Study of the Compaction Dies Used in Powder Metallurgy and its Fatigue Analysis through Software

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Abstract: One of the major tasks in the powder metallurgy process is tool development. In this study, we described some key parameters of the die LIFE and fabricated them using fabrication techniques. EDM machining, which includes variations such as CNC thread reduction EDM machines, is the most common manufacturing method. Roughing and trimming reduction techniques were used to manufacture the punch. Examining FATIGUE LIFE shows the durability of the die in terms of cyclic vanes. This post-graduation thesis investigates the fatigue behavior of press tools made with specific materials and tool designs. The design of the tool is specifically based on cross-sections, and mild steel and aluminum are also possible materials. This piece does a great job of mentioning all the consequences.

Keywords: Powder metallurgy, Compaction Die, Fatigue Life, Design, hardness

1. INTRODUCTION

Powder metallurgy is a manufacturing process that produces precise and highly precise products by pressing powdered metals and alloys under high pressure into rigid moulds. Powder metallurgy has emerged as the primary method of manufacturing bushings, bearings, gears, and various structural additives as a result of the development and exploitation of technological advances[2].

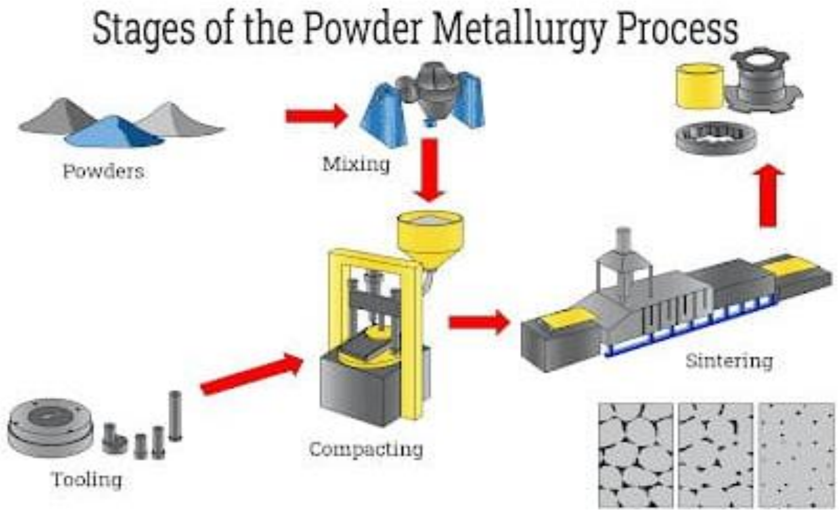

Fig-1 Powder metallurgy process

The sintering mechanism that heats and curing the component to bond the powder fragments is critical to powder metallurgy precision and performance[22]. Sintering takes place at temperatures just below the melting point of steel, creating a strong bond that holds the powdery pieces together. The Powder Metallurgy Process The ancient and unique method of forming and creating patterns from ferrous and non-ferrous metals is known as powder metallurgy[18]. For many years, powder metallurgy has been used to manufacture household goods and electrical appliances. It started as a way to mass produce goods, A component at the heart of the first industrial revolution. This system was only used sporadically until the first decades of the 20th century and is no longer considered a production method. The latest development is additive steel making, one of his four classic variations alongside injection molding and isostatic pressing[10]. The first four steps of powder metallurgy Powder preparation The properties of the products produced by powder metallurgy depend on the properties and properties of the powder[24]. Among the techniques of soft atomization serves as the powder source for powder metallurgy. This technology breaks molten steel into tiny droplets that cool and form fine particles. Atomization is the most common method of producing powders, but there are other options such as chemical reduction, electrodeposition, milling, and pyrolysis. All metals and alloys can be instantly ground into powder, regardless of the system. Powders are analysed and tested for compatibility with powder metallurgy systems before they are blended and blended [21]. Pulling speed, density, compressibility, and strength are variables that can be considered.

The first thing to understand before starting this course is the definition of the term fatigue within the parameters of this guide. The terms fatigue, fracture, and durability are often used interchangeably. Each does so, but only provides a specific meaning.

2. FATIGUE LIFE

There are other ways to define the term, but for this guide, fatigue is defined as a load that is repetitive or otherwise varied without reaching the full point of failure of a single piece of equipment. defined as a failure under

It can also be seen as a result of premedication fissure or defect initiation and development until it reaches a sizeable size. Separation into larger pieces.

The term "fatigue assessment" usually refers to one of two methods: stress life (S-N) or the S-N approach. It is sometimes referred to as total lifespan because of its emphasis on total lifespan. does not distinguish between crack initiation and its growth. This is the most problematic in this process, unlike the local strain or strain life (e-N) approach (also known as the crack initiation method). A fundamental concern in failure is crack growth or propagation after crack initiation. MSC Nastran fatigue assessment is most focused on early types of fatigue assessment and does not affect crack initiation or propagation. They cited MSC Nastran's Cohesive Area Modeling, Digital Crack Closure Method (VCCT), or MSC Fatigue, which uses the LEFM method to predict crack growth, as options for this capability.

The term “shelf life” refers to the sum of all additives that affect the shelf life of the product. The term often includes not only fatigue and failure, but also loading situations, environmental concerns, material characterization, research simulations, and more. All these additives (and more) are accounted for by the appropriate shelf-life software in your company.

Note: Cyclic plastic deformation causes fatigue crack initiation and propagation. Plasticity is required for fatigue failure to occur. This thesis analysis attempts to explain why plasticity is overlooked when determining fatigue life using linear elastic finite element analysis.

3. LITERATURE

High electrical and thermal conductivity, low density, low energy, and high ductility make aluminum the second most used steel in the world and first in the list of most commonly consumed non-ferrous alloys [1, 2]. Approximately 60-80 million tons of aluminum (including scrap iron) are consumed annually, with ores accounting for 75% of this volume [3, 4]. About 25% of the annual requirement is met with aluminum scrap [5]. Another goal is the recycling of aluminum waste [6, 7]. The old process of aluminum recycling is characterized by much lower material consumption due to metal oxidation during melting, slag entrainment, and waste generation. Casting, processing, and other stages [8]. Approximately 50% of chemicals are lost in conventional recycling processes [9, 10]. A very effective method for recycling metals and alloys is powder metallurgy [11]. In powder metallurgy, well-bonded powders are compacted under extreme pressure and sintered to produce the final product [12]. Through the use of powder metallurgy, the scrap produced during metal crushing and processing can be recycled without significant loss of material. In powder metallurgy, materials are processed below their melting point [13]. Finally, there is no tissue loss due to steel oxidation. In addition, powder metal processing makes it easy to create products due to the near-final shape, no additional machining or much less machining is required [14]. As a result, many materials are highly stressed during powder metallurgy processes [15]. Powder metallurgy, therefore, offers great opportunities for the recycling of aluminum. A particularly effective method of producing aluminum foam is powder metallurgy. Powder metallurgy uses fewer resources, produces less waste, and requires less energy [16]. Powder metallurgy process properties such as compressive stress, sintering temperature, and sintering time have a great impact on the physical and mechanical properties of powder metallurgy products. Reinforcement material also greatly affects Houses made of metal foam and composite materials made with the help of powder metallurgy. This work also evaluates the physical and mechanical properties of recycled aluminum, aluminum foams, and composites manufactured using powder metallurgy approaches. Environmentally sound recycling of aluminum is essential for sustainable development, as the revaluation of aluminum ore is limited. An innovative way to recycle aluminum is powder metallurgy, which proposes three different techniques [17]. The first is the direct recycling of aluminum powder and non-reinforced aluminum shavings. the second contains#1 Strengthening Aluminum Scrap Chips in Aluminum Matrix In the third step, various reinforcement materials (SiC, B4C, TiO2, etc.) are reinforced in the scrap aluminum matrix. Figure 1 shows the flow of aluminum recycling using three original methods, including the powder metallurgy method. The physical and mechanical properties of recycled aluminum products depend on many factors, including chip shape and length, chip weight fraction, reinforcement loading, compressive strain, sintering temperature, and sintering time. Various variables are physical and in the following sections, three unique approaches are used to verify the mechanical properties of recycled aluminum. Direct recycling of primary and unreinforced aluminum waste. This direct aluminum recycling method only gives you the starting metal and reinforcement. Aluminum alloy (AA6061) and aluminum matrix composite tips were quickly identified by Foganolo et al. recycling. [18] Using non-reinforced powder metallurgy, aluminum is number one. Chips were recycled using the following methods: Worm extrusion is used and worm urgency is seen with the help of worm extrusion. Aluminum alloy shavings recycled using hot pressing with hot extrusion exhibited higher mechanical properties than aluminum alloy shavings recycled using hot pressing (residual elongation 309 MPa). (292 MPa residual tensile stress). The residual tensile stress (172 MPa) of the Al2O3-enriched recycled (bloodless pressed, extrusion evaluated) aluminum matrix composite was found to be higher than the residual tensile stress (151 MPa) of the starting composite (151 MPa). It is set. Increased energy consequence of improved oxide content material and grain refining. Additionally, Fogagnolo et al. investigated the effects of applying pressure on recycled aluminum alloy at its green density. Figure 2 illustrates the effect of compaction strain on the virgin density of recycled AA6061 and AA6060. The graph indicates that the compaction strain will rise and become almost constant at 700 MPa, which will cause the inexperienced density of AA6061 to rise substantially. Using powder metallurgy without reinforcement and type 1 aluminum, Dragosek et al. also recycled aluminum alloy chips (AA6060) (small and large) [19].

4. BOUNDARY CONDITIONS

A total of three models are studied in this thesis for a good understanding of the fatigue life and safety factor of the compaction dies.

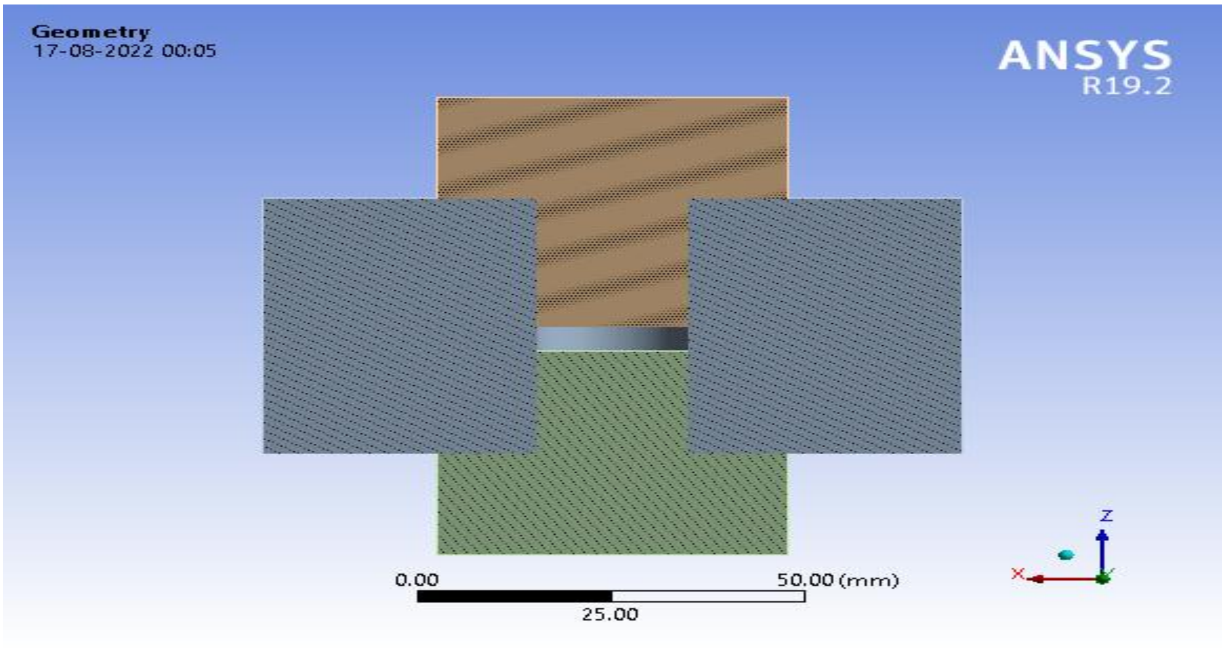

Fig 2 Model-I

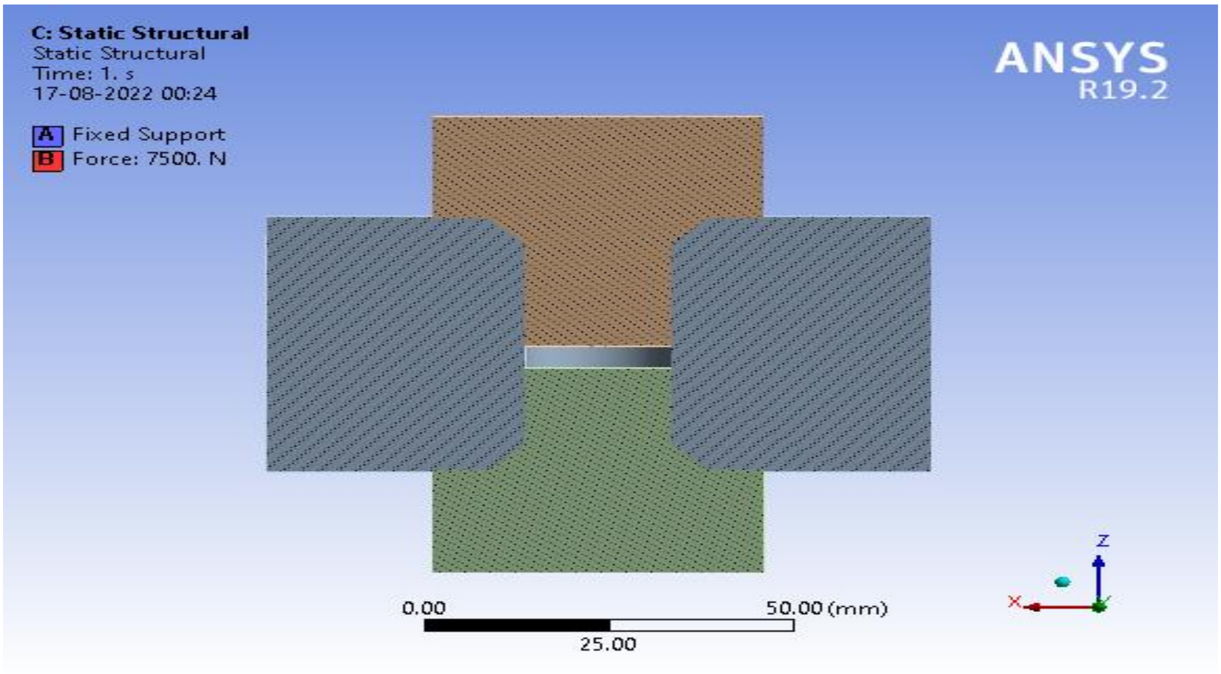

Fig 3 Model-II

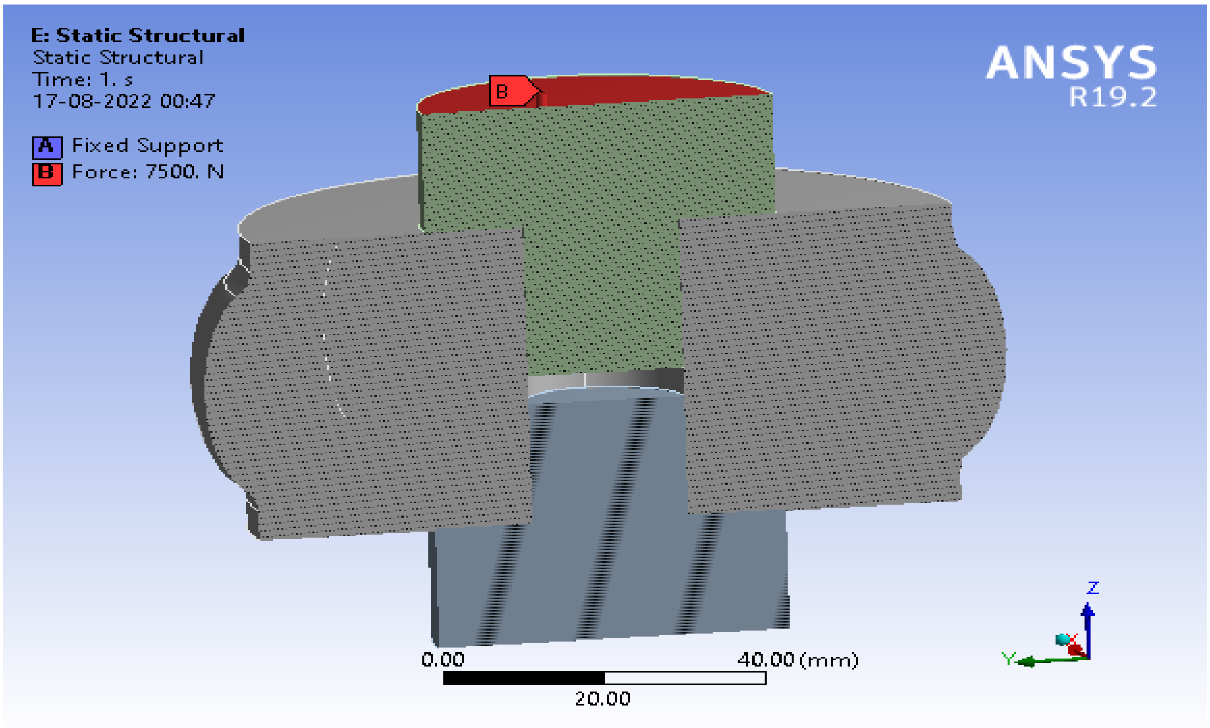

Fig 4 Model-III

5. ANALYSIS

Model-I fatigue analysis pictures are mentioned below, analysis done through ANSYS software. Loading condition reference taken from the reference mentioned at the end of the document[26]

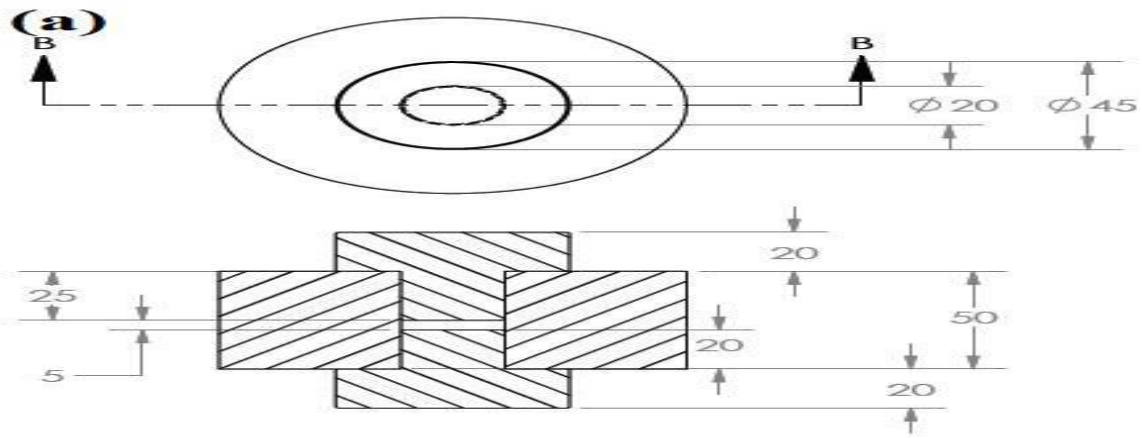

Fig: 5 Dimensions of the die

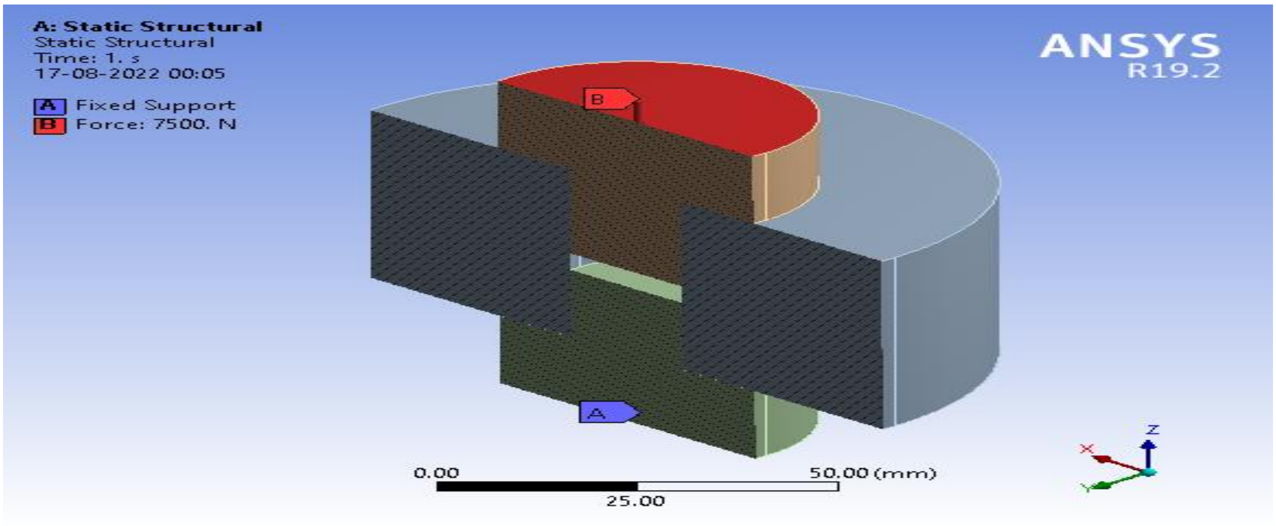

Fig: 6 Dimensions of the die

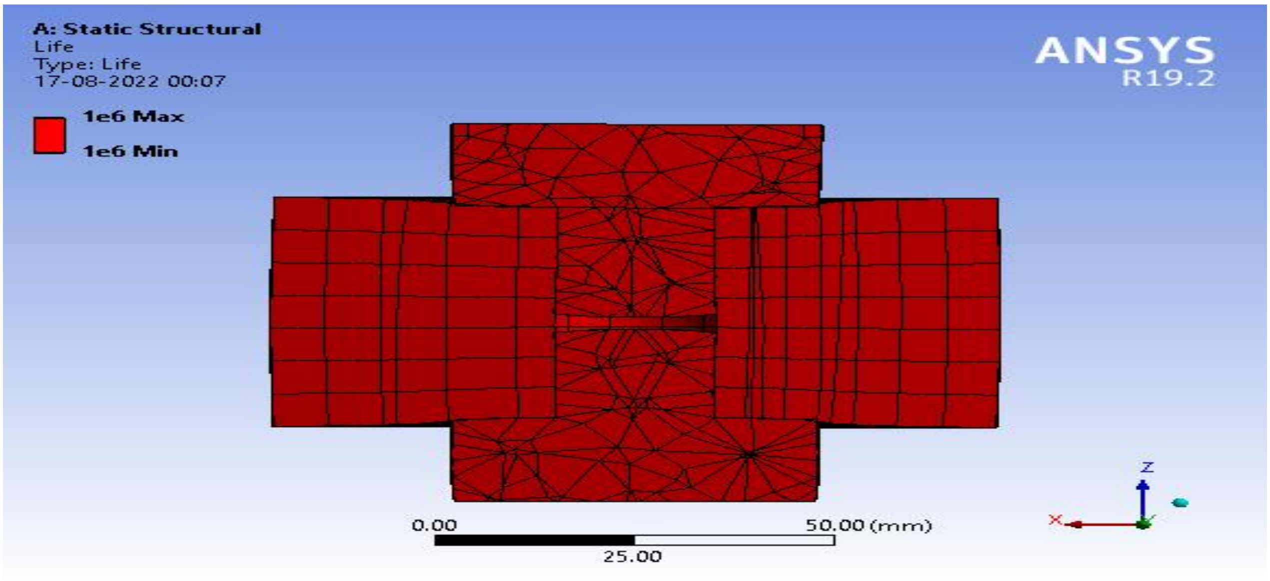

Fig: 7 Life of the die

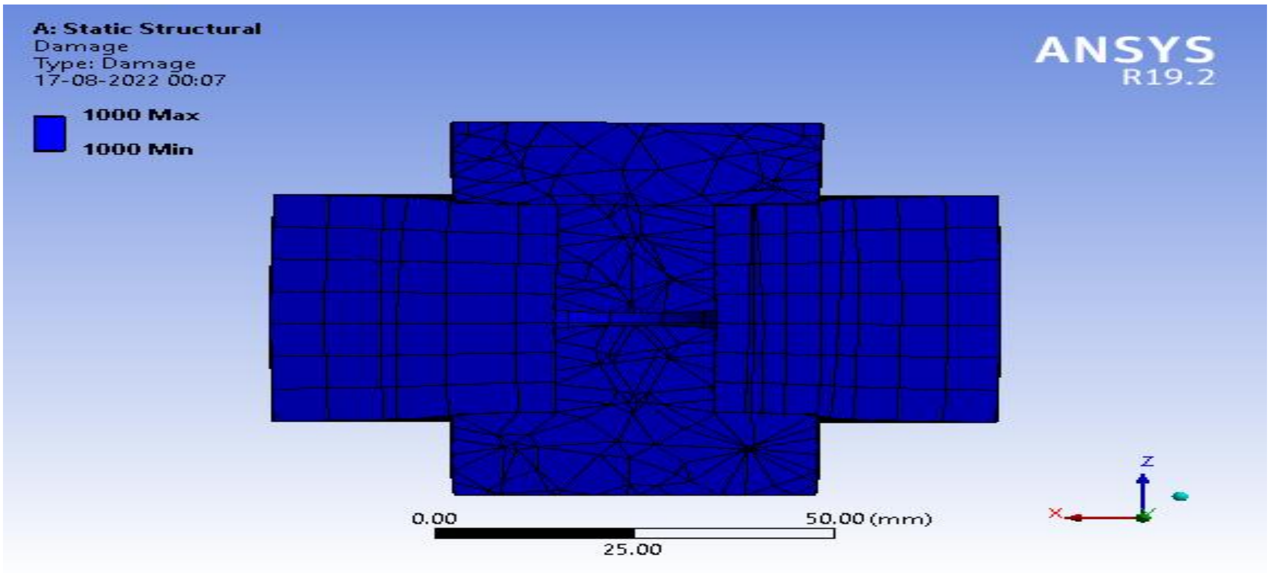

Fig: 8 Damage of the die

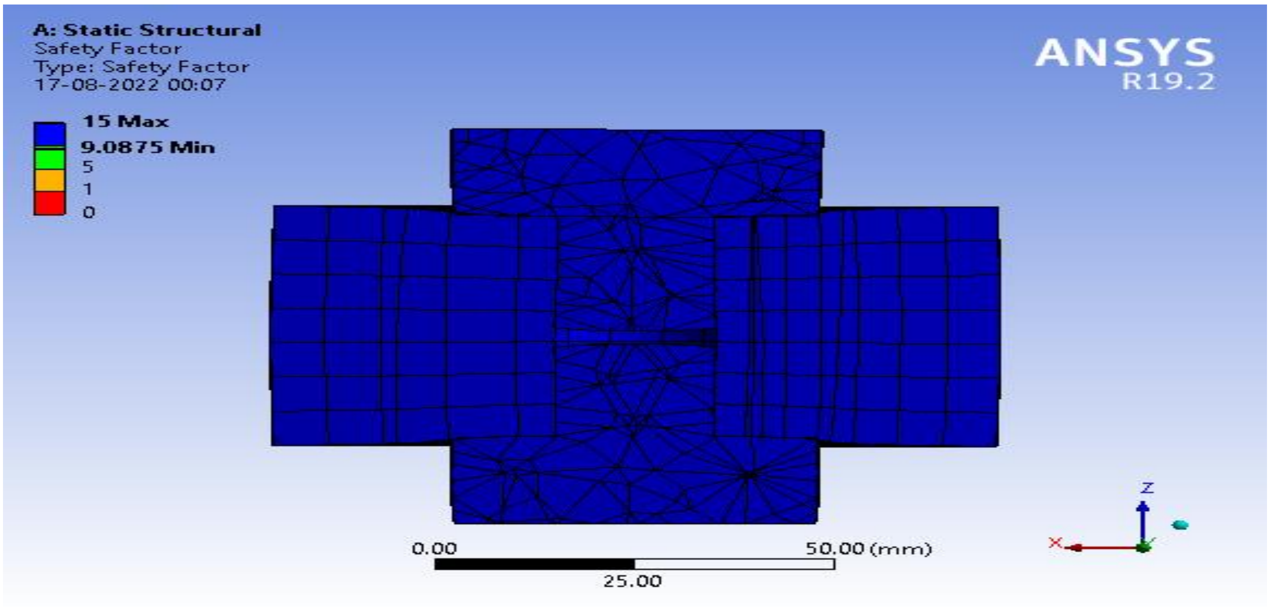

Fig: 9 Safety factor of the die

6. RESULT AND DISCUSSION

In this thesis we've got learned the fatigue behavior of various models of compaction dies, additionally, materials like structural steel and aluminum are considered. The observations made throughout the work are mentioned below.

Structural steel	Life			Damage			Safety Factor		
	Minimum	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Model 1	1.00E+06	1.00E+06	1.00E+06	1.00E+03	1.00E+03	1.00E+03	9.09E+00	1.50E+01	1.50E+01
Model 2	1.00E+06	1.00E+06	1.00E+06	1.00E+03	1.00E+03	1.00E+03	5.01E+00	1.50E+01	1.47E+01
Model 3	1.00E+06	1.00E+06	1.00E+06	1.00E+03	1.00E+03	1.00E+03	2.55E+00	1.50E+01	1.46E+01

Aluminium Alloy	Life			Damage			Safety Factor		
	Minimum	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
Model 1	1.00E+08	1.00E+08	1.00E+08	1.00E+01	1.00E+01	1.00E+01	8.83E+00	1.50E+01	1.50E+01
Model 2	1.00E+08	1.00E+08	1.00E+08	1.00E+01	1.00E+01	1.00E+01	4.96E+00	1.50E+01	1.46E+01
Model 3	1.00E+08	1.00E+08	1.00E+08	1.00E+01	1.00E+01	1.00E+01	2.49E+00	1.50E+01	1.46E+01

1. The above graphs display the safety factor in structural steel and aluminum Die for a distinct model
2. Maximum fatigue life of structural steel Die is 1,000,000 and aluminum alloy is 100,000,000 in all instances however here key aspect is minimum life.
3. Damage is minimal in aluminum models
4. We got the excellent Minimum Safety Factor in structural steel die; however average values are nearly identical in each of the models

7. CONCLUSION

The compaction dies was successfully designed and analys through software like CATIA and ANSYS. Two distinct materials Structural steel and Aluminium alloy was taken for study the fatigue behavior of the three distinct models(1,2,3) of the each die. It was observed that Maximum fatigue life of structural steel Die is 1,000,000 and aluminum alloy is 100,000,000 in all cases. As per universal criteria of fatigue life of die is 10^6. If the die are not failure within this limit the life of die consider as infinite. So we got result in our study of both materials (Structural steel and Aluminum alloy) these material were not failure under 10^6. Aluminium alloy die found were more durable that was 10^8 cycles can withstand instead of structural steel dies. The purpose of this study to use general material like Aluminum alloy and structural steel instead of tool material for making general purpose articles/ artifacts which reduces the cost of tool because the tool material are costly and manufacturing process also tedious.

7. FUTURE SCOPE

In this thesis most effective standard structural steel is studied because of the availability of strain life information and S-N curve, it's far recommended to continue this work with all of the substances which might be utilized in Die manufacturing. Also, experimental work with theoretical validation is particularly recommended.

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