parameters and yield strength of magnesium alloys are considered for evaluation of hoop stresses with given fluid for successful formation of cup in fluid assisted deep drawing process. The fluid pressure (P) is obtained in Ansys Flotran CFD for heavy machine oil is 58.47 N/m^2.This pressure is applied radially on periphery of blank and it is equal to blank holding pressure. The following parameters considered for the analysis

r_p = 40mm , r_d = 45mm

P = 58.47N/m^2

P_h = 58.47N/m^2

fluid medium:

Heavy machine oil

μ = 0.453N-s/m^2

ρ = 986 kg/m^3,

r_j = 95mm, 100mm and 105mm

t = 3.0mm

and remaining data of the process is given in 3.16

substitute the geometry and process parameters in eq.(3.19), a generalized equations for results, which is given in eq.(6.1),eq.(6.2) and eq.(6.3) with r_j = 95mm,100mm and 105mm respectively.

$$\sigma_\theta = \sigma_0 \left[\ln\left(\frac{95}{r}\right) - 1 \right] - 3.02\,[95 - r] \qquad [6.1]$$

$$\sigma_\theta = \sigma_0 \left[\ln\left(\frac{100}{r}\right) - 1 \right] - 3.02\,[100 - r] \qquad [6.2]$$

$$\sigma_\theta = \sigma_0 \left[\ln\left(\frac{105}{r}\right) - 1 \right] - 3.02\,[105 - r] \qquad [6.3]$$

Fig.6.1 Shows the variation of hoop stresses in blank made of magnesium alloys with heavy machine oil obtained using theoretical and finite element simulation. From theoretical analysis the range of hoop stresses for AZ61A-F, HK31A–H24 and AZ31B-0 alloys are 118902993.2N/m^2 – 208105226.4N/m^2, 110795978.2N/m^2– 193916234.7N/m^2 and 81070256.29N/m^2 – 141889931.9N/m^2 respectively.

From finite element analysis the range of hoop stresses for AZ61A-F, HK31A-H24 and AZ31B-0 alloys are 125085948.8N/m^2 – 220175329.50N/m^2, 116557369.1N/m^2 – 205163376.3N/m^2 and 85285909.62N/m^2 – 150119547.8 N/m^2 respectively.

The hoop stresses from theoretical analysis are maximum at r = 90mm for AZ61A-F alloy is 208105226.4N/m^2 and in AZ31B-0 alloy which is 141889931.9N/m^2. At r = 60mm the least variation is observed for AZ61A-F alloy is 118902993.2N/m^2, AZ31B-0 alloy is 81070256.29N/m^2 .High hoop stresses are found for AZ61A-F magnesium alloy and least inAZ31B-0 magnesium alloy and within these HK31A-H24 magnesium alloy are observed.

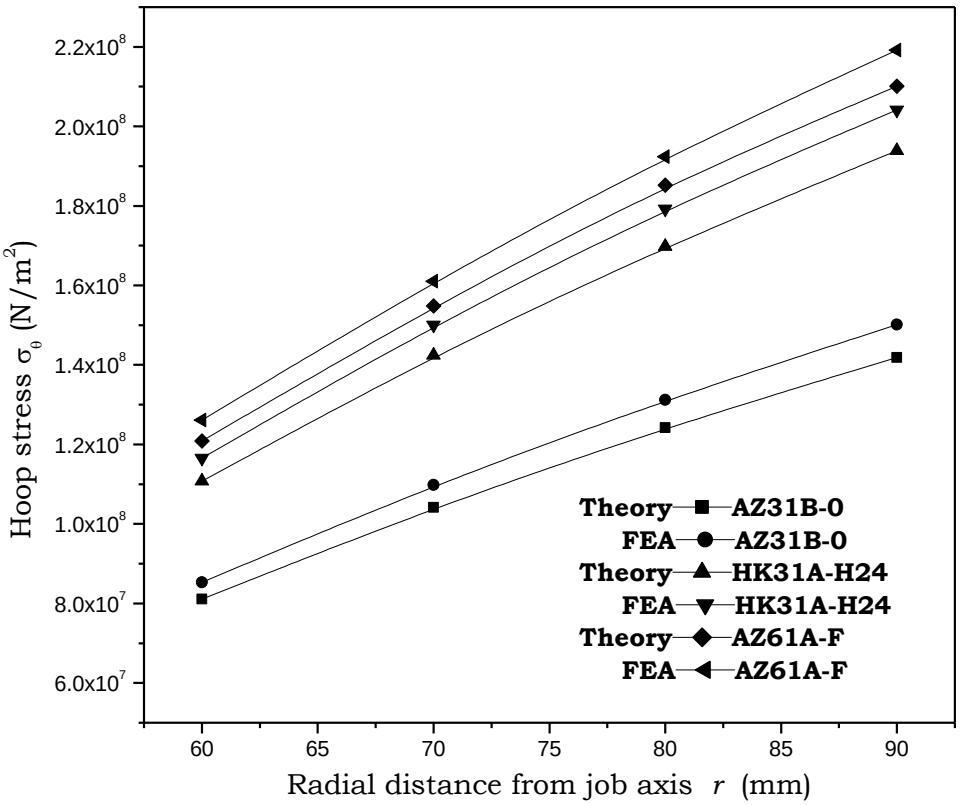

Fig.6.1 Variation of hoop stresses in magnesium alloys blanks at r_j = 95mm

A similar variation is observed from finite element analysis, maximum at r = 90mm for AZ61A-F alloy is 220175329.50N/m^2 and in AZ31B-0 alloy which is 150119547.8N/m^2. At r = 60mm the least variation is observed for AZ61A-F alloy is 125085948.8N/m^2, AZ31B-0 alloy is 85285909.62N/m^2 .High hoop stresses are found in AZ61A-F magnesium alloy and least inAZ31B-0 magnesium alloy and within these HK31A-H24 magnesium alloy are observed.

The average percentage variation between the theoretical and finite element analysis is 5.2%. From this analysis, the order of hoop stresses of magnesium alloys is AZ31B-0 < HK31A-H24 < AZ61A-F observed.

Fig.6.2 Shows the variation of hoop stresses in blank made of magnesium alloys with heavy machine oil obtained using theoretical and finite element simulation. From theoretical analysis the range of hoop stresses for AZ61A-F, HK31A–H24 and AZ31B-0 alloys are 107681483.6N/m^2 – 196820716.8N/m^2,100280867.9N/m^2– 183401124.5N/m^{2}and 73376277.24 N/m^2 – 134195952.9 respectively.

From finite element analysis the range of hoop stresses for AZ61A-F, HK31A-H24 and AZ31B-0 alloys are 113065557.8N/m^2 – 207842676.9N/m^2 , 105294911.3 N/m^2 – 193671587.5 N/m^2 and 77045091.1 N/m^2 - 141710926.3 N/m^2 respectively.

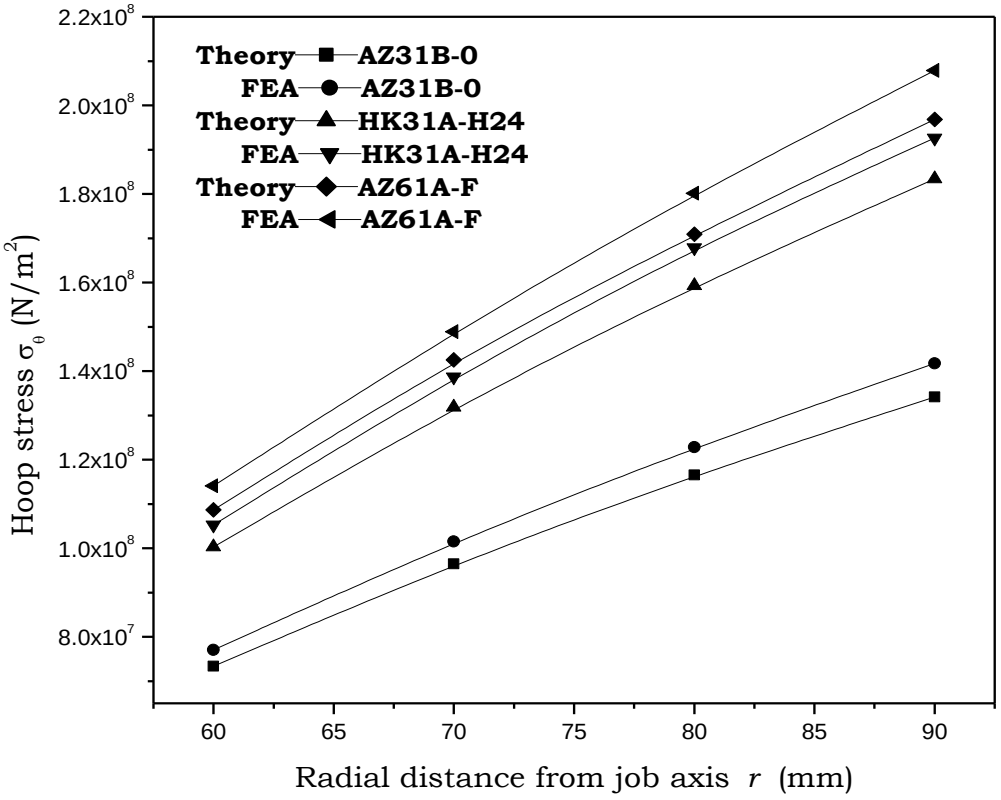

Fig.6.2 Variation of hoop stresses in magnesium alloys blanks at r_j = 100mm

The hoop stresses from theoretical analysis are maximum at r = 90mm for AZ61A-F alloy is 196820716.8N/m^2 and in AZ31B-0 alloy which is 134195952.9N/m^2. At r = 60mm the least variation is observed for AZ61A-F alloy is 107681483.6N/m^2, AZ31B-0 alloy is 73376277.24N/m^2 .High hoop stresses are found in AZ61A-F magnesium alloy and least inAZ31B-0 magnesium alloy and within these HK31A-H24 magnesium alloy are observed.

A similar variation is observed from finite element analysis, maximum at r = 90mm for AZ61A-F alloy is 207842676.9N/m^2 and in AZ31B-0 alloy which is 141710926.3N/m^2. At r = 60mm the least variation is observed for AZ61A-F alloy is 113065557.8N/m^2, AZ31B-0

alloy is 77045091.1N/m^2 .High hoop stresses are found in AZ61A-F magnesium alloy and least in AZ31B-0 magnesium alloy and within these HK31A-H24 magnesium alloy are observed.

The average percentage variation between the theoretical and finite element analysis is 5.03%. From this analysis, the order of hoop stresses of magnesium alloys are AZ31B-0 < HK31A-H24 < AZ61A-F found.

Fig.6.3 Shows the variation of hoop stresses in blank made of magnesium alloys with heavy machine oil obtained using theoretical and finite element simulation. From theoretical analysis the range of hoop stresses for AZ61A-F, HK31A-H24 and AZ31B-0 alloys are 96884662.55N/m^2 – 186086895.7N/m^2, 90278899.37N/m^2 – 173399155.9N/m^2 and 66057767.71N/m^2 – 126877443.3N/m^2 respectively.

From Finite Element analysis the range of hoop stresses for AZ61A-F, HK31A-H24 and AZ31B-0 alloys are101535126.3N/m^2 – 196135588.1N/m^2, 94612286.54N/m^2 – 182762710.3N/m^2 and 69228540.56 N/m^2 – 133728825.2 N/m^2 respectively.

The hoop stresses from theoretical analysis are maximum at r = 90mm for AZ61A-F alloy is 186086895.7N/m^2 and in AZ31B-0 alloy which is 126877443.3N/m^2. At r = 60mm the least variation is observed for AZ61A-F alloy is 96884662.55N/m^2, AZ31B-0 alloy is 66057767.71N/m^2 .High hoop stresses are found in AZ61A-F magnesium alloy and least inAZ31B-0 magnesium alloy and within these HK31A-H24 magnesium alloy are observed.

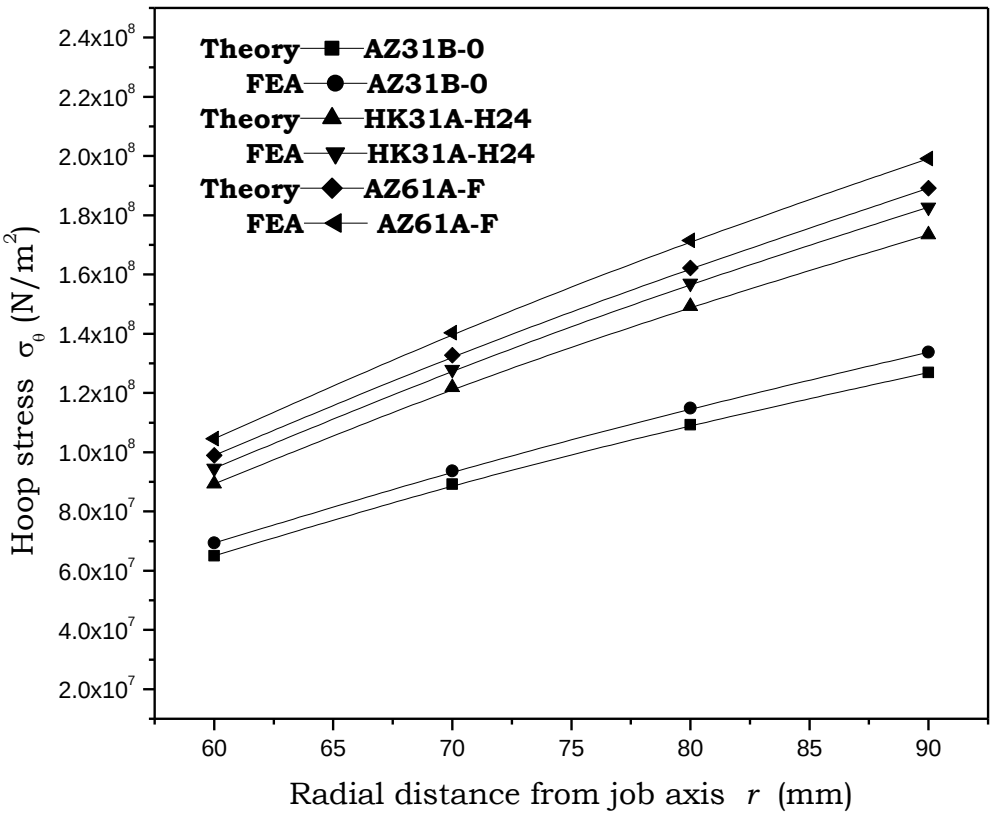

Fig.6.3 Variation of hoop stresses in magnesium alloys blanks at r_j = 105mm

A similar variation is observed from finite element analysis, maximum at r = 90mm for AZ61A-F alloy is 196135588.1N/m^2 and in AZ31B-0 alloy which is 133728825.2N/m^2. At r = 60mm the least variation is observed for AZ61A-F alloy is 101535126.3N/m^2, AZ31B-0 alloy is 69228540.56N/m^2 .High hoop stresses are found in AZ61A-F magnesium alloy and least inAZ31B-0 magnesium alloy and within these HK31A-H24 magnesium alloy are observed.

The average percentage variation between the theoretical and finite element analysis is 4.85%. From this analysis, the order of hoop

stresses of magnesium alloys are AZ31B-0 < HK31A-H24 < AZ61A-F found. The nature of graphs is linear.

The order of variation of hoop stresses of magnesium alloys with heavy machine oil as medium is as follows

$$\sigma_\theta \big|_{r_j=95mm} > \sigma_\theta \big|_{r_j=100mm} > \sigma_\theta \big|_{r_j=105mm}$$

The hoop stresses increase with increase in the radial distance of the blank from the job axis and also hoop stresses decrease with increase in the radius of blanks of magnesium alloys. These are due to viscosity of fluid, the shear stresses and shear forces acted on the blank surface during the drawing process.

Hoop stresses also depend up on process parameters, yield stress of alloys and fluid pressure. The high hoop stresses leads to minimum drawing time and also higher in forming limits. These hoop stresses are used to get good results of deep drawability of magnesium alloys.