AUTOMATION OF MANUAL PLASTIC INJECTION MOULDING MACHINE

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RAMANAGOUDA BIRADAR
WIT, Ashok Chowk, Solapur, Maharashtra, India
Email: ramanagouda.cb@gmail.com

DIPAK SHEWALE
WIT, Ashok Chowk, Solapur, Maharashtra, India
Email: dishewale@gmail.com

ANJALEE BATTUL
WIT, Ashok Chowk, Solapur, Maharashtra, India
Email: Anjubattul27@gmail.com

ABSTRACT:

The project work is mainly concerned with the automation of plastic injection moulding machine, which is being operated manually. To avoid human effort and fatigue, we developed a design to automate the machine, which uses roller screw mechanism. Analysis of parts has been carried out using analysis software package ANSYS 16.2 to find the determinants by importing the models which are created using SOLIDWORKS. The theoretical and analytical results have comparatively less difference and are within the permissible limits.

KEYWORDS: Automation, Roller screw

INTRODUCTION:

Injection moulding is a manufacturing process for producing parts by injecting material into a mould. Injection moulding can be performed with a host of materials, including metals, (for which the process is called die-casting), glasses, elastomers, confections, and most commonly thermoplastic and thermosetting polymers.

PROBLEM IDENTIFICATION:

A visit to the reputed Pvt.Ltd. Industry is done. We observed the problem faced by them during the manufacture of plastic products using plastic injection moulding machine. Problem was, due to the manual handling of the lever, pressure and torque difference occurred and because of that, faulty products were being produced. Due to this, 10-12 % products were rejected.Presently, they have been applying uneven pressure and torque by the hand operated lever. To overcome this, we decided to make the existing machine semi-automatic. Because of the increasing interest in this area, we have chosen this problem definition for our project work.

LITERATURE REVIEW:

- SoumyaKanti Manna [1]

This article will describe an innovative way of implementing the automation of an injection moulding machine using microcontroller which in turn will reduce total automation cost.

- B. Pramujati and J. Hernandez [2]

A new approach for controlling part cooling in plastic injection moulding is developed using a Plastic Injection controller and coolant flowrate as the manipulated variable.

- C. T. Wong, S. Sulaiman[3]

This paper presents the design of plastic injection mould for producing a plastic product. The analysis and simulation can define the most suitable injection location, material temperature and pressure for injection.

OBJECTIVES OF THE WORK:

The following are the objectives of the work:

1. To give constant torque to the plunger of the manual plastic injection moulding machine.
2. To adopt a mechanism for feed automation of plunger of manual plastic injection moulding machine.

DESIGN AND FABRICATION OF MACHINE:

PLUNGER LOAD CALCULATION:

For design of the attachment we have to know the plunger load. For that we calculate load at end point of plunger by analytically, experimentally and with the help of Ansys 16.0 software.

Average man can apply 40kg force on the lever. So that we have applied the maximum 40kg force on the lever and calculate the force developed at the plunger.

Here, 1kg = 10 N [4]

Therefore, 40kg = 400N

Moment at center of the lever or pinion,

M_B = 400*0.3= 120 N.m[4]

Same Moment will be transfer to the point at the pinion touches the plunger,

M_C = 120= 0.012*F [4]

F= 10000N

EXPERIMENTAL CALCULATION:

To calculate relation between the load applied on the lever and the plunger force, we take the reading for the different loads on the lever.

Fig. No.1. Load measurement of existing machine

TABLE I Force calculation table

Load applied on lever(kg)	Force developed at plunger(kg)	Force multiplication
0.338	6.1	25.52
1.052	22.07	24.2
1.130	10.42	24.616
0.52	13.28	26.76

Avg. multiplication=25.6

ANALYTICAL CALCULATION:

We have done the analysis to calculate the force developed by the plunger. For that we applied the 10000 N force at the top of the plunger and calculate the moment developed at the pinion center.

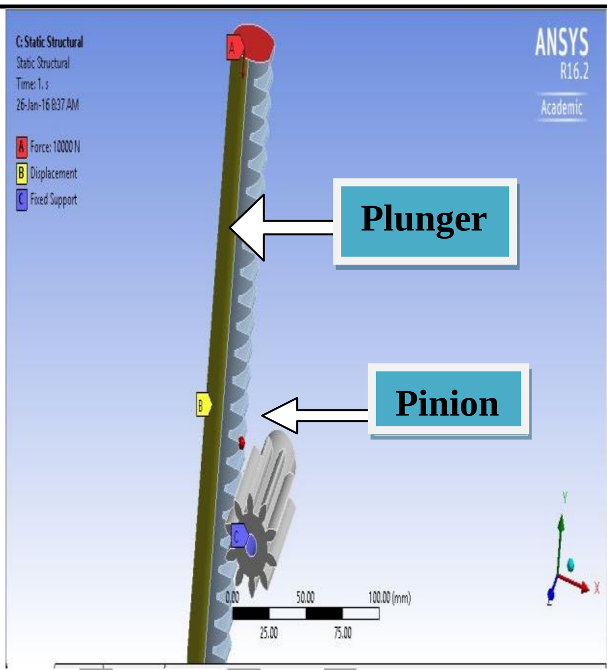

Fig. No.2. Force and constraints on plunger and pinion

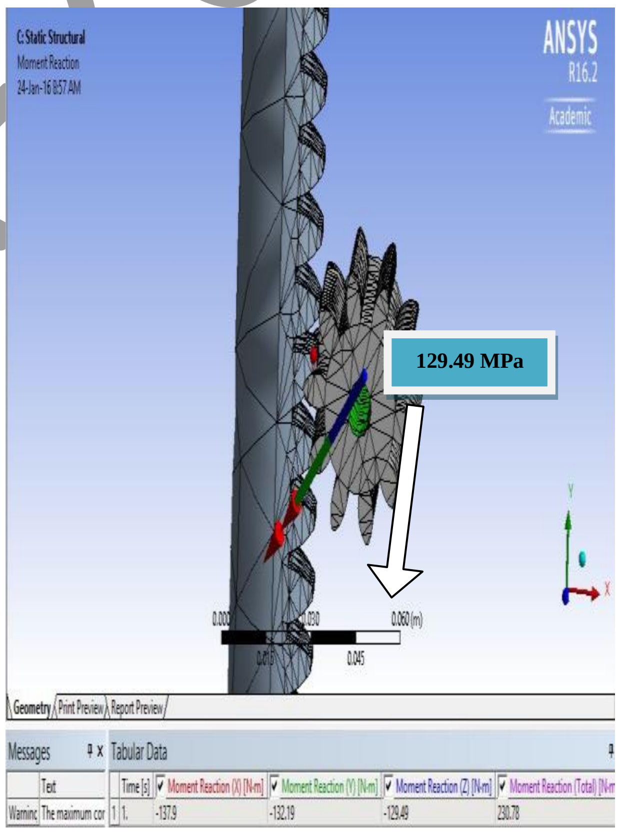

Fig. No.3. Moment at center of pinion

The moment developed at the center of the pinion is 129.49 N.m. (-ve sign indicate counterclockwise direction).

TABLE II Force and Moment calculation

Method	Moment at axis of the pinion (N.m)	Force developed at plunger (N)
Conventional	120	10000
Experimental	--	9917.51
Analytical	129.49	10000

DESIGN OF PARTS AND ASSEMBLY:

TABLE III Requirement of the dynamic capacity

Parameter	Symbol	Value	Units
considered pitch/lead	P_h	5	mm
total plunger travel	S	180	mm
jobs per hour	j	50	
cycles per hour		60	
hours per day		7	
days per year		260	
years per machine		5	
Minimum life	L_{10}	455000	cycles
life in revolutions	L_{10}	16380000	revolutions
dynamic carrying capacity	C_{areq}	74.7414573	kN

TABLE IV Dimensions from catalogue [5]

Parameters	Symbol	Value	Units
Dia. of shaft	d_0	25	mm
inner dia. of cylinder	D_0	78	mm
lead of thread	P_h	5	mm
dynamic capacity	C_a	78.2	kN
static load capacity	C_{oa}	149	kN
theoretical eff.	η_p	0.87	
cylinder outer dia.	D	53	mm
length of roller set	l_{rs}	78	mm

TABLE V Machine part list

Name of the part	Quant -ity	Material	Specification
Main threaded shaft	1	MS (flame hardened)	25mmOD 260mm length
Threaded rollers	3	MS (flame hardened)	21mmOD 52mm length
Nut	1	MS	89mm OD 68 mm length
Plates	5	MS	130mm OD 10mm thick
Cylinder	1	MS	89mm OD 200mm length
Small gears	6	MS (flame hardened)	17mm OD 5mm thick
Ring Gear	2	MS (flame hardened)	56mm ID 5mm thick
Bush	6	Brass	8mm ID 10mm OD
Thrust bearing	1	-	35mm ID
Ball bearing	1	-	25 mm ID

DESIGN OF MAIN BODY:

We calculate the force developed at the plunger for 40kg of load applied at the lever. The 40kg is the maximum force which can be applied by the average man. But the previous machine can bear up to 120kg of load at the lever and the catalogue of the machine shows that the machine is designed for the 120kg of load.

Therefore, we have to design our attachment for a 120kg of load at the lever.Hence the load required at the plunger for which we should design our attachment is 30000N.

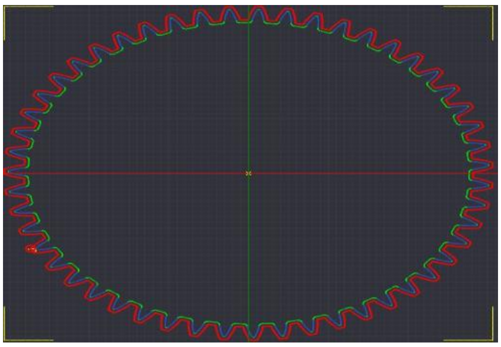

Fig.No.4.Tool path developed in CAM-BAM

DESIGN AND MANUFACTURE OF GEARS:

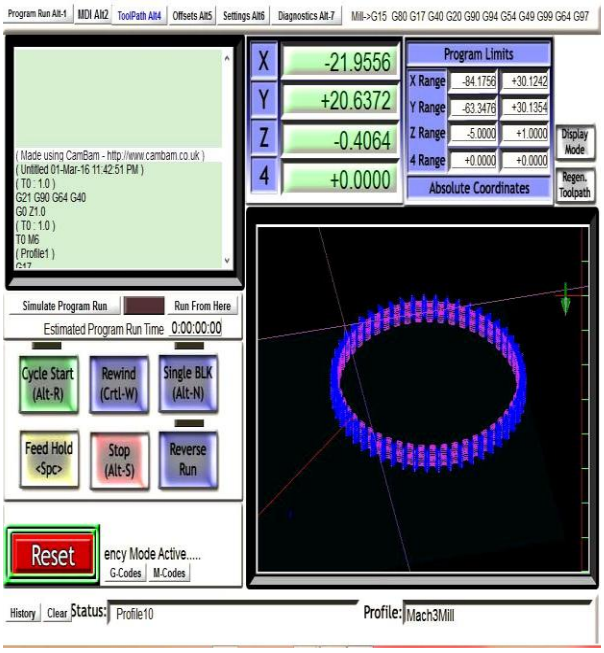

Fig. No.5. Programming and model in Mach 3mill

ASSEMBLY OF THE MACHINE:

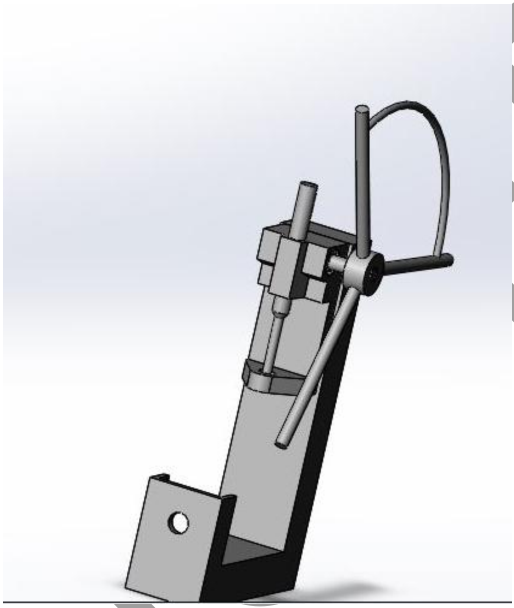

Fig. No.6. Existing machine

Using dimensions as shown in the table no.4 and according to the requirement, we manufactured the parts of machine assembly as listed in the table no.5. Manufacturing is done using CNC machine available at the Industry. And, assembled the manufactured parts, and thereafter assembly is running successfully. Solid model of the existing & assembly is in the fig no. 6 & 7 respectively.

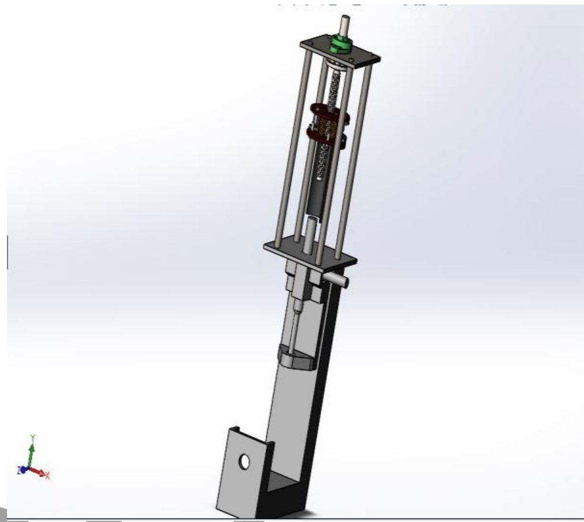

Fig. No.7. Assembly modified machine

RESULTS and DISCUSSIONS:

DESIGN OF ROLLER SCREWS:

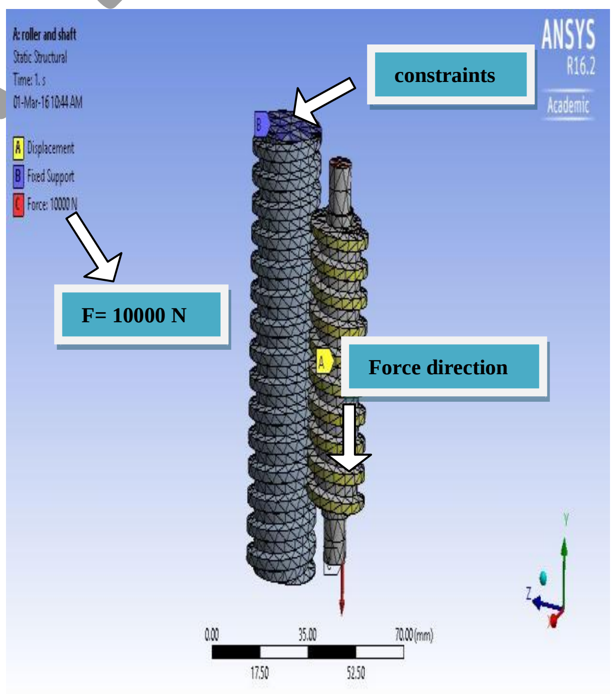

Fig. No.8. Roller screw force constraints

Stress analysis done on the roller screw as it is a critical part in the assembly. Maximum stress developed on roller screw is 68.58 MPa and the permissible stress is 80 MPa for the mild steel material which means our design is safe.From the literature review, we get that roller screw is the critical part. By doing analysis we proved that our design is safe for the developed load on the threaded rollers and shaft.

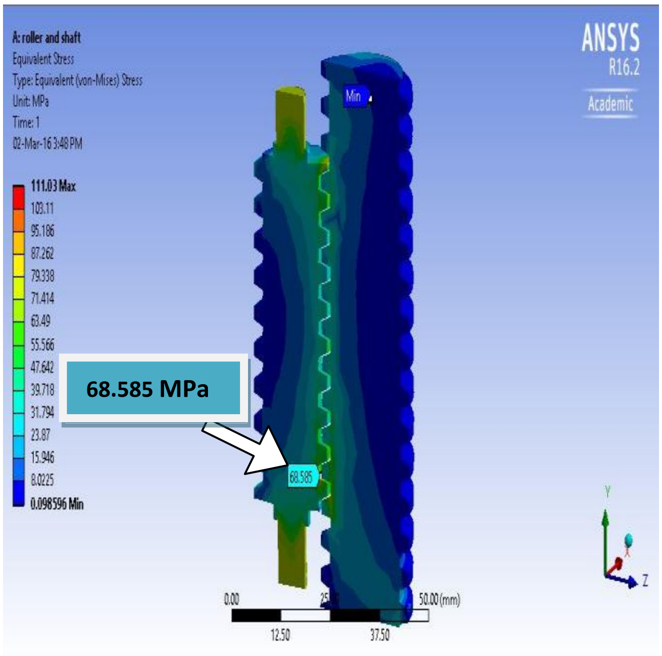

Fig. No.9. Maximum stress developed at root

TABLE VI Shear stresses of the parts

Sr No.	Component name	Shear Stress (by analytical) (MPa)	Shear Stress (by theoretical) (MPa)
1	Roller screw	68.585	65.05
2	Nut	27.67	26.84
3	Plate	31.335	14.92

CONCLUSION:

From the study the roller screw thread is critical part of roller screw mechanism. So we designed and did analysis on different parts of moulding machine viz. roller screw, plates, gears etc. using CATIA and ANSYS 16.2. The shear stress obtained by theoretical and analytical methods approximately same each other also they are in permissible limit. Hence our design is safe.

FUTURE SCOPE:

Automated model has no stopper to control plunger movement. In future we can attach end stopper for better controlling of plunger movement. Also there is a scope of use of switches to the attachment to drive the motor in both clockwise and anticlockwise direction.

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