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Design & Analysis in Injection Moulding Machine System to Reduce the Torsional Failure of Screw

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***Abstract*— The Injection moulding process is commonly used manufacturing process for the production of plastic parts. The plastic being melted in injection molding machine and then injected into the mould. The barrel contains reciprocating screw for injecting the material into the mould and the material is also melted into the barrel. This project deals with, the solution of problem occurred for reciprocating screw of Injection molding machine. It identifies and solves the problem by using the modeling and analysis techniques. The problem occurred in the reciprocating screw of machine which is wearing of threads due to effect of temperature of mold materials (flow materials) i.e. Nylon, low-density polypropylene, polystyrene, PVC etc., The main work was to model the components of machine with dimensions, and perform static and thermal analysis with parts of injection molding machine parts like reciprocating screw.[2] The analysis of reciprocating screw provides the possible solution to reduce the wear or damage on reciprocating screw, hence avoiding the high cost and time lapse**

Keywords* — *Reciprocating screw, gear box, motor capacity, rigid flange coupling, barrel heaters, Catia V5 and Ansys 14.

I. INTRODUCTION

The injection molding process is most commonly used manufacturing process for production of plastic parts. As a raw material plastic is used in this process such as low density polyethylene, nylon, polypropylene, flexible PVC, polystyrene and machine used for the injection process is the injection molding machine. Raw material is melted in the injection molding machine and then forwarded into the mold with the help of reciprocating screw where it cools and solidifies into the final product part. The reciprocating screw is mounted on gear box in the barrel; barrel contains heaters for heating the raw material. In the injection process raw material is melted by heat and pressure. While forwarding material the material enters the grooves of reciprocating screw. The reciprocating screw completes the shot volume and returns to reverse position. Two types failure occurs in the injection process bending failure and torsional failure of threads due to effect of high melting temperature of mold material and pressure created because of that. The objectives involved are:-

A. To model reciprocating screw using modelling Software CATIA V5R20

B. Analysis of reciprocating screw using ANSYS 14.5 software

C. To identify the wearing of threads and provide the possible solution.

D. To provide thermal solution for the system.

II. MATERIALS AND METHODES

This chapter describes the details of injection molding process, design of reciprocating screw with material EN-41B (SAE 52100) , design of coupling such that coupling should become weaker element to avoid the failure of reciprocating screw because of torsional failure causes in injection molding process due to effect of temperature of mold materials (flow materials).Various materials can be used in this process like linear low density polyethylene, Nylon, polystyrene, PVC etc. But, material of product used in this process is linear low density polyethylene (LLDP).

A .Design Of Reciprocating Screw

For designing the coupling we need the value of maximum torque, which is occurring in the injection process. That value is possible to calculate using motor power (kW) and existing damaged reciprocating screw design. Motor used for the injection process is of 15 HP i.e. 11.1855kW, Motor RPM = 1440 Gear box used in injection process is 1:15. Because of gear box effective power causing to the reciprocating screw is

$$\text{Effective power} = 11.1855 \times 15\ kW$$

$$= 167.7825\ kW$$

Torque transmitted will be,

$$T = \frac{60 \times 10^6 \times 167.7825\ kW}{2\pi \times \frac{96}{60}} = 1.0687 \times 10^5 Nmm$$

B. Modelling Of Reciprocating Screw

For the further static and thermal analysis of reciprocating screw we have to make model. For making model it requires dimensions of reciprocating screw. It is taken by using digital Vernier Calliper and modelling has been done by using CATIA V5. It is shown as in figure.

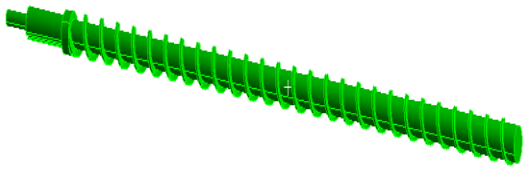

Fig-1 3D Model of reciprocating screw

C. Analysis of Existing Reciprocating Screw

Analysis of existing reciprocating screw is done by using software ANSYS R14.5 by providing properties of reciprocating screw material and CATIA model. Then it is feed into the ANSYS R14.5 and static and thermal analysis has been done. We have made analysis by using properties of two different materials. First of all we have made analysis by using material EN24, it could not avoid that much failure of reciprocating screw,

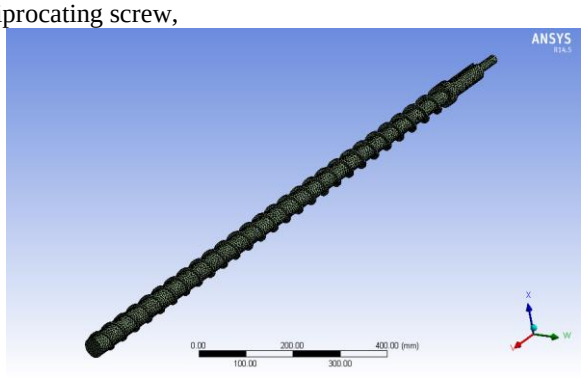

Fig-2 3 D Model -Mesh - Image

D. Inputs Provided To The Ansys R14.5 Software For Analysis Of Reciprocating Screw:

TABLE 1 PROPERTIES OF MATERIAL

Materials	SAE52100 (EN41B	SAE4340 (EN24)
Young's modulus (PA)	210×10^9	205×10^9
Poisons Ratio	0.3	0.292
Density (kg/m³)	7810	7850
Thermal Expansion	11.9×10^-6	12.3×10^-6
Yield Tensile strength (PA)	9.1×10^8	470×10^6
Ultimate Tensile Strength (PA)	672×10^6	689×10^6
Specific heat J/g-K	0.475	0.475
Thermal conductivity W/m-K	46.6	44.5

E. Testing of coupling:

As this is industrial based sponsored project we have carried out testing of this project in Industry. First of all we have connected the coupling in between gearbox and reciprocating screw, it is observed coupling can sustain the torque occurring in the injection process, if process goes normally without any hurdles. Then we have stop heating by switching off a heater. Because of which melting of material will be stop, After some time it is observed that coupling broken up instead of reciprocating screw.

Fig-3 Coupling Broken

III. RESULT AND DISCUSSION

A. *Analysis results for material EN 24*

After analysis on software ANSYS R14.5 following values of total deformation and equivalent stress is obtained as given below.

TABLE 2 E24 ANALYSIS REPORT

ANSYS R14.5 analysis report for EN 24		
Total Deformation in mm	0 Min	0.092955Max
Equivalent stress in MPa	1.6567×10^{-6}	2502.0 Max

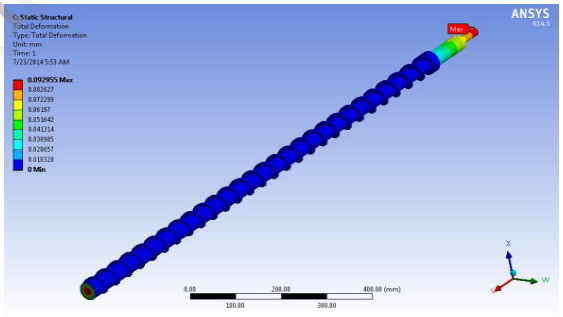

Fig-4 Model -Static Structural -Total Deformation-Image

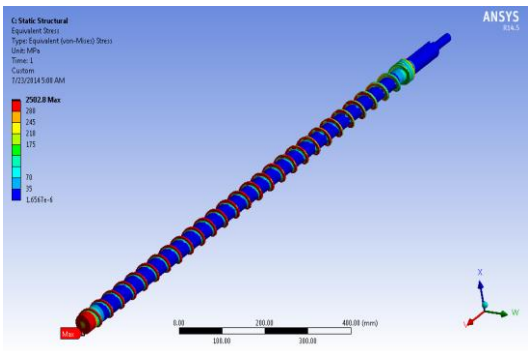

Fig-5 Model - Static Structural - equivalent stress - Image

From above obtained results it observed that failure of reciprocating screw is confirmed. In equivalent stress analysis it is observed that failure threads are confirmed and which takes at maximum equivalent stress value which is equal to 2502MPa. And it is too much high. So it is not possible reduce the failure of reciprocating screw.

B. Analysis results for material EN 41

After analysis on software ANSYS R14.5 following values of total deformation and equivalent stress is obtained as given below

TABLE 3 ANALYSIS REPORT FOR EN 41

ANSYS R14.5 software analysis report for EN 41		
Total Deformation in mm	0 Min	0.0091867Max
Equivalent stress in MPa	1.6567×10^{-6}	26.695.0 Max

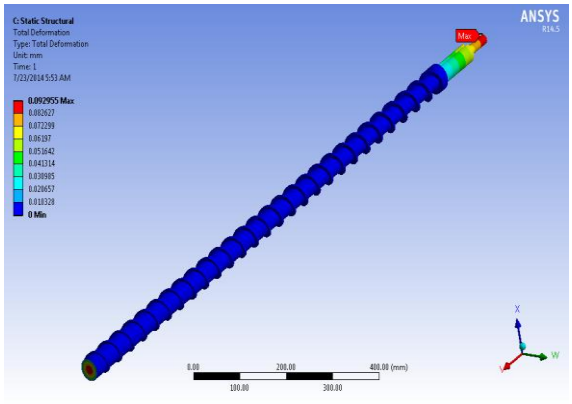

Fig-6 Model > Static Structural > deformation > Image

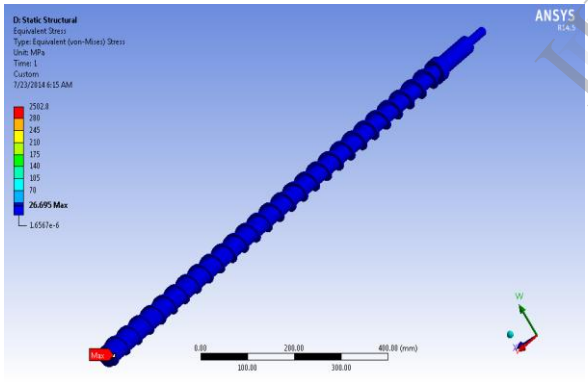

Fig-7 Model - Static Structural -equivalent stress- Image

From above obtained results also it observed that, this material; EN 41B gives better results than EN24, it has less chances of failure, But failure of reciprocating screw is confirmed. In equivalent stress analysis it is observed that failure threads at the end part is confirmed and which takes at maximum equivalent stress value which is equal to 2502MPa. And it is to much high. So it is not possible reduce the failure of reciprocating screw.

C. Thermal Analysis

For this material EN 41B we have done thermal analysis also it gives clear idea of different temperature zones in reciprocating screw. By analysis we can get idea of how the temperature varies and temperature at any point.

TABLE 4 MOULD TEMPERATURE

MOULD TEMPERATURES (° C)				
MATERIAL	T1(Metering Zone	T2(Compression Zone)	T3(Feed Zone)	T4(Drive Zone)
EN 41B	190	170	150	60

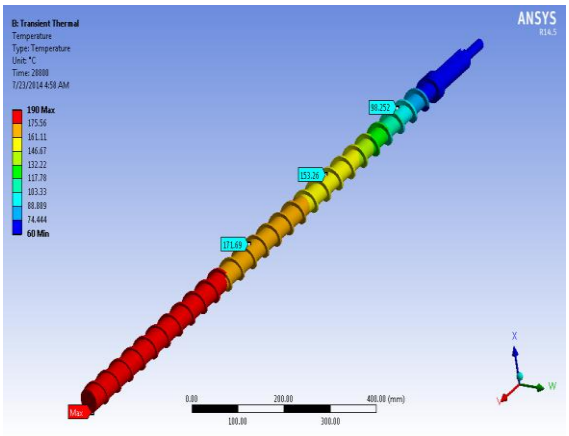

Fig-8 Variation of temperature

D. Analysis of Coupling

In analysis of coupling we can observe that, coupling shows maxim possibility of failure than reciprocating screw. And maximum value of equivalent stress is obtained is also to much higher than reciprocating screw which is equal to15721 MPa compared to 2502.0 MPa.

TABLE 5 ANALYSIS OF COUPLING

Analysis of Coupling		
Total Deformation mm	0	0.60204
Equivalent elastic strain mm	2.8695×10^{-7}	0.091828
Equivalent stress MPa	0.026355	15721

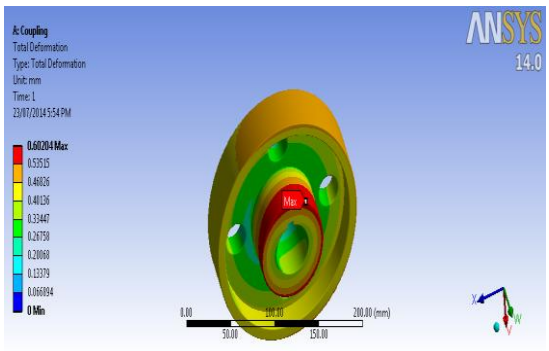

Fig-9 Model - Static Structural - total deformation

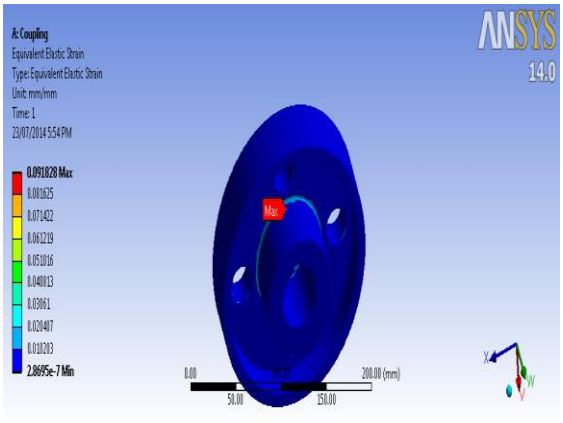

Fig-10 Model -Static Structural -equivalent elastic strain

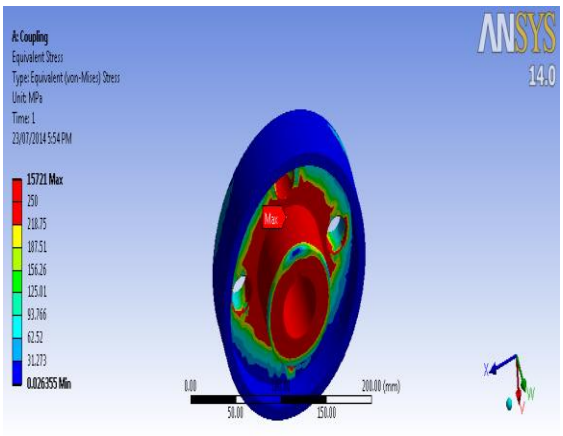

Fig-11 Model - Static Structural -equivalent stress

III. CONCLUSION

For reciprocating screw of material EN24 (SAE4340). of injection molding machine Static structural analysis performed on screw using ANSYS R14.5 software analysis applying torque at the end on motor side and keeping whole surface of screw as fixed support side, it is found that reciprocating screw has more chances of failure. In the same way For reciprocating screw of material EN-41B (SAE 52100) of injection molding machine Steady state Thermal analysis & Static structural analysis performed on screw using ANSYS R14.5 software analysis applying torque at the end on motor side and keeping whole surface of screw as fixed support side, it is found that this reciprocating screw also has more chances of failure. For reciprocating screw of material EN-41B (SAE 52100) also has done thermal analysis and it has shown variation of temperature along the full reciprocating screw length and it also can give temperature of material at different point.

In analysis of coupling we can observe that, coupling shows maximum possibility of failure than reciprocating screw. And maximum value of equivalent stress is obtained is also to much higher than reciprocating screw We can say from analysis of coupling as shown in figure and reciprocating screw, coupling is weaker one than reciprocating screw and it will really fail before or we can say avoiding the failure of reciprocating. The coupling is the better solution for reducing at least torsion failure of the reciprocating screw by making coupling element than reciprocating screw in injection molding process.

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