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# Estimation of Performance Parameter for magnetic material selection using MDL

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***Abstract: Sound system is grouping of microphones, signal processors, amplifiers and loudspeakers in compact state which are operated or controlled by mixing console which makes the pre-recorded sound more clearly audible. It is used to distribute these sounds to larger area. But in audio systems speakers plays an important role as it produces audible sound, and in speakers the sound is produced by magnets. Magnet is an important part of the sound system. Selection of proper magnet for sound system is a very big challenge because it depends on various selection criteria. So, it becomes necessary to identify and prioritize those parameters that influence the sound quality that is produced through magnets. In this regard eight parameters are taken into considerations which are having huge impact on selection. Modified Digital Logic (MDL) was used to prioritize these parameters; maximum energy product was emerged as the most critical parameter that affects the magnet required for the sound system. This helps the decision makers to select proper magnetic material for the sound system.***
***Keywords: Sound System Industry, MDL, Selection Parameters***

## I. INTRODUCTION

Sound system industry is a one of the oldest industry. Sound system first developed during World War II. True sound system developed around 1976 by Dolby laboratories. A sound system is the electronic transducer which is used to convert the electronic audio signal into an audible sound (Jang, D., Yoo, J. H., et. al., 2018) [1]. Dynamic speaker is widely accepted in 2010 arena. Kellogg and Chester invented it in 1925. Dynamic speaker follows the same rule as like dynamic microphone however it works reversely to convert electrical signal into sound. Electrical audio signal passes through the voice coil then a loop of wire is sling in a rounded slot between two poles of the magnet. By Faraday's law of induction, it's allow to move to and fro due to this the diaphragm (cone design) coil is attached, it tends to move in to and fro by exerting air force to produce sound waves (Jing, Q., et. al., 2017) [2]. Moreover, there are different types of methods to produce sound waves from electrical signal, rather than basic one.

Magnets are main part of any sound system. There are a variety of magnetic materials available in market to fulfil this requirement. But suitable magnetic material selection is always a challenge for sound system manufacturer because this selection is based on a number of parameters have physical and magnet properties of material. In order to make thin selection easier, the prime focus of manufacturers is to rank those factors which affect magnetic material selection (Alam, M., et. al., 2017) [3]. In the present case there are no comprehensible boundaries in vision of decision makers in the boundaries in vision of decision makers in the brainstorming while estimating performance parameters. So, it is very essential to find prime feasible output in stipulation of nominating critical parameters that affects the performance most, using a logical technique. In this context, MDL is used to prioritize performance parameters that consequence in the maximum gain to the sound system manufacturing company.

## II. EVALUATION CRITERIA

Evaluations are required because selection of magnetic material is a difficult task to make decision regarding the selection criteria. For Selection of the critical parameters, eight necessary parameters have been documented from catalogue of sound system. The selection parameters were extracted from different catalogues of magnets which are used in sound systems.

The identified parameters are discussed below:

### *A. Cost*

The economics of cost play a big role in which material is the best choice. A magnet's cost is mainly driven by the cost of its raw materials and their availability. Most applications use low cost materials. Thus, it is more important aspect in the selection of the magnets for sound system.

*B. Coercivity (Hc)*

The resistance to change in magnetisation in the magnetic material, nearly equal to field intensity compulsory to demagnetise the magnetic material completely is known as coercivity. By studying magnetic hysteresis loop we can determine the coercivity of magnetic material, which is known to be magnetisation curve. The magnetisation curve is measured on time scale by which the coercivity of the material depends upon. Actually, coercivity is the property to convert the magnetisation to the neutral position. To reduce the hysteresis losses, we have to keep coercivity as low as possible (Tang, X., et. al., 2018). [4]

*C. Remanence (Br)*

Remanence is known as measurement of magnetic flux density or magnetic induction after magnetisation, stays in the magnet. It can use as a source of information, by collecting magnetic memory in the magnetic storage devices. By the time magnetic saturation decreased successfully in the applied field back to zero results in permanently macroscopically magnetisation (Chen, L., et. al., 2017). [5]

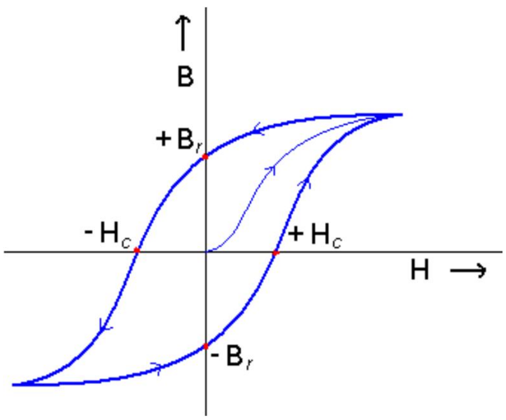


Fig: 1 Coercivity (Hc) and Remanence (Br)

*D. Compressive Strength*

Compressive strength is the property of the material to bear loads which tends to deform the structure. Just opposed to tensile strength which bear loads tends to elongate. Compressive stress is that force which causes a material to deform into smaller volume. Accordingly, magnetic flux path gets short and reduce the magnetic core. Compressive strength affects magnetic property greatly (Thirumalai, C., et. al., 2017). [6]

*E. Hardness*

Hardness is the ability or property of the material to oppose indentation. It determines the hysteresis loss, larger the area larger hysteresis loss. As hardness increase high remnant magnetizations also increase. It also determines the magnitude of coercive force (Parr, R. G., & Chattaraj, P. K. 1991). [7]

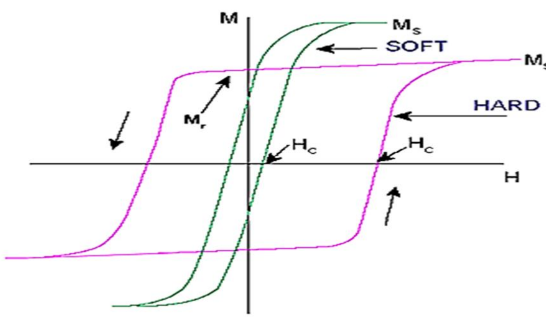


Fig: 2 Typical magnetic hysteresis loops of soft and hard materials

*F. Tensile Strength*

The resistance of a material to breaking under tension. The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. It is the outcome of the altering stress on the magnetisation of a magnetic material leads to change in behaviour of magnetisation has been noticed to rise or fall under the exposure of same stress and same exteriorly applied field. The tensile properties of the material get influenced by magnetic field due to change in magnetic induction intensity (B). With the rise in magnetic induction intensity (B) there is rise in tensile strength and elongation. On tensile properties the magnetic field has positive effect (Abiri, A., et. al., 2017). [8]

### *G. Curie Temperature (Tc)*

It is a temperature due to which ferromagnetic substance losses it's ferromagnetism and becomes paramagnetic is said to be as curie temperature. Due to rise in temperature the magnitude of atom thermal vibrations rises. By their property of rotation, it's having more randomisation of atomic magnetic moments. Atomic thermal vibrations prevent the forces between the adjacent atomic dipole moments which results dipole alignment till some point in the absence or presence of external field. As a result, the concentration of magnetisation at the beginning decreases constantly and then quickly drops to zero. Intrinsic magnetic moment of the material changes its direction in this critical point (Tang, Y. Y., et. al., 2017). [9]

### *H. Maximum Energy Product (BH) $_{max}$*

The measurement of magnetic energy stored in highest amount in the magnet is known as maximum energy product. By these properties of field strength and flux density we can easily attain the maximum product of $BH_{max}$. $BH_{max}$ can identify by product of H, B, the air gap in the magnet's surrounding, where the magnetic field energy density is maximum. We need smaller magnet if the product is higher. To measure this, standard unit is $KJ/m^3$ (Kilojoule per cubic meter) or MGOe (Mega-Gauss-Oersted) (Wang, Z., et. al., 2017). [10]

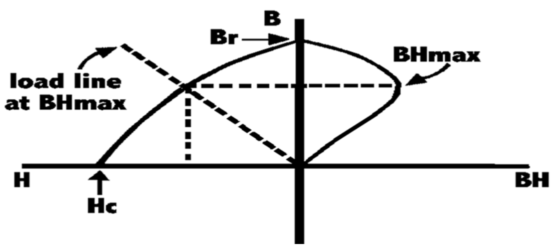


Fig: 3 Maximum Energy Product (BH) $_{max}$

## III. METHOD

### *A. Modified Digital Logic (MDL)*

MDL is a methodology employed to find out the weightage for evaluation criteria. It is a customized version of Digital logic method. Digital logic is a technique in which a table is created in such a manner that two criteria are believed at every time (Rathi, R., et. al., 2016). All likely arrangement of properties is compared and only a yes or no decision for each assessment. MDL possess salient benefits over Digital logic. The prime importance of which is that least significant criterion is not given zero and two equally important criteria may be assigned equal numeric value. The parameters discussed in the section two have dissimilar impact on performance of magnetic properties and therefore cannot be allotted equal weightage (Rathi, R., et. al., 2017).

Consequently, it turns out to be very essential to find the preferences of each criterion. With the consideration of decision experts, a decision grid is created using a combination-wise comparison of selected parameters. One, two and three numeric values are assigned for less, equal or more significant parameters subsequently (Rathi, R., et. al., 2015). We should have the possible positive decisions number to construct MDL matrix (N).

$$N = p\,(p-1)/2 \qquad \text{(a)}$$

Number of parameter can be denoted as'p'. For a particular decision the summation of all positive decision, on normalisation having final weight (Wj) as (Rathi, R., et. al., 2017): [11]

$$W_j = D_j / \sum_{j=1}^{p} Dj \qquad \text{(b)}$$

## IV. RESULT AND DISCUSSION

The current research deals with the selection of magnetic material for sound system which should be in our budget and also there should be no compromise with the quality of the sound. There are various parameters which influence the quality of the sound but we selected the best few parameters which influence most. To increase the performance of the sound system proper magnets should be selected, after lot of brainstorming within the groups and continuous discussion with the mentor regarding the parameters which are to be taken into the consideration.

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The identified selection parameters were analyzed by MDL approach. MDL being a weighted approach provides the decision makers, equal opportunities to formulate well equipped strategies for proper selection of magnetic material for sound system. Present analysis shows that maximum energy product was found to be important parameter responsible for the selection of magnetic material for sound system and tensile strength was found to be the least important factor that affects the proper selection of magnetic material for sound system. Other important parameter that affects the selection of proper magnetic material are remanence and coercivity respectively (refer Table 2). It is also observed that tensile strength and compressive strength were founded as the least important parameters which will affect the selection of magnetic material for sound system.

(Refer Figure 4)

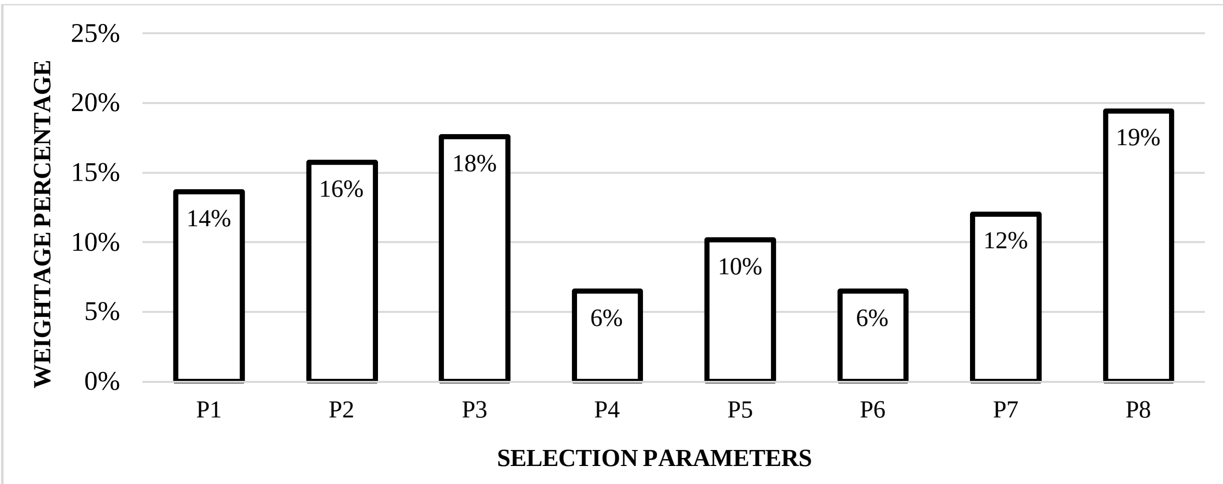


Fig: 4 Contribution to all Selection Parameters

Table: 2 Weightage of the selection parameters calculated using MDL

| Selection Parameters | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | Positive Decision | Weightage % | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| COST (P1) | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | 15 | 14 | 4 |
| COERCIVITY (P2) | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 1 | 17 | 16 | 3 |
| REMANENCE (P3) | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 19 | 18 | 2 |
| COMPRESIVE STRENGTH (P4) | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 7 | 6 | 7 |
| HARDNESS (P5) | 1 | 1 | 1 | 3 | 2 | 3 | 1 | 1 | 11 | 10 | 6 |
| TENSILE STRENGTH (P6) | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 7 | 6 | 8 |
| CURIE TEMPERATURE (P7) | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 1 | 13 | 12 | 5 |
| MAX. ENERGY PRODUCT (P8) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 21 | 19 | 1 |

1= Least Important, 2=Equally Important, 3=Highly Important

## V. CONCLUSION

In today's competitive world survival in the market is quite difficult task. The recent advancement in the technologies in the field of sound system, so to give tough competition in the market selection of proper magnetic material is necessary. So, an attempt has been made to capture the parameters that influence the selection of magnets for sound system. Eight parameters were found that will help in selection of magnets for sound system. Modified digital logic (MDL) method was employed for selection of magnetic material for sound system. The maximum energy product (BHmax) was found to be most important parameter for the selection of magnetic material for sound system followed by remanence. In this system cost does plays an important role, some of the cases the cheaper can be recommended like ferrite, but for better performance we have to give lesser importance to it however not for every case.

Coercivity, Curie temp. are the other factors which comes into picture whenever we are talking about the magnetic property and thus this effectively influence the selection criteria.

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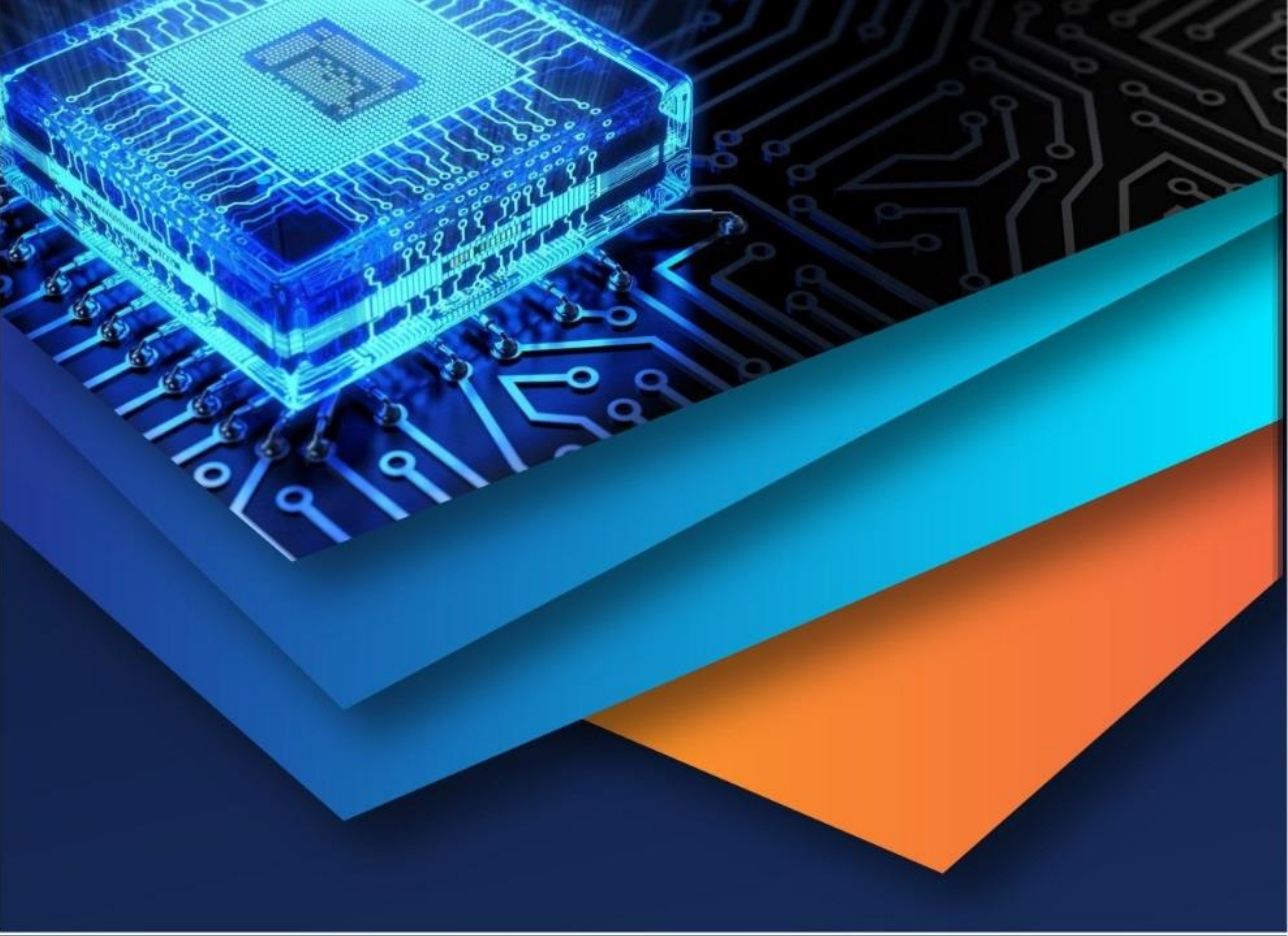

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