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Sheet Flow Simulation for Sheet Metal Die Optimization Using Simcenter 3D Software

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Abstract: This research paper explores the advantages and applications of scrap flow simulation in sheet metal dies manufacturing processes. Scrap flow simulation provides valuable insights into material utilization, die design optimization, and overall efficiency in sheet metal forming operations. The study investigates the impact of scrap flow simulation on reducing waste, improving tool life, and enhancing the quality of sheet metal components, ultimately contributing to the advancement of manufacturing processes.
Keywords: Scrap Flow Simulation, Sheet Metal Dies, Die Design Optimization, Material Utilization, Manufacturing Efficiency.

I. INTRODUCTION

Sheet metal forming process is an analytical one in the production of various components for industries such as automotive, aerospace, and electronics. Efficient utilization of materials and optimization of die designs are crucial for enhancing productivity and minimizing waste in sheet metal forming operations. In sheet metal dies it is often noticed that scrap is not moving properly due to some design errors or mechanism error and this resulting down time production and some other troubles in die handling.

With scrap flow simulation we can predict that scrap is moving in proper ways or there is some problem in contacts, and we can rectify this in early design phase.
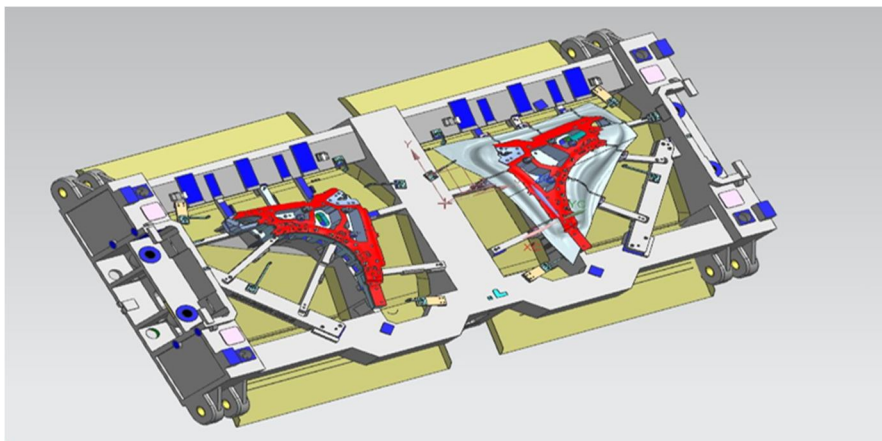

Fig1: 3D Layout of sheet metal die insert.

The primary goals of this research are:
1) To review the current state of sheet metal forming processes and challenges associated with material waste.
2) To explore the applications and benefits of scrap flow simulation in sheet metal dies.
3) To analyse the impact of scrap flow simulation on die design optimization, material utilization, and overall efficiency.

Here is an overview of investigation on existing literature on sheet metal forming processes, challenges related to material waste, and the role of simulation techniques, with a specific focus on scrap flow simulation with the help of various research works based on the sheet metal dies, scrap flow simulation and problem related to it and its impact on plant's overall equipment efficiency.

Hai-Qing Chen et al. in 2023, Researched on "Simulation and optimization of scrap wagon dismantling system based on Plant Simulation". In this research, based on the existence of manufacturing unit layout and the flow of processes, a miniature investigation was operated using the manufacturing unit working platform with the utilization of the efficiency of each working unit and yielding output of the disassembling component as indicating gauges. Worry about falling during disassembly is a solution[1].

Iain P. Flint et al. in 2020, Performed research on "Material Flow Analysis with Multiple Material Characteristics to Assess the Potential for Flat Steel Prompt Scrap Prevention and Diversion without Remelting". This research presented an article on the analysis of flowing of steel material manufactured in 2013 in Europe. This research considered the flowing of steel material described by mass and also by grade, thickness, and coating for the first time. The outcomes showed that thin gauge energized drawing steel was the most required steel grade around the industry and most of the scrap of that grade was produced by the automotive industry [2]. Sravan Tatipala et al. in 2020, Researched on "A Hybrid Data-Based and Model-Based Approach to Process Monitoring and Control in Sheet Metal Forming". Their research offered summary of the usual process of monitoring and regulate approaches along with their disadvantages in the dynamic handling of the sheet metal manufacturing process. They also highlighted a structure for the monitoring and regulating automotive sheet metal formation [3]. Marta C. Oliveira and José V. Fernandes in 2019, Performed research on "Modelling and Simulation of Sheet Metal Formation Processes". In this research, they worked on the numerical solution of sheet metal forming processes i.e. FEM (Finite Element Methods). It became an essential device for the designing of elements and their manufacturing processes in the industries ranging from automotive to aerodynamic, packaging and household appliances also[4]. Dario Baffari et al. in 2019, Performed research on "Aluminium sheet metal scrap recycling through friction consolidation". In this research, they introduced a process i.e. FSC for direct recycling of scrap metal and receiver rods have an inhomogeneous morphology and mechanical resistance due to the delay of vortex fronts in the chamber. To increase productivity, technologies that reduce working hours and expand work should be adopted[5]. Miklós Tisza in 2015, "Researched on Material and Technological Developments in Sheet Metal Forming with Special Regards to The Needs of The Automotive Industry". The main purpose of his research was to provide a common understanding of the recent improvements in sheet metal manufacturing, with the demands of the automotive industry as the main driving force behind those advancements [6]. Okwu Isaac and A.K Le-ol in 2014, Performed a case study on "Development of a Quality Control Programme for steel production". This study includes a dynamic process , where the job timings might be changed according to the uncertainties in order to ensure continuous production process for delivery of final products on time. To do this , a solution was developed which is known as Model Predictive Control (MPC). It tackled the analogous process scheduling problems, and the surging skyline route that allows the application of the lagrangian relaxation algorithm for solving the model of the scheduling problems in a skyline fashion. The outcomes showed that the assumed process yields significantly better results[7]. Andreas Ludwig et al. in 2012, Researched on "Modelling of Multiscale and Multiphase Phenomenon in Material Processing". In their research, they worked on how CFD application could help the Scientists and engineers can better understand the concepts of engineering processes with the help of some examples such as: (i) Specific introduction of the incompatibility of metals including heat, movement and envelopment of non-metallic materials and non-metallic chemicals. Effect of light pressure; (ii) Many events and stages during large slab casting, including flow-induced columnar to equiaxed transformation and three-dimensional formation of separation channels; (iii) Electroslag remelting process Multiphase magnetized fluid dynamics; (iv) Melt flow and solidification of thin and large centrifugal castings[8]. K. Hariharan et al. in 2009, Performed research by using the sheet metal formation analysis with a title "Material Optimisation". In their study, they focused on the optimization of material by deduction in raw dimensions of sheet metal parts. Select roof panels as vehicle components for analysis. Under this article, the weight of blank size for the element is deducted by 1.57%. The CAD model of the formation tools for analysis is scanned by the help of a CMM. The maximization is done by forecasting FLD and also conforming the allowable deduction in thickness[9]. Professor Dr. B. Ravi, Mechanical Engineering Department in 2008, Researched on Casting Simulation and Optimisation. In his paper, he described the advantages (tangible and intangible) of recycled materials, limitations (technological and resource-related) and some good strategies to reduce limitations. It is based on an annual review of the computer system between 2001 and 2006, with input from approximately 150 manufacturers, and a thorough consultation including visits to more than 100 foundries. His research ensures quality and high yielding without any shop floor trials, and also reduces the lead-time for the first good sample production. Productivity also improved [10].

II. METHODOLOGY

A. Cad model Development of Die Insert

The work starts with developing a cad model for investigating the die insert. For this purpose, Siemens UG- NX Software was used. After studied various sheet metal dies, the working on this die insert was started according to the position of die insert, design the suite for scrap. With this suite, scrap will be guided for scrap removal process. This design has a limitation on designing part which is the effect of gravity that will impact the falling of scrap material.

B. Scrap Flow Simulation Techniques

An exploration of various simulation techniques, including Finite Element Analysis (FEA) used to simulate scrap flow in sheet metal Dies.

C. FEA Analysis of the Model

FEA stands for Finite Element Analysis. It is a numerical technique used in engineering to analyse the behaviour of structures or components under various loading conditions. FEA involves dividing a complex structure into smaller, simpler elements, and then solving the behaviour of each element. The results from these individual elements are then combined to predict the overall behaviour of the entire structure.

The connections of each scrap with the scrap cutter were defined, and every part which will be in contact after falling the scrap.

Then the co-efficient of friction for the material was defined. Also defined the gravity value was defined because impact of gravity will affect the falling factor.

After defining all these parameters, Simcenter 3D software was used to run this simulation as shown in Fig2.
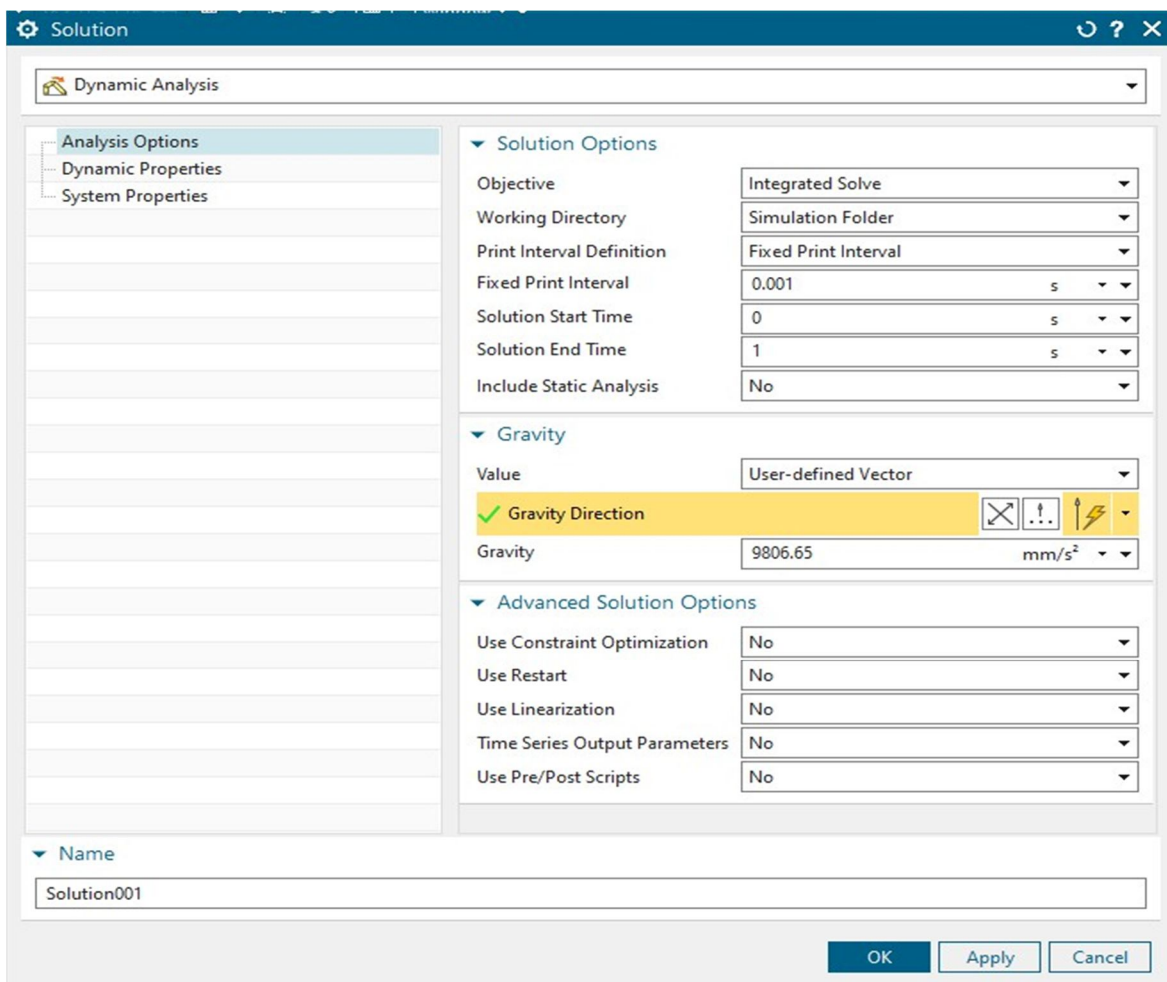

Fig2: The Solution Parameters.

D. Die Design Optimization

After Designing the Cad model of die the primary work to identify the suite area and identify the possible stucking area with the help of Simcenter 3D software (motion module).

Discussion of how scrap flow simulation can inform and optimize die designs, leading to improved material flow, reduced scrap, and increased manufacturing efficiency. With running the solution, the prediction of the exact behaviour of scrap can be done and sometimes in industry scrap stuck between the die insert and suite. This results in the poor die handling situation. If this method in early phase design is considered, the optimization of the die design will be easy.

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In Desing optimization, the thickness of suite can be reduced. This will also give cost cutting and design optimization.
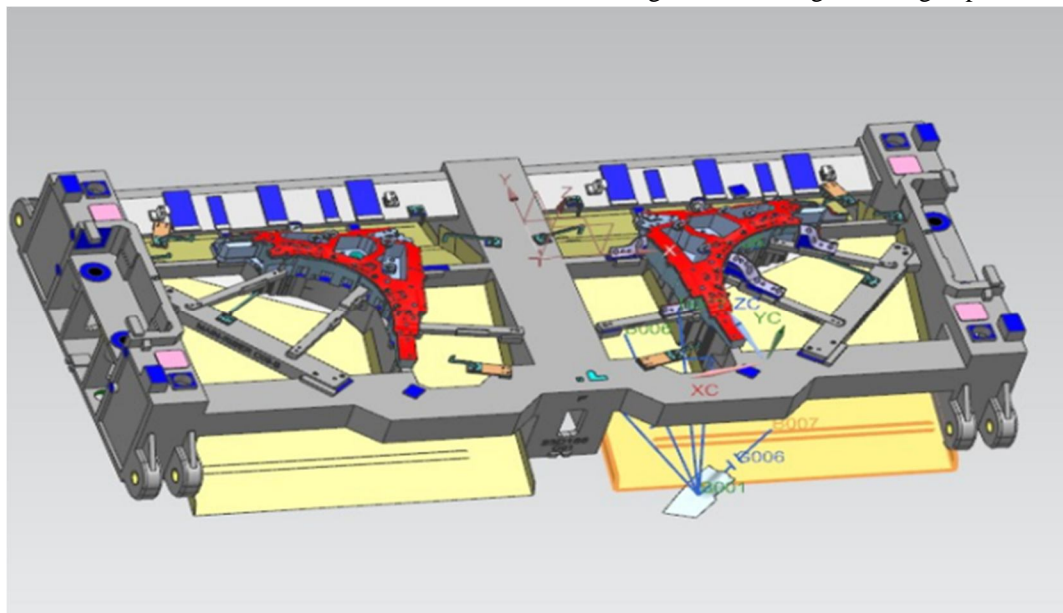

Fig3: Scrap with die insert.

III.   RESULTS AND DISCUSSION

The presentation and analysis of results from the case studies, highlighting the tangible benefits achieved through the implementation of scrap flow simulation in sheet metal forming process.

In this study, the process initiates from designing a sheet metal die insert along with the scrap. In Simcenter 3D software, contact of scrap with each part of die insert along with the physical properties of material was defined.

In this Sheet metal die, die housing was made of Cast Iron material.

Also, the gravitational impact while scrap is falling was defined. In Simcenter 3D software, the direction of gravity with all the parameters used were defined for simcenter 3D solver to solve the mathematical calculations.

In results, it was found that the scrap was coming without any problem. It gives a direction in any sheet metal die design that can predict the behaviour of scrap while designing a sheet metal die.

This study gives a direction that with the help of this study and using this procedure, the optimization of the die design can be done. This will also help in maintain the Overall Equipment Efficiency of a Plant .
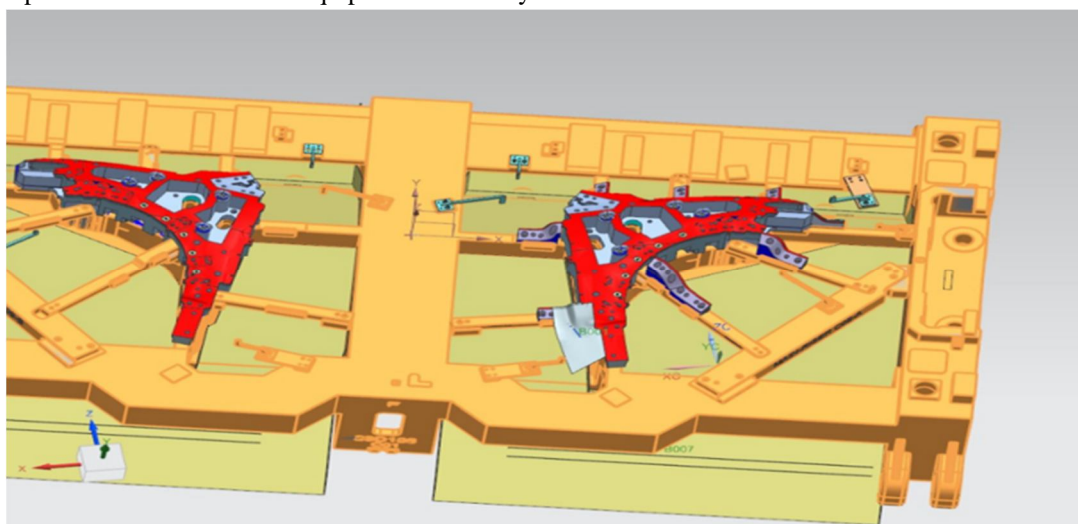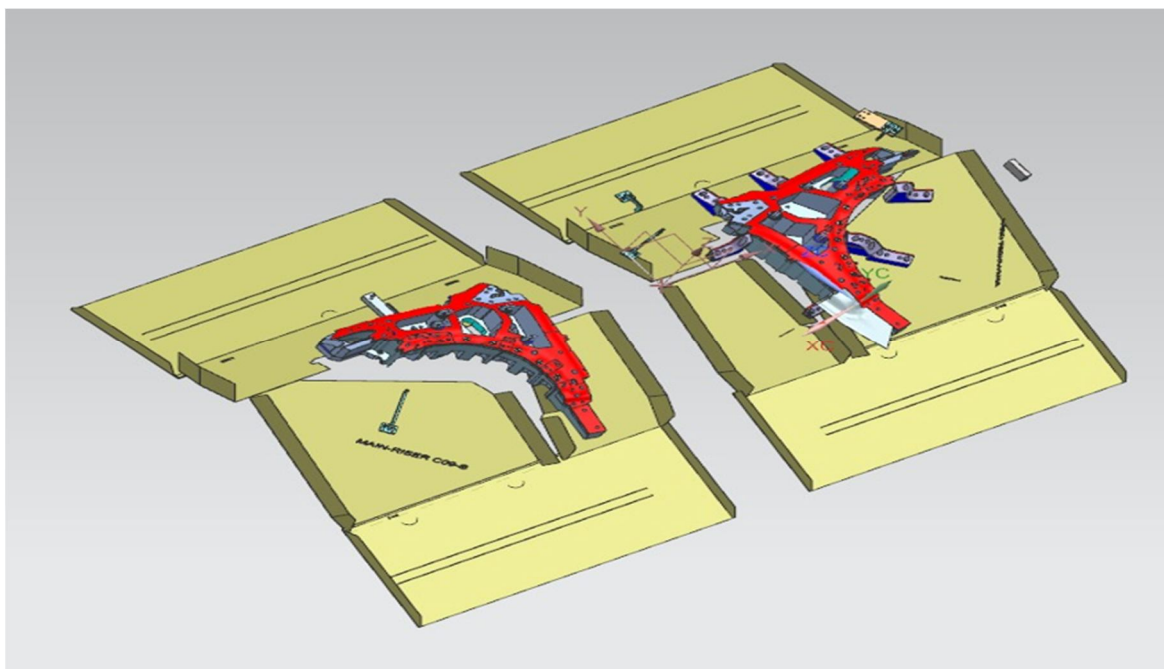

Fig4: Sheet metal die with suite.

Fig5: The resulted sheet metal die.

IV. CONCLUSION

With this study, the prediction of the behaviour of scrap flow falling can be done which results in the reduction of the down time of production and it will help to achieve higher overall equipment efficiency of any production plant.

On other hand due to improper handling of die scrap, it stuck in the die and causing of die defect. Our study will help to reduce these kinds of impact and die. The main purpose of this study was to reduce the production down time by die Scrap flow simulation. With this study and sheet metal die design, there will be very less chance of production down time due to scrap stucking situation. On other hand this will also help to design the exact position on scrap cutter in sheet metal dies.

This study will help in cost cutting in die development, increase the productivity of sheet metal die and reduce the breakdown time of plant. The discussion was done on this problem with various O.E.M manufacturers that they were facing big issue due to the sheet metal stucking. And finally, this solution becomes helpful to them towards die design optimization.

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