I. INTRODUCTION

Idealized cost-optimized coil outlines with good field quality are considered. The outlines are free of any restrictions, imposed by assumptions on the shape of the conductor. The outline is defined by a Fourier series, the coefficients of which are numerically optimised.

II. OPTIMIZATION METHOD

The coil shapes are split into line current elements as shown in (3) in order to calculate the harmonics. The optimization procedure itself used for all cases in this report can be summarized as:
1) Variables - The Fourier series coefficients determining the coil outline, \( a_i \), including \( a_0 \), are used as variables for the optimizer.
2) Inequality constraint - The absolute value of the reduced coil harmonics \( |b_3|, |b_5|, |b_7| \) and \( |b_9| \), defined at two-thirds of the aperture radius \( r_0 = (2/3)R_a \), must be less than or equal to 2 units.
3) Equality constraint - The main field \( B_1 \) must match the required central field.
4) Objective - Minimization of the cross-section area of the coil \( A_c \).

III. RESULTS

It was necessary to use 7 coefficients to define the outlines (1). Introduced shape factor \( \gamma \) allowing to represent outlines as function of \( B, J \) and \( R_a \). The optimised shapes are shown as function of \( \gamma \) in (2). The coil area is related to \( \gamma \) with a simple fit (4). The optimised outlines are more efficient than any other commonly used shape (5).

IV. CONCLUSION

Using numerical optimisation a more efficient idealized cross-section was found. The idealized coil cross-sections presented should be regarded as a guideline in order to find an outline during the initial stages of the design process.

\[ \gamma = \frac{10^6 B_1}{2J_\phi R_a} = \frac{10^6 B_1}{J_\phi a} \]

\[ A_c = \frac{\pi R_a^2}{\gamma} = 2.77\gamma^2 + 1.77\gamma \]