INTRODUCTION

When a new task of product design begins, it is often a “redesign” in nature. So, many design processes either start with or are based on existing designs. In order to quickly reply to the changes of customers' needs or apply a new technique to the existing products, variant design or redesign of the past design results is a good way in this situation. Further, reuse means high quality, low cost, short lead-time to market. All these advantages are helpful to quickly respond to changes of design requirements, which perhaps emerge in the different stages of the whole product lifecycle process. From the point of view of PLM (Product Lifecycle Management), reuse of such knowledge is worth studying [1].

In the later stages of manufacturing, assembly, sales, maintenance and recycling of product development processes, new information will be collected while problems appeared at the stages. These consequent stages of design during the product lifecycle would possibly have their constraints to the final feasible design [8].

These constraints should be taken into consideration while design iterations proceed one after another. Design knowledge of history cases will be helpful to “redesign” task in the following two aspects. On the one hand, failures occurred in the past and the relevant information could be used to avoid similar errors occur in the similar product development environments later. Reusing knowledge of failures to avoid errors in the designs is helpful to avoid unnecessary iteration. On the other hand, the design and the linkages with its depended rationales or rules in past iterations would be useful in redesign task to accelerate the design process [4]. Hence, reusing the design iteration records would be benefit to design the components.

The effectiveness of design reuse consists of improvements in the key factors of production, namely cost, quality, and time-to-market. It is expected that production efficiency can be increased because the designers do not have to start from scratch. Product quality can be improved by reusing the sub-systems or components which quality and validity have been proven. In addition, the outcome of the design can be better predicted, which is valuable to the early decision-making stage. By properly reusing existing technologies, significant benefits can be achieved with respect to cost, time, product quality, and performance [2].

OBJECTIVE-
The aim of this paper is to provide a method for reusing engineering design knowledge. The requirements of the manufacturing industry to create product variants the ability to capture and re-use design knowledge and the capability to support design. The main objective to support the reuse of design knowledge which will reduce the time taken to carry out design.

To Study theory related to design knowledge reuse.

To propose a method to improve design knowledge access.

To prepare detailed procedure and flow charts for design knowledge reuse of mechanical spring.

To develop system for spring design knowledge reuse.

THEORY OF DESIGN KNOWLEDGE REUSE

There are a variety of proposals and analyses of design reuse methodologies and systems in the research literature. They come from a variety of domains including engineering design science, computer aided design / computer aided manufacture (CAD / CAM), artificial intelligence, and knowledge management. The analysis show that still there is lack of support for early conceptual design problems which needs to look after. Effective design reuse is a whole system issue:

• Product design processes,

• Information management, and

• The products must be considered together.

Process (modeling) represents knowledge and can be applied to reusing design knowledge. Process models can be integrated with other aspects of design. A variety of approaches have been developed, however the integration is often not applicable to the whole design process.

Knowledge Based Engineering (KBE) issues in conceptual design are centered on information gathering, and the capture and reuse of design knowledge [3]. Design knowledge, once embedded in
KBE systems, is not reusable to the non-programmers. These demands for a common approach for knowledge reuse through the entire product development cycle.

**Knowledge based engineering**

Knowledge Based Engineering (KBE) is a term describing the application of knowledge to provide some level of automation in the engineering task. The term could be argued as being interchangeable with ‘intelligent design’ and ‘design automation’. KBE can be applied to a wide range of design tasks. KBE as a general technology type can be applied to a range of problems. It cannot be considered as a stand-alone design reuse solution; it requires a supporting methodology. Knowledge-based engineering (KBE) provides a way of formalizing and automating product development [5]. Design knowledge is utilized to expedite the cycle time from product design to manufacturing, at the time it assures the artifacts meet standards across design and manufacturing disciplines. In terms of shared understanding and knowledge representation, the development of ontology and its application to engineering design is providing a means to represent domain knowledge: understanding product (or manufacturing, service, or any domain) concepts, data elements, and relationships between concepts. Figure 1 shows an overview flow of knowledge based system.

![Fig. 1. an overview flow of knowledge based system.](image)

**Design Knowledge**

Design knowledge in product development integration system is a generalized concept. It includes the product design information and the information derived from design information. Design information includes the form information such as engineering document, calculation expressions, CAD data, and other informal information such as measurement and tolerance of design, scheme selection, market information, market forecast, gist of decision-making, and so on. The result includes the knowledge re-created by product design, such as experience and rules. Design knowledge in product development integration system can be categorized as follows: Market information, design parameters, Engineering material, system scheme, function design, structure, process, relation knowledge, process planning information, experience, and rules. Market information knowledge includes consumer advices, individualization demand, market direction, and so on; design parameters include applied standard, technique parameters and technical requirements, etc. [6]; engineering material knowledge includes handbook, catalog, standard, etc; rules include all what is created by field experts and knowledge engineers during their cooperation. Various categories of design knowledge are shown in the figure 2 below.

![Fig. 2. Design knowledge categories](image)

**Design knowledge reuse**

The knowledge elements that this method will address are: product, task and process. For a given design project, product knowledge (requirements, dimensions, users, and a range of other parameters) is provided through a design process interface, along with task knowledge (how to carry out that task). Process knowledge forms a central element of the design project, by guiding the design personnel in their activities (what task happens first, which task is next). The process knowledge also includes links to relevant task and product knowledge sources. Figure 2 above, shows how the interaction of these elements enables knowledge reuse. Assuming that the system is in place, and has been used for a previous project, the situation is as follows: the past project informs the current project, by providing product, process and task knowledge. The process knowledge is a formal process model, describing the product development activities and their sequence. Product knowledge includes a parameter set that is required by the design process. As each task is completed, the product parameters are updated. They are also provided to subsequent design tasks to show the task input and constraints [7]. For each task, a how to description is provided? Each element will be described in more detail below in Fig. 3.

![Fig. 3 Components of design knowledge reuse.](image)
METHODOLOGY.

Design is a process of repetition. The unwanted iterations can be avoided by creating a useful database which consists of ready design for every application of spring. If the application is new then a new design is prepared and stored for the next use. The existing design from database can be used with little modifications in it as per the requirement of the designer.

After design a 3-D model is generated for the corresponding design if required.

The software tools used as follows.

- Visual Basic 6.0- Faster compiler, Allows database integration with wide variety of applications etc.
- Excel- To store the design.
- CATIA 17- For generating model.

The methodology is implemented by using following flowcharts.

Flow chart for design iterations:-

Before going to methodology which we will use in this project, we will discuss about design iterations means repetition of design steps. Iteration starts at the design requirements and will be finished at the state that the design result passes the review point. Therefore, a review point is very important to design iteration. When the result do not pass the review point in the iteration cycle, the parameters of the design objective should be revised and thus another new “redesign” process should be started until it pass the review point. So, the design activities repeat until a good design result was obtained. It is the iteration in a component level of the design process. Similarly, a product design process also has its iterations in the product level. Design iterations will be described in more detail below in Fig.4.

Flow chart for system working:-

First press save button to save the design. If the user is new then he can go for help, otherwise he can directly go for design. If the application is repeated then the design is reused on the basis of parameters. After design 3-D model is generated. System working will be described in more detail in Fig.5.

Flow chart for application selection:

The application is selected from database. If application not available in database save the application in the database and use the application. Application selection will be described in more detail below in Fig.6.

Flow chart for material selection

After selecting the application select the material. If designer wants to use material other than database then enter the name of material along with the values of stresses, values of different moduli and save in the database and go for next design step. Material selection will be described in more detail below in Fig.7.

Fig.4 Flow chart for design iteration

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can make catia to work with values given by vb because there is no any actual connection between vb and catia) then this macro saves all parameters in variable and this variable are used for further creation of geometry)

Step-2 How to model this spring in catia-Go to macro and then press record. Steps for helical compression square spring. To start of catia then, select yz plane and click to sketch at distance cd/2 take one point, on this point take one circle with radius = wd/2 click to exit sketch. Then click to helix, give start point of helix as point created in above step then give no of turn = number of turns, and pitch = pitch. Click OK then click to insert -volume-volume sweep- then select geometry as circle and profile as helix. Click ok. Then on select xy plane -click to sketch-then draw a circle greater than dia = cd.exit-volume extrude-click circle-give any thickness away from spring body. – ok then go to operation-remove-remove this newly generated cylinder from previous spring. Mirror it about the pane created at distance (pitch*no of turns)/2, now stop recording. Edit this recorded macro by edit button. Now just replace all numeric value by variable after putting code for opening and closing of excel sheet.

RESULTS
The results are in following sequence
Input form: - Enter the parameters for which spring is design.
Output form: - The information for design output is indicated.
Reuse form: - The reuse basis parameter is selected for reuse.
Display form: - This shows existing design for reuse.
Edit form: - The change in existing design as per requirement for reuse basis.
The output is saved in excel.
3-D model of spring is generated.

Helical Compression

Input form for helical compression spring- Enter the required parameters of design in input form. If the \( P_{min} \) is zero then the load is static load. If \( P_{min} \) is positive other than zero then the load is dynamic load. Input form for helical compression spring will be described in more detail below in Fig.8.

\[ \text{Fig.8 Input form for helical compression spring} \]

Output form for helical compression spring- After entering the input parameters the result is obtained in output form as shown in fig.4.2. If the factor of safety is less than one the design is safe because stress induced is 0.3 to 0.4 times stress permitted. Output form for helical compression spring will be described in more detail below in Fig.9.

\[ \text{Fig.9. Output form for helical compression spring} \]

Reuse form for helical compression spring- If the application is available in the database for selected application. To reuse the design parameter is selected. The designs are arranged with nearest difference for reuse. After selecting parameter for reuse enter the value for parameter. For reuse the designer can select only one parameter. Reuse form for helical compression spring will be described in more detail below in Fig.10.

\[ \text{Fig.10 Reuse form for helical compression spring} \]

Display of existing design for reuse helical compression spring- After entering the value of reuse parameter the system will arrange similar types of design with nearest possible difference. The existing design is shown by using display form. By pressing next design button all the designs in the database can be seen. Display of existing design for reuse form for helical compression spring will be described in more detail below in Fig.11.

\[ \text{Fig.11. Display of existing design for reuse form for helical compression spring} \]
parameters and style of ends or without any change same design can be reused. Edit form for reuse form for helical compression spring will be described in more detail below in Fig.12.

![Fig.12. Edit form for helical compression spring](image)

The output is saved in excel form and stored for the next reuse. Output stored in excel for helical compression spring will be described in more detail below in Fig.13.

![Fig.13. output in excel form for helical compression spring](image)

3-D model for helical compression spring is generated by using Catia17 & 3-D model for helical compression spring shown in Fig.14.

![Fig.14. 3-D model for helical compression spring of plain end.](image)

CONCLUSION

In conclusion, it is crucial to consider design reuse within the context of design. The design reuse approach should be developed alongside the design methodology, since the methodologies are not mutually exclusive. Rather, design methodology and design knowledge reuse are reliant on one another; each leads the other.

Around 20% of the designer’s time is spent searching for and absorbing information. Furthermore, around 40% of all design information requirements are met by personal stores, despite the fact that more appropriate information may be available from other sources. The type of information used changes during the design process. The Design Reuse Process Method is a cyclic process where knowledge is abstracted from an old design and used to build or enhance the domain method and reuse library, which in turn are used to support the new design. Design for reuse was considered to provide greatest benefits, followed closely with design by reuse, the reuse library and the domain method. Design for reuse is a more fundamental approach to design reuse than design by reuse, and requires greater change.

Design reuse, with all its perceived benefits, remains problematic. Most reuse problems were cases of reuse not taking place: belief that reuse was desirable but not practiced. The next most common problem was an unexpected amount of additional effort to reuse. Others include knowledge loss through inappropriate replication, and error where existing designs were reapplied to new purposes (performance failure).

The benefits of reuse are provided by fast access to the right information, and hindered by organizational, environmental, engineering, cognitive and motivational factors. Design is a process of iterations, which brings cost and delay. In order to shorten the design time, some unnecessary iteration should be avoided. For eliminating unnecessary iterations, a new knowledge reuse model based on design knowledge reuse is developed. In this model, design knowledge is represented through the database in which previous designs are stored. As per the application and the design force the design is reused. As we use the system the number of designs in the database increases which makes the system more knowledgeable for the next use. The system developed so flexible that we can prepare design for new application and stored for reuse. Also new material can be added as per availability of the material. The system helps to use previous successful design from database to reduce number of repetitions.

**Future Scope**

- Force analysis of spring when subjected to static and dynamic load.
- Detailed analysis by changing the material properties and working conditions.
- By keeping record of previous failure cases for reference.

**DISCUSSION**

The 3-D model for remaining types of springs the new design and design reuse for helical tension spring, helical torsional spring, spiral spring and leaf spring can be done by using the same method. The methodology is same for all remaining types of spring.

In this paper, the design and modeling of spring has been discussed. Taking into account the above contribution we have tried to help the small scale industry by introducing this design knowledge reuse concept which will be very much helpful for them.
intending to make a spring for various applications and by using different materials. Various future scope or changes can be implemented in the database of spring according to the need of the respective firm. For example, Force analysis of spring when subjected to static and dynamic load, detailed analysis by changing the material properties and working conditions, by keeping record of previous failure cases for reference.

ACKNOWLEDGEMENT
Success is a manifestation, inspiration, motivation, diligence and motivation. Working on this paper has been one of the most wonderful and exiting experience of my life. This project not only bears the testimony of extensive effort but also reflect the cooperation, help and guidance which I received from time to time. It is obvious that I acknowledge them for their tender help without which would never have been completed. I owe this moment of satisfaction with a sense of gratitude to my project guide “Prof.M. S. Kirkire” for his valuable guidance, suggestions, active involvement with my paper from time to time and without whose help this paper would have been impossible. I am very thankful to head of the department “Mr. D V Malekar” for the valuable support and guidance provided to me. I have great pleasure in offering my sincere thanks to all staff of Mechanical Engineering Department for their kind help.

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